### Sunday, March 30, 2014

#### **Pre-Conference Workshop—Equity and Ethics Committee Sponsored (Free – 60 participants max)** *Awakening Dialogues: Advancing Science Education, Research, Practices and Policies as Equity Researchers* 8:00am – 12:00pm, King's Garden 4

Organizers: Felicia Moore Mensah, Teachers College, Columbia University Jerome Shaw, University of California, Santa Cruz Deborah Roberts-Harris, University of New Mexico Deborah Morrison, University of Colorado at Boulder Leon Walls, University of Vermont

**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 in science education. This year participants will engage in critical dialogue about advancing science education research, practices, and policies that affect the work of equity-minded scholars in science education. Workshop participants will network with facilitators representing the spectrum of various career stages and research interests. Along with eminent scholars in the field, participants will have the opportunity to dialogue and learn how to promote equity research within an ever-changing political arena that impacts our work as equity scholars.

#### Pre-Conference Workshop—Publications Advisory Committee (Free – 50 participants max) Developing High Quality Reviews for the Journal of Research in Science Teaching

8:00am – 12:00pm, Commonwealth 2

#### **Presenters:**

Joseph S. Krajcik, Michigan State University

Angela M. Calabrese Barton, Michigan State University

**ABSTRACT:** The purpose of this preconference workshop is to provide professional development for JRST reviewers. It will also provide valuable information to new researchers on what reviewers look for in a manuscript and how to prepare a manuscript for publication. During this 4-hour workshop we will work with reviewers to develop knowledge and skills for preparing high quality reviews for JRST, foster conversation on expectations for and purposes of reviews, and discuss how to handle common reviewer problems and questions. This session welcomes returning reviewers as well as those who are new to academia and are interested in submitting to and getting published in JRST or anyone who would like to become a reviewer for the Journal. JRST Editors and Associate Editors will facilitate the session.

#### Pre-Conference Workshop—Research Committee (Free – 50 participants max)

### Writing Competitive Proposals for Programs in NSR's Division on Research on Learning in Formal and Informal Settings

8:00am – 12:00pm, Rivers

**Presenters:** 

David L. Haury, National Science Foundation

Celestine H. Pea, National Science Foundation

Ellen McCallie, National Science Foundation

**ABSTRACT:** Through DRL's programs, the National Science Foundation supports innovative research, development, and evaluation of learning and teaching across all STEM disciplines. This workshop will help participants understand the missions and priorities of DRL's programs and provide guidance in writing competitive, high quality proposals. The workshop is structured to include opportunities for collaborative work, discussion, and questions. The content of the workshop includes: 1) the contexts of STEM educational research in DRL; 2) characteristics of and significant changes in DRL's major programs, including Research on Education and Learning (REAL; formerly REESE), Advancing Informal Science Learning (AISL; formerly ISE); Discovery Research K-12 (DRK-12), Promoting Research and Innovation in

Methodologies for Evaluation (PRIME), Innovative Technology Experiences for Students and Teachers (ITEST) and Faculty Early Career Development (CAREER); 3) NSF's proposal review process and merit review criteria; 4) hands-on experience refining proposal concepts; (5) characteristics of competitive proposals; and 6) common weaknesses in poorly-rated proposals. Both novice and experienced researchers are encouraged to attend and join in the discussions. Participants are also encouraged to bring proposal concepts and letters of interest for discussion.

#### Pre-Conference Workshop—Research Committee (Free – 50 participants max)

Developing and Validating Learning-Progression-Based Written Assessments

8:00am – 12:00pm, King's Garden 3

#### **Presenters:**

Karen Draney, University of California, Berkeley

Jenniger H. Doherty, Michigan State University

Charles W. Anderson, Michigan State University

**ABSTRACT:** Participants will practice strategies for developing learning progression-based written assessment systems with attention to reliability, validity, and efficiency. Activities in the workshop will include all stages in a design, development, and evaluation cycle. Specific goals include:

- 1. Participants will evaluate constructed response items according to Learning Progression Item Design Criteria.
- 2. Participants will evaluate item scoring guides according to Learning Progression Scoring Guide Design Criteria.
- 3. Participants will discuss strategies for training coders and scoring assessments in reliable and efficient ways.
- 4. Participants will use response data to evaluate items with respect to different types of validity evidence, including difficulty, discrimination, fit to model, and match to other evidence about students' reasoning (clinical interview transcripts).
- 5. Participants will evaluate revisions in learning progression frameworks for qualities that support reliable, valid, and efficient written assessments.

#### Pre-Conference Workshop—Research Committee (Free – 50 participants max)

Toward Coherence in Quantitative Research Practices in Science Education

8:00am – 12:00pm, King's Garden 1

#### **Presenters:**

Joesph Taylor, BSCS Susan Kowalski, BSCS Molly Stuhlsatz, BSCS Christopher Wilson, BSCS

**ABSTRACT:** This workshop will explore current statistical and psychometric practices in science education research and how themes in these practices may facilitate or inhibit knowledge growth in the field. Workshop facilitators will draw on their own meta-analytic research as well as the synthetic work of other science education researchers. In this interactive workshop, participants will learn about and apply recommended statistical and psychometric tests and reporting practices by working with real data and interpreting real output from statistical analyses.

#### Pre-Conference Workshop—Research Committee (\$50 – 30 participants max)

Building Knowledge Base for NGSS by Fostering Partnerships between Research and Practice 8:00am – 12:00pm, King's Garden 2

**Presenters:** Bill Penuel, University of Colorado Boulder Ted Willard, National Science Teachers Association Dan Gallagher, Seattle Public Schools Kevin Crowley, University of Pittsburgh Jennifer Russell, University of Pittsburgh Tana J. B. Peterman, University of Washington Philip Bell, University of Washington

Deborah L. Hanuscin, University of Missouri-Columbia

Seattle Area Teachers and Pittsburgh Area Practitioners Spanning Formal and Informal Sectors

**ABSTRACT:** This workshop, co-facilitated by science education researchers, a NSTA program director, and a district science coordinator, will provide guidance to researchers and practitioners about how to develop joint projects to fill gaps in knowledge needed to implement the Next Generation Science Standards successfully. The workshop will provide participants with concrete strategies for: (1) identifying persistent problems of practice from both practitioners' and stakeholders' perspectives, (2) developing a collaborative design process that leverages the expertise of practitioners, researchers, subject matter experts in science, and other stakeholders, and (3) formulating design goals that foreground supports for implementation, equity, and diversity.

#### Pre-Conference Workshop—NSTA and NARST (Free – 40 participants max)

Communicating Research to Teachers, Administrators, and Policy Makers

8:00am – 12:00pm, King's Garden 2 Presenters:

Deborah L. Hanuscin, University of Missouri-Columbia

Kate Scantlebury, University of Delaware

David Beacom, National Science Teachers Association

Al Byers, National Science Teachers Association

**ABSTRACT:** This workshop focuses on providing NARST members writing strategies to publish their research in NSTA journals, newspaper and other forms of communication.

### Concurrent Session #1 1:00pm – 2:30pm

#### **External Policy and Relations Committee Sponsored Session**

Symposium – Bridging the Policy-Research Divide: Practical Strategies for Science Education Researchers 1:00pm-2:30pm, Commonwealth 2
Presider: Todd Hutner
Discussants:
John Settlage, University of Connecticut, john.settlage@uconn.edu
Darleen Opfer, RAND Education
Karen Lionberger, The College Board
Michelle D. Young, University of Virginia
ABSTRACT: Many science educators are frustrated by educational policy that ignores research findings. Perhaps the

**ABSTRACT:** Many science educators are frustrated by educational policy that ignores research findings. Perhaps the frustration is evidence of a general failure to make research accessible and informative. This session will address mechanisms by which educational policy is developed. Experts from various organizations will describe their work and the potential for contributions by science education researchers. Central to this discussion will be examining ways in which information can be packaged. A better understanding about the genre, format and content of effective position papers provides a deeper appreciation about how to craft documents to influence local, state and national educational policy. Following the presentations by panelists, they will then be asked to comment upon sample policy documents. Selected NARST members will provide drafts of their position papers that will then be subjected to critique. As a consequence this session, attendees will develop a clearer sense for the perspectives of policy-shapers as well as witnessing the practicalities of writing and editing documents and testimony that will have a greater likelihood of influencing educational policy.

Strand 2: Science Learning: Contexts, Characteristics and Interactions *Affect, Identity, and Creativity* 1:00pm-2:30pm, Heinz **Presider:** Tirupalavanam G. Ganesh

What Not To Do? Identifying Classroom Experiences Associated to Student Disaffection with Physics Geoff Potvin, Clemson University, gpotvin@clemson.edu Zahra Hazari, Clemson University Allison Godwin, Clemson University

**ABSTRACT:** Research on student affect is often framed in a way that seeks out practices that improve student outcomes – such as attitudes, motivation, etc. – comparing to traditional or unreformed practices as the default, "do no harm", status quo. In this work, we instead use a construct of student "disaffection" to identify practices which are significant predictors of this undesirable outcome. Drawing on data from a recent nationally-representative survey of students enrolled in introductory college classes, we use multiple regression analysis to examine students' high school physics experiences. Importantly, amongst other classroom practices, we find that students who indicate their teachers relied on lecturing more regularly have significantly higher measures of disaffection. We also test for gender interactions, to identify experiences which are differentially associated to disaffection for men and women. To this end, we find that female students' evaluations of their teachers to have a strong relationship with their disaffection (e.g. lower teacher evaluations are associated to higher disaffection), whereas male students show no such association. The implications for our evaluation of good teaching practices is discussed.

Longitudinal Study of Effects of Inquiry-based Science Camp on Underachieving Children's Affective Perceptions of Learning Science and Positive Thinking Zuway-R Hong, National Sun Yat-Sen University, a3803429@ms49.hinet.net Huann-Shyang Lin, National Sun Yat-Sen University

#### Hsiang-Ting Chen, National SunYat-sen University Hsin-Hui Wang, National SunYat-sen University

**ABSTRACT:** Development of expertise in modeling is central to the development of scientific expertise (NRC, 2008). Given the recent emphasis to integrate computational thinking in K12 science curricula (Repenning, 2013; Sengupta, et al., 2013), this paper reports results from the first long-term, microgenetic study of 5th grade children's co-development of computational thinking and scientific modeling in the context of learning kinematics. We present a case study of one student's shift from programming to modeling and a whole-class analysis of the development of facets of computational thinking in the context of modeling phenomena. Our analysis identifies the nature of children's progressive symbolization—how the process of progressively refining one's representation of some aspect of the world can contribute to a deeper understanding of a domain (Hall & Stevens, 1995; Lehrer & Pitchard, 2002; Lehrer & Schauble, 2002; Enyedy, 2005)——as children gradually adopted agent-based programming and modeling as the representational "language" (Giere, 1998) in their science classroom over 28 weeks.

#### Interdisciplinary Thinking and Physics Identity

Tyler Scott, Clemson University, tdscott@clemson.edu Zahra Hazari, Clemson University

### Geoff Potvin, Clemson University

**ABSTRACT:** One goal of education is to help students become well-rounded citizens who can think broadly across boundaries. In addition, individuals with interdisciplinary thinking skills can be valuable contributors to modern research challenges by understanding and recognizing interdisciplinary connections and working in diverse teams. However, there is little research on the connection between interdisciplinary thinking and physics education. What aspects of physics classroom practices and experiences foster interdisciplinary thinking? What effect does interdisciplinary thinking have on the development of students' physics identities? Using a physics identity theoretical framework with data from a national survey, this study found that characteristics of interdisciplinary thinking are significantly correlated with higher levels of physics identity development. Notably, there is no significant connection between these characteristics of interdisciplinary thinking and a student's math identity. Also, several factors of the physics classroom environment and pedagogies are significantly related to interdisciplinary thinking.

#### When Do Small Groups Work during Inquiry-Based Science Laboratory Activities?

Martina Nieswandt, University of Massachusetts Amherst, mnieswan@educ.umass.edu

Elizabeth H. McEneaney, University of Massachusetts Amherst

Renee Affolter, University of Massachusetts Amherst

**ABSTRACT:** This qualitative study examines affective and micro-social dynamics of small group work that foster or hinder science learning in a ninth grade environmental science class (N=16). Results suggest that successful group work and meaningful science learning will only take place when students collectively construct a triple problem solving space as they work on an inquiry task. The group must attend to and develop the "content space" (the problem to be solved), the "relational space" (the challenges based on social interactions within the group), and the "affective space" (the emotional life of the group). The results point to that these three spaces have to be collectively developed and maintained during the group work. If groups fail to manage any of the three collective spaces, group collaboration is unsuccessful and learning is minimal.

#### Implications of Gifted Student Selection Techniques for Supporting Scientific Creativity in Young Children Lisa M. Martin-Hansen, California State University Long Beach, l.martinhansen@csulb.edu Erin E. Peters-Burton, George Mason University

**ABSTRACT:** When schools attempt to identify gifted children, quantitative measures are part of that identification process. In schools that focus upon STEM education and also work with children who are being evaluated for a gifted and talented program, one wonders how well the typical measures used for identifying gifted children related to characteristics of those working in science, technology, engineering and mathematics. Are some tools more closely aligned than others? Should there be new tools created? This research is a qualitative content analysis of six quantitative measures typically used in identifying gifted children examining the fit with components of creativity and scientific thinking including flexibility, original thinking, creation of technical products, advances in scientific knowledge, understanding of scientific

phenomenon, scientific problem solving, imagination, thinking about scientific processes, visual processing, and visual manipulation. A matrix was constructed mapping the components to each of the gifted measures. It is evident that most measures of gifted child attributes were poorly aligned with characteristics of creativity in science. The researchers make recommendations regarding the use of the assessments for gifted child identification when STEM is the major focus as well as recommendations for new possible measures.

#### Strand 2: Science Learning: Contexts, Characteristics and Interactions *Online, Blended, Game-Enhanced, and Tutor-Supported Science Learning* 1:00pm-2:30pm, Fort Pitt **Presider:** David L. Fortus

Assessing Student Learning in Summer Online Graduate Science Courses Sanghee Choi, University of North Georgia, schoi@ung.edu April Nelms, University of North Georgia

Chantelle Renaud-Grant, University of North Georgia

**ABSTRACT:** The purpose of this study is twofold: (a) to identify factors and common challenges experienced by students enrolled in summer, online graduate science courses and (b) 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 for the study were 50 inservice middle grade teachers who enrolled in summer graduate online courses. Data was collected from three graduate online courses that included two sections of Physical Science courses and a section of Science and Mathematics Curriculum and Assessment course. End-of-course surveys with graduate students and end-of-course interviews with course instructors and their journals throughout the study were collected. Results suggest that online learning experiences should be more tailored to make connections to the individual student than is possible in face-to-face classrooms to create a more engaging and meaningful learning environment to increase the effectiveness of online learning. The result of this study will provide valuable information for successful online learning and for instructional design to support effective online teaching.

#### Analyzing Actions and Interactions in a Game-Like Approach to Curriculum Based on Video Game Research Carol A. Rees, Thompson Rivers University, Crees@tru.ca

**ABSTRACT:** The decline in young peoples' interest in STEM education and careers is causing concern worldwide. Efforts to encourage interest are best aimed toward middle-school students. Outside school middle-school students learn very effectively through videogames. Research into what it is that makes this learning so effective has led Gee (2007) to identify a set of learning principles evident in video games. Work described here is part of a design-based research study that uses Gee's principles to create a game-like approach to STEM curriculum. Here we use discourse analysis to investigate actions and interactions of a small group of students and their teacher in the first iteration of this approach. Three groups of three students and their teacher role-play STEM professionals (on and offline) in an authentic but make-believe scenario, learning about heat transfer, designing houses to reduce heat transfer, and helping reduce environmental impact. Findings indicate that although some of Gee's learning principles were upheld through actions and interactions of the students and teacher, there were exceptions. Findings provide useful information for development of future iterations of this game-like approach to curriculum and for development of learning games that engage interest of middle school students in STEM curriculum.

# Motivational Support and Student Inquiry Engagement: A Self-Determination Theory Perspective on Online Scientist-Mentoring

Stephen C. Scogin, Texas A&M University, stephen.scogin@icloud.com

**ABSTRACT:** PlantingScience (PS) is a blended curriculum developed by the Botanical Society of America (BSA). PS is unique in its use of scientists as online mentors who communicate asynchronously through text with assigned student-teams engaged in inquiry projects. Using Self-Determination Theory (SDT; Ryan & Deci, 2002), this mixed methods multiple-case replication study (Yin, 2009) investigated the potential impact of online scientist-mentors' motivational

support on student inquiry engagement. I constructed a motivational support rubric to measure scientist-mentors' support of students' autonomy, competence, and relatedness through online discussions. With extreme group comparison (Chase, 1964) as a model and SDT as a theoretical framework, three groupings identified as higher scientist-mentor motivational support (HMS; n = 3), mid-range scientist-mentor motivational support (MMS; n = 4), and lower scientist-mentor motivational support (LMS; n = 3) were developed from the ten cases in the study. Results indicated overall student inquiry engagement was greatest in HMS cases and lowest in LMS cases. As online opportunities grow in science education, this study's findings inform practices that increase the broader impact of scientists through mentoring opportunities, provide motivational support to science learners, and promote deeper student inquiry engagement.

# Investigating the Tutor-Learning Effect: Identification of Predictors of Tutors' Productive Behaviors Jonathan B. Velasco, University of Nebraska - Lincoln, jon.velasco@huskers.unl.edu Marilyne Stains, University of Nebraska Lincoln

**ABSTRACT:** Studies on tutoring have been largely focused on the learning gain of the tutees, often in secondary settings or clinical laboratories. Few studies have investigated the learning gains of the tutors in naturalistic settings in higher education. This study explored the interconnection between tutor perceptions of tutoring, behaviors displayed in a tutoring session, and tutor learning as a result of the session. Interviews with privately-hired tutors were collected to identify major themes in tutor perception. Tutoring sessions were video recorded to identify tutor behaviors in a typical session, and Pathfinder networks were collected before and after each tutoring sessions to monitor any changes that could signify tutor learning. A cluster analysis of the interview responses has shown four sets of overall tutor perceptions. A case study analysis of one tutor-tute pairing shows a possible link between the tutor's view of tutoring as an opportunity to rehearse their own knowledge and the use of ordered, stepwise instruction. Comparisons of Pathfinder networks indicate conceptual rearrangement or reinforcement, depending on the extent of integration of major topics covered during a session. A cross-case analysis among three tutors will be conducted to further characterize links between perceptions of tutoring, tutor behaviors and learning.

#### Strand 2: Science Learning: Contexts, Characteristics and Interactions Scientific Inquiry, PBL, Instrumentation, and Issues of Scale 1:00pm-2:30pm, Sterlings 2 & 3

# Relative Magnitude Estimations for the Durations of Geoscience Processes by 11-13-yr.-old Indonesian Learners

#### Kim Cheek, University of North Florida, k.cheek@unf.edu

**ABSTRACT:** Many geoscience processes occur at temporal and spatial scales outside the realm of daily human experience and are difficult for learners to grasp as a result. Lack of experience with large numbers may be partly responsible. Literature on magnitude estimation for cardinal numbers indicates students use a linear spacing model when they map numbers in a known range, but numbers in an unknown range are mapped using a uniform spacing model. This study investigated whether regular use of large monetary units would enable children to demonstrate more accurate notions of the magnitudes of long temporal units, crucial for understanding geologic processes. Thirty-nine Indonesian 11-13-yr.olds. marked the locations of time periods, ranging from one year to ten billion years on a series of timelines. Forty percent of pupils used a linear spacing model when mapping time periods and 60% used a uniform spacing model. Between group differences were highly significant ( $p \le 0.001$ ) with a large ES. Within group comparisons for spacing of time periods and analogous monetary units showed no difference in how those using a linear spacing model placed the two measures, but results were ambiguous for the uniform spacing model group. Implications for science teachers are discussed.

Promoting Productive Disciplinary Engagement in Instrumented Investigations Chandan Dasgupta, University of Illinois at Chicago, cdasgu2@uic.edu Tom Moher, University of Illinois at Chicago Tia Shelley, University of Illinois at Chicago Alexandra Silva, University of Illinois at Chicago Leilah Lyons, University of Illinois at Chicago Brenda Lopez, University of Illinois at Chicago Tia Shelley, University of Illinois at Chicago Alexandra Silva, University of Illinois at Chicago Leilah Lyons, University of Illinois at Chicago Brenda Lopez, University of Illinois at Chicago

**ABSTRACT:** Understanding the effective use of scientific instruments is an important part of the practice of science. One emerging class of classroom-accessible instruments are inexpensive sensors that can be deployed in large numbers to collect data about the local environment. In this paper, we describe how one such technology—the motion-detecting field camera, or camera trap—was used in the context of a five-week unit on local animal diversity, relative abundance, and food preferences. The instructional design goal was to foster positive disciplinary engagement: small group discourse focusing on the science topic at hand, using the methods of the discipline, and advancing their understandings of science concepts and methods (Engle & Conant, 2002). In this paper, we describe the trajectory of a group of three students who showed the most evidence of positive disciplinary engagement, generate a hypothetical account of the factors that allowed those episodes to be more or less effective, and describe design revisions intended to address ineffective strategies.

*Examining the Roles of Instructor Pedagogy and Student Motivation and Self-Regulation on Student Learning* Katrien van der Hoeven Kraft, Mesa Community College, vanderhoeven@mesacc.edu Lisa A. Gilbert, Williams College at Mystic Seaport

Megan H. Jones, North Hennepin Community College

Jonathan C. Hilpert, Georgia Southern University

**ABSTRACT:** Decades of research at the primary, secondary and post-secondary levels consistently reveal that reformed teaching practices lead to greater student learning gains. And yet, the role that the pedagogy employed plays in these learning gains and how these impact student motivation and use of learning strategies has not been well examined, particularly at the college level. This project examines the interplay between instructor pedagogy, student motivation and learning strategies in introductory geology classrooms across the country. Applying a data set of over 1,100 students in 17 different classrooms at a range of types of institutions to a hierarchical linear model, we have been able to quantify the role that instructor pedagogy and student motivation and employment of learning strategies impacts student grade and learning gains. From this analysis, we have determined that 9% of the variance in student grade is attributable to the instructor, over a third of which (38%) is due to the instructor pedagogy as measured by external observations. Lastly, we see a relationship between student expectancy for success and how student-centered a class is, which may have implications for how to support students with lowered expectations of success in general science courses.

### Strand 4: Science Teaching--Middle and High School (Grades 5-12): Characteristics and Strategies Investigating Curriclum and Assessment 1:00pm-2:30pm, Smithfield

Presider: Sara P. Raven

Investigating Ways Prospective and Practicing Science Teachers Co-Plan and Co-Implement Curricular Reform

Lauren H. Swanson, Whittier College, lswanson@whittier.edu Lorelei R. Coddington, Claremont Graduate University

David Bourgaize, Whittier College

**ABSTRACT:** This study explored one program's efforts to facilitate partnerships between prospective and practicing science teachers. During the program, three undergraduates and two high school teachers co-planned and co-implemented lessons aligned to the Next Generation Science Standards. Furthermore, the undergraduates and teachers participated in scientific research projects of their own design. The research examined these participants' within-program experiences, the nature of the developing partnerships, and the curricular materials they produced to identify the ways in which new standards were incorporated into classroom practice. We contend that engaging in both research and teaching experiences allowed for all participants to be valued contributing members to their partnerships and overall community.

Teachers' Perceptions of High-Stakes Testing and Accountability in Elementary Science Georgina O. Lindskoog, University of Miami, glindskoog@umiami.edu Jaime Maerten-Rivera, University of Miami Soyeon Ahn, University of Miami Brandon S. Diamond, University of Miami Okhee Lee, New York University

**ABSTRACT:** High-stakes testing and accountability is a topic of great debate because of the effects it can have on student learning. Teachers' perceptions of high-stakes testing and accountability may affect their teaching practices, which in turn could have an effect on student learning. This study examined fifth grade science teachers' perceptions of high-stakes testing and accountability and variations in teachers' perceptions by teacher demographic (i.e., gender and ethnicity) and professional variables (i.e., science background, ESOL endorsement, and number of years of teaching ). The study involved 220 ethnically and linguistically diverse teachers who completed questionnaire and background forms and who taught ethnically and linguistically diverse students in a large, urban district. Data were analyzed using simultaneous multiple regression. Results support existing themes in the literature that teachers perceive standards positively, but high-stakes testing and accountability and the impact on teaching practices negatively. Although teachers' perceptions were overall consistent across teacher demographic and professional variables tested, variations were observed based on ethnicity, years of teaching, and ESOL endorsement.

A Framework for Assessing Cognitive Demand of Instructional Tasks in the NGSS Era

Miray Tekkumru Kisa, University of Pittsburgh Learning Research and Development Center,

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Mary Kay Stein, University of Pittsburgh

Christian Schunn, University of Pittsburgh

**ABSTRACT:** With the release of the Next Generation Science Standards (NGSS), students are now expected to learn the scientific body of knowledge by meaningfully engaging in the practices of the discipline instead of learning science by reading about science in books or by memorizing the steps of the scientific method. Whether and how the NGSS shape student learning will depend on a variety of "channels of influence" (NRC, 2002) including assessments, curricular materials, teacher education programs, and, of course, instructional practice. The tasks given to students constitute a recognizable and consequential unit of activity across all of these channels of influence. The purpose of this paper is to advance a framework for assessing the cognitive demand of instructional tasks. The Task Analysis Guide in Science helps users to classify tasks according to two critical features: 1) the extent to which science content and the scientific practices are integrated, and 2) the level of cognitive demand by identifying the various combinations of "science content" and "scientific practices" that comprise science tasks. The framework could be a useful tool, like the Task Analysis Guide in mathematics education, both for practitioners and researchers to guide the improvement and study of science teaching and learning.

#### Strand 5: College Science Teaching and Learning (Grades 13-20) Related Paper Set – Peer Teachers in Large STEM Courses: Comparison of Three Models from North America

#### 1:00pm-2:30pm, Rivers

**ABSTRACT:** Low student performance in large introductory science classes at the university level is a continual thorn in the side of science educators, and one that we hope our various Peer-Led Team Learning (PLTL) approaches can solve. These papers come from a large public university in the southeastern US, a large private university in the northeastern US, and a large public institution in Canada. Building connections with faculty and fellow students through the peer teaching experience provides a stronger link between the individual and the university, and can improve the university experience. We have found that peer teachers report feeling more engaged and involved with the learning process, their students, course content, and the university. However, all face similar challenges revolving around their role as a peer, but also as a teacher. Lastly, PLTL approaches can improve the performance of students enrolled in large STEM courses. We look forward to engaging session participants in determining which aspects of our various programs are most successful and should be recommended for use at other institutions.

Strategic Alliances and Allies in University Education: Peer Teachers/Educators Meredith M. Thompson, Boston University, mtknight@bu.edu Kate Popejoy, University of North Carolina at Charlotte

A Team Approach to Successful Learning (TASL): Developing Learning Coaches in Large Lecture STEM Courses

Kate Popejoy, University of North Carolina at Charlotte, kate.popejoy@uncc.edu Kathryn Asala, University of North Carolina at Charlotte

Insight into Involvement: Perspectives from Peer Educators Meredith M. Thompson, Boston University, mtknight@bu.edu Peter S. Garik, Boston University Kathryn Spilios, Boston University

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

*Translating the STEM Experience* 1:00pm-2:30pm, Sterlings 1 **Presider:** Saouma B. Boujaoude

The Positive Impact of the SETGO Program on Confidence and Attitudes of STEM Majors Tracy L. Huziak-Clark, Bowling Green State University, thuziak@bgsu.edu Toni A. Sondergeld, Bowling Green State University

Christine Knaggs, Lourdes University

Moira van Staaden, Bowling Green State University

**ABSTRACT:** After five years of evaluation of the SETGO program findings suggest that students feel more confident not only in their preparation for the rigors of a STEM degree, but also in their decisions to complete the degree. Participants cite the small group learning environment, faculty and peer mentoring, as well as integrative learning activities and research experiences as reasons for their increased confidence and attitudes. The three-pronged approach to meeting needs at different levels of the STEM pipeline also had direct impact on the successful nature of the overall program.

Abstraction Thresholds in Undergraduate STEM Curricula

Hannah Sevian, University of Massachusetts Boston, hannah.sevian@umb.edu Gabriela A. Szteinberg, University of Massachusetts Boston

Lance C. Pérez, University of Nebraska-Lincoln

**ABSTRACT:** This study hypothesizes that most undergraduate STEM curricula have an abstraction threshold, at which point a typical student's current capacity for abstraction is not matched to the complexity of the problems posed in the course. Drawing from results in developmental theory and cognition, this study applies a representation mapping framework to develop a method for identifying the types of cognitive processing, rules or similarity, and the degree of abstraction used in problem solving. Analysis of students' capacity for abstract reasoning is compared to the cognitive demand of problems representing the 'accountable disciplinary knowledge' that students are expected to demonstrate in their courses, in order to determine whether an abstraction threshold occurs. Students' facility with both processing types, and the degree to which they demonstrated abstraction, were found to increase from Organic I to Organic II to Thermochemistry, as the cognitive demand of the problems also increased. A comparison of results from chemistry courses will be presented. Comparison of results from chemistry and electrical

engineering contributes to an understanding of how domain-general and discipline-dependent cognitive processing interact in two disciplines.

Assessing the Development of Undergraduate Researchers' Scientific Thinking Skills Using Performance Data Joseph A. Harsh, Indiana University Science Education, jharsh@indiana.edu

John Esteb, Butler University Department of Chemistry

Adam V. Maltese, Indiana University Science Education

Mikaela L. Schmitt-Harsh, Carleton College Environmental Studies

**ABSTRACT:** Within the sciences, undergraduate research experiences (UREs) are widely touted as one of the most powerful educational devices to develop student skills in preparation for STEM careers. However, while extant literature has identified a range of participatory benefits associated with UREs, research to date has largely relied on indirect self-report data, which may limit inferences about the causal effects of these experiences on student skill outcomes. In an effort to more accurately gauge the educational effectiveness of UREs, the present exploratory study complimented self-report data with performance measures to assess the development of student scientific thinking skills during their research experience. Performance data were collected from chemistry students (n=36) in a larger national study on UREs using a situated open-response instrument designed to test scientific thinking skills in solving real-world problems. Early findings suggest the reliability and validity of the instrument to assess the extent to which UREs contribute to the development of a range of targeted skills. This innovative work begins to offer direct evidence to the effect of UREs on students' research competencies, which may be of particular use to faculty and administrators for the refinement of these experiences to improve student training.

*Measuring University Students' Science Communicatio Efficacy in Middle and High Schools* Xiufeng Liu, State University of New York at Buffalo (SUNY), xliu5@buffalo.edu Fu Lei, State University of New York at Buffalo (SUNY)

**ABSTRACT:** In the US, there is a long history of involving university students in K-12 science education, such as the NSF-funding program Graduate STEM Fellows in K-12 Education (GK-12). While the benefits of GK-12 and similar service learning programs have been reported, direct measurement of university students' gains using standardized measurement instruments is still lacking. The present study intends to fill this gap. It focuses on university students' self-efficacy in science communication. The development of science communication efficacy instrument followed a construct modeling approach. Science communication efficacy in the present study was defined as university students' beliefs in their capabilities to help middle and high school students understand science. The draft measurement instrument consisted of 20 rating-scale items addressing three major aspects of science communication to middle and high school students: understanding students, developing science content, and explain the content. The draft instrument was given to university students who were part of a NSF-funded project that assigned university graduate and undergraduate students to middle and high school classrooms. Altogether, 87 students completed the draft instrument. Rasch analysis results suggest preliminary evidence of validity and reliability, although the instrument still requires some improvement.

#### **Strand 6: Science Learning in Informal Contexts**

*Symposium – Building a Compelling Case for Informal Science Education: Are We on the Right Track?* 1:00pm-2:30pm, King's Garden 2

**Discussants:** 

David Kanter, Kanter Learning Design and Research Jennifer DeWitt, King's College London, jennifer.dewitt@kcl.ac.uk Kevin Crowley, University of Pittsburgh Martin Storksdieck, The National Academies Philip Bell, University of Washington James Bell, Association of Science and Technology Centers Bronwyn Bevan, Exploratorium **ABSTRACT:** Five years after the publication of Learning Science in Informal Environments, this symposium will provide an opportunity for Strand 6 members and others interested in the field of informal science education to take a look backwards and forwards and to reflect on increasingly urgent questions for our field. We will hear from those involved in the creation of the LSIE volume and in more recent efforts to create a roadmap for bridging research and practice. The session will be framed by the overarching question of whether we are conducting the kind of research we should be – and for what purpose. Some of the specific questions our presenters will consider include: What kind of research should we be conducting to better understand learning in informal environments? To support practice? To convince policymakers of the value of informal science experiences? Is it a matter of framing the same research in different ways, or do we need to collect different kinds of data to address different questions? What do we as a field need to do to build a compelling case for informal science education? And to whom? We expect this session to involve a lively and timely debate around key issues.

#### **Strand 7: Pre-service Science Teacher Education**

### Symposium – Rigorous and Responsive Science Learning by Design: Transforming Classrooms and Practice-Based Teacher Education

1:00pm-2:30pm, Duquesne

#### **Discussants:**

Jennifer L. Cartier, University of Pittsburgh Jessica J. Thompson, University of Washington, jjthomps@u.washington.edu Hosun Kang, University of California Irvine David Stroupe, Michigan State University Sara Hagenah, University of Washington Melissa Braaten, University of Wisconsin Scott McDonald, Pennsylvania State University Douglas B. Larkin, Montclair State University

**ABSTRACT:** In this interactive symposium session we aim to discuss robust forms of student learning created in science classrooms, and to inquire into the role of a practice-oriented teacher preparation programs in transforming both science teaching and learning. We will present segments from classroom videos and a set of four empirical studies that illustrate both teachers' success and struggles in supporting ambitious and equitable forms of learning in classrooms. The studies all stem from a teacher education program that focuses on four core science teaching practices: planning for big ideas, eliciting students' ideas, supporting sense-making within and across activities, and pressing for evidence-based explanations. Three teacher educators from different institutions who are also using some of the core practices and tools will also present their success and challenges in supporting pre-service science teachers' development of instructional practices. Participants will be invited to collectively and collaboratively inquire into their roles as teacher educators and programs that support rigorous and equitable learning.

### Strand 8: In-service Science Teacher Education *The Role of Mentoring in Inservice Teacher Education* 1:00pm-2:30pm, Benedum

Presider: Julie C. Brown

### *Culturally Responsive Mentoring Conversations as Reflective Practice for Secondary Science Teachers of Minoritized Students*

Sara E. Tolbert, University of Arizona, saratolbert@email.arizona.edu

**ABSTRACT:** In this paper and presentation, I share results from a study of 4 science teachers and 4 facilitators (instructional coaches) at 4 different schools participating in the Te Kotahitanga Professional Development Programme in Aoteaora New Zealand. Te Kotahitanga is an educational reform project that has significantly impacted the participation, achievement, and retention of indigenous Maori students in secondary schools. Specifically, I investigated how the facilitators, using evidence from prior research and classroom observations, engage science teachers in reflective conversations around culturally responsive science teaching. Results indicate that these mentoring conversations, when

facilitated by culturally competent mentors, can be powerful tools in helping teachers become better educators of underserved students in science.

*Face-To-Face, Online, and Hybrid Designs for Mentoring* Ya-Wen Cheng, University Of Missouri, yck86@mizzou.edu Mark J. Volkmann, University of Missouri Deborah L. Hanuscin, University of Missouri-Columbia

**ABSTRACT:** Teacher professional development as an important subject of education reform is essential for teachers to develop knowledge and competence they need to succeed in their classroom and career. Mentoring as a supportive mechanism is broadly used in online and face-to-face environment to assist teachers to develop content knowledge and pedagogical skills. However, face-to-face or online mentoring have limitations. The combination of face-to-face and online venues for learning (blended or hybrid learning) has the potential to eliminate the limitations. The purpose of this qualitative case study is to investigate the benefits of a hybrid environment in terms of supporting effective mentoring. Data sources included interviews, coach observation forms, mentor reflection forms, as well as artifacts and field notes. The result suggested that hybrid delivery model provide a more flexible learning environments than face-to-face and online designs. In addition, specific teaching challenges teachers face might be best addressed through different modes of communication. For example, questioning strategy and classroom management challenges are best addressed through face-to-face and hybrid environments, because coaches need to observe classroom events in order to discuss them. This finding is important for designing a PD to assist teachers to overcome the challenges by utilizing different modes of communication.

How Mentoring Helps to Develop Nature of Science Teaching

Kader Bilican, Ataturk University, kader.bilican@gmail.com

Valarie L. Akerson, Indiana University

Vanashri J. Nargund-Joshi, New Jersey City University

**ABSTRACT:** The current study explored the influence of mentoring on an elementary teacher's NOS understandings and teaching practice in an informal teaching setting. In this study the mentor and mentee were encouraged to share and discuss ideas, and improve science teaching regarding NOS through reflection, shared planning, and co-teaching practices. Data included open-ended questionnaires, interviews, classroom observations, video-tapes of classroom instruction, and audio-recordings of weekly meetings between the teacher and mentor. Results of the study revealed that the elementary teacher improved both her nature of science understanding and nature of science teaching practice.

### "Those Experiences have Made Me Who I Am!" Narratives of Novice Science Mentors About Their Mentoring Practices

Samina Naseem, Michigan State University, naseemsa@msu.edu

Gail Richmond, Michigan State University

**ABSTRACT:** The literature about teacher mentoring suggests the importance of relevant and ongoing professional development for teacher mentors at all levels. However, it is much more commonly the case that most mentor teachers volunteer and do not have access to such professional development (PD). From past research, we also have a descriptive sense of the practices of experienced mentors, but little is known about mentoring practices that novice science mentors (NSMs) employ, and the sources from which they draw their mentoring decisions. The paper discusses practices of four NSMs, working with Midwestern State University. Data includes twenty-five interviews, conducted over a period of five months. Our research presents an analysis of personal narratives of NSMs about mentoring, and provides useful understanding of their mentoring practices and experiences that led them to enact those practices. It also provides insight to think about ways to support NSMs' professional development, and to rethink about areas of improvement for science student teachers in general.

Connecting with Colleagues: Influences of Social and Technical Systems in Online Communities of Practice for Science Educators

Susan G. Straus, RAND Corporation Albert Byers, National Science Teachers Association Rita Karam, RAND Corporation Mathew Lewis, RAND Corporation **ABSTRACT:** 

#### **Strand 8: In-service Science Teacher Education**

Symposium – Voices of Transformation: Changing School and Collaborating to Build STEAM Education 1:00pm-2:30pm, King's Garden 3
Presider: Kara Coffino
Discussants:
Bhaskar Upadhyay, University of Minnesota
Kara Coffino, University of Minnesota
John Alberts, Austin School District, Minnesota
Jean McDermott, Austin School District, Minnesota
Andrew Rummel, University of Minnesota
Nate Swayer, University of Minnesota
ABSTRACT: In this symposium we present a collaborative effort in building a middle grade school that focuses on

ABSTRACT: In this symposium we present a collaborative effort in building a middle grade school that focuses on STEAM education for all. All the research presented here bring theory and practice together from the perspectives of individuals who are the real agents of transformation in the teaching and learning of science and STEM related fields. There are very few occasions when school leaders, the implementers of research findings and theories, have dialogues to conceptualize and build a school that promotes science education for all. There are many STEM initiatives around the country but the researchers and practitioners in this session present findings that push us to think and challenge the purposes and value of STEM education and how science education fits within this structure for school leaders and researchers of science education.

### Strand 10: Curriculum, Evaluation, and Assessment *Curriculum Analysis and Development* 1:00pm-2:30pm, Birmingham

Presider: Sevim Sevgi, Middle East Technical University

# Contextualizing Instruction as an NGSS "Effective Classroom Strategy:" Translation between Curricular Materials and Teacher Enactment

#### Kathryn Frances Drago, East Carolina University, dragok@ecu.edu

**ABSTRACT:** The newly published Next Generation Science Standards will require concerted effort for implementation and sustainability. Previous science standards have been critiqued because they have not always translated into increases in students' science achievement and may not offer equitable learning opportunities for non-dominant student groups. The NGSS list several effective instructional strategies involving contextualizing instruction to support the learning of these students. In this paper, I begin investigating how an NGSS-aligned, project-based science unit might support such contextualizing instruction in the classroom. I coded both the written curriculum materials and video of its enactment in an urban case-study classroom for instances of contextualizing instruction. Analysis of these data showed that students' personal experiences were initially used as a frame for learning, but the curriculum could better support this form of contextualization when content becomes more abstract. Likewise, curricula could more regularly support students in finding the curriculum personally meaningful by frequently engaging them with sub-questions of the DQ. Last, the findings suggested that future NGSS-aligned curricula might face challenges supporting students in creating a context for classroom learning with meaningful experiences gained in earlier courses and finding contextualizing phenomena that are both powerful and time-efficient.

# Culturally Relevant Science Education for Mexican Nahua Students: Design Principles for Curricular Contextualization

Ingrid M. Sanchez-Tapia, University of Michigan, ingridsa@umich.edu Joseph S. Krajcik, Michigan State University

**ABSTRACT:** Mexican indigenous communities see science education as a gateway to participation in socio-scientific debates that affect their quality of life. However, science education has historically undermined their worldviews, thus creating tension between indigenous cultures and school science. This conflict impedes indigenous communities' access to scientific literacy. Responding to the need of indigenous peoples for Culturally Relevant Science Education, this study is aimed at designing contextualization principles for science curricula by accounting for students' traditional knowledge and practices. The analysis will focus on designing curricular features with the potential to trigger students' cognitive engagement while supporting them in becoming competent in their own culture and in Western science. This approach informed the creation of a modified curriculum on Inheritance and Natural Selection for 7th grade Nahua students. Our study operationalizes the ideas of culturally relevant pedagogy and multiple ways of knowing so that they become concrete in the form of curriculum design principles, lessons, and activities in a middle school biology unit. Our proposed approach to curricular contextualization is essential to achieve equality in education for ethnic minority students by providing them with access to Western science while legitimizing their traditional knowledge, thus increasing their potential engagement in science.

# Trailing Students Conceptual Understanding of the Law of Conservation of Matter through Curriculum Channa N. Barrett, Texas Christian University, channa.barrett@tcu.edu

**ABSTRACT:** This study explores urban secondary students conceptual understanding of the Law of Conservation of Matter by looking at what Van Den Akker calls the intended, implemented and attained curriculum (Van Den Akker, 1998). 30 students and three of their prospective, secondary chemistry teachers participated in this study. The intended curriculum studied were the standards and the urban district's curriculum. The implemented curriculum was studied to gain perspective on teachers' perceptions of the intended curriculum. To study the attained curriculum, or the actual learning and learning experiences from the law of conservation of matter, students were given a traditional test, comparing their scores on the conceptual questions versus the algorithm questions (balancing equations, basic stoichiometry). Additionally, students were given a non-traditional test of two lab pictures, and they were asked to explain the pictures as it relates to a system and the law of conservation of matter. Results from this study showed that students could give a surface definition of the law of conservation of matter, however showing a lack of conceptual understanding. This is because the curriculum and thus the implemented curriculum lacked a sound foundation for learning the law of conservation of matter; an important chemistry concept.

#### Developing a Standardised Categorisation of the Science Curriculum

#### Per Morten Kind, Durham University, p.m.kind@durham.ac.uk

**ABSTRACT:** The paper aims to develop a standardised categorisation of the science curriculum for use in assessment and curriculum development. It starts with a model suggesting scientists engage in five practices (Theorising, Experimenting, Evidence Evaluation, Engineering and Communication) and use three types of knowledge (Science conceptual knowledge, Science procedural knowledge and Science epistemic knowledge). These are placed as main categories and developed further into sub-categories in two successive stages. First, by comparing the categories to learning objectives and statements in existing curriculum documents, and next by using the categorisation to classify assessment items. In a third stage, the final categorisation is used to analyse exams produced by different examining boards, as a way of testing the usability of the standardised categorisation. The outcome shows important differences between the examining boards. Each board, it seems, establishes certain types of items that are repeatedly used by item developers. Between boards, there are significant differences in their priority of science practices. A further test of the categorisation will be to see if it works as a tool to help examining committees to improve assessment by creating a better balance of learning objectives and generating new ideas for test items.

# Sixth Graders' Engagement with, and the Accessibility of, Science Texts: Considering Prose-Graphic Considerateness

Mary Heitzman van de Kerkhof, University of Michigan, mheitzma@umich.edu

**ABSTRACT:** The purpose of this research is to characterize students' engagement with prose and graphics when reading science texts. Scientific texts typically entail prose (written language) and graphics (iconic representations, e.g., diagrams). Students must become critical readers of both representations if they are to make meaning from the text and fully access its science information. In an individual interview format, 20 sixth graders read two science texts. The data included read aloud with think aloud comments and responses to stimulated recall, prior knowledge, interest, and comprehension questions. I used the data to identify and characterize students' prose-graphic engagement. Students' misinterpretations of the prose seemed to lead to misinterpretation of the associated graphic, which, for struggling readers, may contribute to lack of full comprehension of the entire text. Additionally, students used, valued, and were aware of using connective features in graphics to interpret, understand, and be interested in the entire science text. The findings are evidence to incorporate texts' prose-graphic considerateness (i.e., accessibility of the instructional ideas) as a primary principle toward creating and evaluating science texts. The findings also inform guidelines to create texts with the goal of prose-graphic considerateness, such as use of connective features in graphics.

### Strand 11: Cultural, Social, and Gender Issues

Access to Teaching and Learning 1:00pm-2:30pm, King's Garden 5 Presider: Mary Hoelscher

Sustaining an Underrepresented STEM Preservice Teachers Collaborative Community: Two Years of Benefits and Tensions

Reynee Kachur, University of Wisconsin Oshkosh, kachurr@uwosh.edu

### Michelle A. Fleming, Wright State University

**ABSTRACT:** This study examined the use of a collaborative community approach to recruit and retain underrepresented undergraduate STEM preservice teachers at a mid-size state university over two years. Several barriers, benefits and tensions to the project will be discussed. Four themes emerged from this holistic, multi-method case study. Most noteworthy, the STEM education collaborative community sustained positive attitudes toward science and increased participants' access to the teaching profession, building their capacity to learn more about the profession. This study seeks to explore solutions to recruitment and retention of underrepresented preservice teachers and address issues of equity and access in undergraduate education.

Examining Barriers for Underrepresented Racial/Ethnic Minorities in Biomedical Research and Medical Programs

Devasmita Chakraverty, University of Virginia, dc5na@virginia.edu

Dorothy Andriole, Washington University in St. Louis

Donna Jeffe, Washington University in St. Louis

Heather Wathington, University of Virginia

Robert H. Tai, University of Virginia

**ABSTRACT:** Blacks and Hispanics are the two largest minority groups that are vastly underrepresented in medicine and biomedical research in the United States (AAMC, 2012; NSF, 2011). The purpose of this study is to examine specific barriers reported by students and post-degree professionals in the field through the following questions: How do underrepresented groups in medical schools and biomedical research institutions report experiencing academic barriers and the challenges these barriers pose to their success as individuals in the program? To answer this, we qualitatively analyzed 82 interviews from Project TrEMUR applying grounded theory. Barrier analysis for the two largest URM groups indicated that, while Blacks most frequently reported racism, gender barriers, mentoring, and personal barriers, Hispanics most frequently reported economic barriers, language barriers, institutional and workplace environment barriers, and gender-role barriers. Further, examining barriers using the "Individual-Institutional" theoretical framework indicated that barriers do not occur in isolation, but due to an interaction between the individual and its institution. Additionally, the

barriers for Hispanics and Blacks are qualitatively different and the "one size fits all" approach may not be suitable for interventions.

Chafing Borderlands: Obstacles for Science Teaching and Learning in Teacher Education Kristina Andersson, Uppsala University, kristina.andersson@gender.uu.se Anita Hussenius, Uppsala University Annica Gullberg, University of Gävle Anna T. Danielsson, Uppsala University Kathryn Scantlebury, University of Delaware

**ABSTRACT:** In a research and intervention project we are studying how an increased awareness of gender issues in science among preservice teachers influences their identities as teachers, and their views on teaching. A cohort of preservice teachers (N=120) has been followed through their first year of science courses. As an integral part of these science courses our intervention has introduced critical perspectives on gender and science as related to the culture of science. One result is how different cultures come in conflict and in the interstices in between these cultures chafing emerge. From the analysis of the empirical material, written assignments and audio recording seminars, we identify three chafing borderlands: 1) The stereotypic image of science and the nurturing/caring aspect of early childhood and primary school, 2) Gender and the stereotypic image of science, and 3) Gender knowledge and the stereotypical view of women and men. It is important to be aware of the different cultures within education and their chafing borderlands. Addressing these chafing's explicitly is beneficial for pre-service teachers' knowledge of pedagogy of science in the sense that they thereby can counteract stereotypical teaching of science and open up for taking all children's different interests of science into account.

Can Material Feminism Make Gender Matter in 21st Science Education Research? Kathryn Scantlebury, University of Delaware, kscantle@udel.edu Anita Hussenius, Uppsala University Kristina Andersson, Uppsala University Annica Gullberg, University of Gävle

Anna T. Danielsson, Uppsala University

**ABSTRACT:** This theoretical paper will discuss how science education researchers could use the tenets of material feminism to re-examine equity issues in science education. Material feminism is engaged in understanding encompass issues of agency (human and non-human), body, culture, discourse and the material world and could provide a framework to re-structure science education research to focus on gender issues. The concepts of intra-actions, agential realism, and apparatus illustrate the need for 'making matter matter' in feminist studies. Intra-actions position matter as agentic, and as important as discourse. Agential realism examined intra-actions between human and non-human entities in particular contexts. Apparatus emerge from the specific material-discursive practices that construct researcher subject and the object of the research. The engagement of matter through intra-actions brings into play material-discursive practices. The implications for science education research could be in reframing studies to consider how the material, such as the physical arrangement of laboratories, laboratory equipment, and the body/embodiment of who is a scientist influence the teaching and learning of science. Science educators could examine how apparatus is impacted by their discourse and the material, such as the embodiment of the science learner influences the material-discursive practices of the researcher and researched.

Strand 12: Educational Technology Informal Science Learning with Technology 1:00pm-2:30pm, King's Garden 1 Presider: Janell Nicole Catlin

*Summer Learning in a Digital Sandbox* Sumi Hagiwara, Montclair State University, hagiwaras@mail.montclair.edu **ABSTRACT:** In an effort to develop a STEM program that integrates each discipline to prepare a 21st century learner, the following proposal examines an inclusive summer STEM program for eighteen children in grades 1-6. Technology in the form of a digital game based program, Minecraft, is the focus of this study. The proposed presentation will explore the impact of the Minecraft game that has been embedded as part of a thematic STEM summer program. The presentation will report on learner outcomes based on student interaction with problems and challenges embedded within the game. Qualitative data in the form of observations, pre-post survey data, and student focus groups have been gathered and analyzed using grounded theory. The study summarizes outcomes of student engagement in problem solving within the Minecraft world, and explores how gaming can be to integrated into STEM instruction to support teaching and learning in a problem-based digital medium. Questions that guide this study are: 1) How are students thinking critically when they are in the Minecraft world? 2) What characteristics of problem solving and critical thinking are participants demonstrating in the Minecraft world?; 3) How are students engaged in problem solving individually and collaboratively?

After-School and Informal STEM Projects: Self-Selecting or Self-Defeating?

David B. Vallett, University of Nevada Las Vegas, david.vallett@unlv.edu Richard L. Lamb, Washington State University Len Annetta, George Mason University

Rebecca Cheng, George Mason University

Karen Peterman, Karen Peterman Consulting

**ABSTRACT:** As part of a recent NSF-funded project in which secondary students created Serious Educational Games, we examined the traits of the learners that opted to participate in the project and compared them to those that did not participate. We found that although the both sets of students came from the same six classes, and matched in proportions of gender, ethnicity, and age, those students that chose to take part in the project scored higher on several cognitive and affective measures related to STEM fields. These findings suggest that STEM programs using a learner self-selection and other forms of convenience sampling for recruitment and comparison grouping are likely to exclude learners with lower levels of interest and self-efficacy in STEM fields, and that more comprehensive means of participant selection may be required to reach underrepresented or disinterested learners.

#### *The Character of Parent-Child Conversations at an Interactive Science Simulation Experience* Michael Tscholl, University of Illinois, Urbana-Champaign, mtscholl@cs.ucl.ac.uk Robb Lindgren, University of Illinois, Urbana-Champaign

**ABSTRACT:** This paper presents preliminary data from a study of parent-child discourse around an interactive simulation designed to teach children about of the nature of gravity and planetary motion in an informal learning environment. The simulation is performance-based and happens in a public space, providing a particular challenging environment for educationally valuable interaction. The study aimed to investigate whether parents and children would engage in dialogic exchanges or more didactic interaction; and what kinds of conversational acts characterize dialogic exchanges. A first analysis found that though didactic interaction was predominant, a significant number of dialogic exchanges also occurred. Further analysis shows that dialogic interaction is characterized by providing or eliciting explanations. These results are compared to similar studies of conversations in informal science education environments, and discussed in relation to the design of the interactive situation.

### Challenging Students' Conceptions of Scientists: Development of the Scientists in Context Checklist Paul Baldwin, University of North Georgia, paul.baldwin@ung.edu

Joseph S. Covert, University of North Georgia

**ABSTRACT:** This research focused on using media to influence student conceptions of science and scientists. The research began with the development and application of a unique media evaluation instrument, the Scientists in Context Checklist (SSC). The SCC was developed from the Draw-A-Scientist Test (DAST) with added emphasis on contextual and social factors. The SCC was then used to evaluate the level of stereotypical and non-stereotypical features in potential treatment videos. A quasi-experimental study was conducted with 198 sixth grade, earth science students in which the treatment consisted of a series of selected videos depicting mainstream scientists. The DAST was employed in a pretest, posttest format to determine the extent of change in participants' images of scientists following the experimental treatment. Initial DAST analysis revealed that the research participants possessed traditional scientist stereotypes as

reported in previous studies. Following the experimental treatment, a statistically significant difference was noted between the pre- and posttest data, indicating a reduction in the stereotypical images possessed by the research participants.

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

#### Symposium – Awakening a Dialogue between Science Education and EcoJustice

1:00pm-2:30pm, Brigade

Presider: Deborah J. Tippins, The University of Georgia

#### **Presenters:**

Logan M. Leslie, University of Georgia, lleslie@uga.edu

Deborah J. Tippins, The University of Georgia

Pauline W. U. Chinn, University of Hawaii - Manoa

Debra Mitchell, University of Georgia

Giuliano Reis, University of Ottawa

**ABSTRACT:** This symposium showcases the utility of EcoJustice philosophy in science education. EcoJustice philosophy provides an excellent framework for analysis, because it deals with both ecological and cultural concerns, providing a bridge between the two rather than favoring one over the other as other philosophical viewpoints tend to do. This symposium illustrates how EcoJustice facilitates this balance, focusing on several key components of EcoJustice philosophy: considering cultural assumptions, the importance of local action, empowering the disenfranchised, valuing of pluralism, protecting the commons from enclosure, and mindfulness. Speakers will consider how this philosophical framework can serve science education in a variety of settings: using a Hawaiian model of EcoJustice to address the needs of native Hawaiian students; using EcoJustice to look at the value of "action gardening"; examining how EcoJustice philosophy helps to address concerns of problematic definitions of "normal" and the "natural" that lead to discrimination and exclusion in the story of Marianna, who carries the Trisomy 21; and finally examining how EcoJustice philosophy provides insight into how messages within video games, specifically how one particular game, Portal 2, provides players with views on the interaction of science and nature.

#### **Strand 15: Policy**

Symposium – What is a STEM school?

1:00pm-2:30pm, King's Garden 4 **Presider:** Carla C. Johnson

#### **Discussants:**

Margaret Ashida, STEMx<sup>TM</sup> Network, Battelle Carla C. Johnson, Purdue University Susan R. Bodary, Education First Wesley Hall, Tennessee STEM Innovation Network

Steve Zipkes, Manor New Technology High School

**ABSTRACT:** In recent years the United States has seen a surge in the creation of STEM (science, technology, engineering, and mathematics) schools nationally. This increase has been spurred through both federal investments (e.g. Race to the Top) as well as state and local level commitments to investing in the future talent pipeline. In September, 2010, President Obama issued a challenge to the U.S. educational system to create more than 1000 new STEM-focused schools over the next decade, including 200 high schools. As the push for more STEM focused schools has emerged through policy by most accounts, our understandings of how STEM schools are conceptualized and characterized remains unclear and the empirical research base is just beginning to compile. Given the growing momentum for STEM schools, it is a pivotal time to begin to identify existing effective STEM school models and begin to synthesize available evidence to build frameworks to continue to move the field forward. In this policy strand sponsored session, national leaders from policy, K-12, and higher education arenas will share a variety of perspectives on this topic to spark an ongoing conversation focused on conceptualizing STEM schools and moving understandings of STEM education forward.

### Concurrent Session #2 2:45pm – 4:15pm

#### **International Committee Sponsored Session**

Symposium – Addressing Critical Features of Context-Based Science Curricula
2:45pm-4:15pm, King's Garden 1
Presider: Hsiao-Lin Tuan, National Changhu University of Education
Discussants:
Koos Kortland, University of Utrecht, The Netherlands
Manuela Welzel-Breuer, University of Education Heidelberg, Germany
Suzanne Vrancken, Utrecht University
Sabine Fechner, Leibniz University of Hannover
Patrick Loffler, University of Koblenz-Landau
Karolina Broman, Umea University, Sweden
ABSTRACT: Several decades of developing context-based curricula have passed with a growing body of knowledge about their effectiveness on students interest (Bennett, Lubben & Hogarth, 2007; Ultay & Calik, 2012). However, typical critical aspects of this development are consistently reported and should be subject to further study. According to Pilot and Bulte (2006), these critical aspects concern evidence about: " How curriculum development in small learning communities of coaches and teachers can be scaled up and become fruitful for a larger group in a system (p. 1107). "

What contexts are appreciated by students and how the settings relate to conceptual learning of science (p. 1109). " Development of assessment items, the design of adequate tasks, and analysis of students response to these items. This knowledge is necessary to make assessment in accordance with higher order learning aims (p. 1107). This symposium brings together state-of-the art research on critical aspects for both chemistry and physics education which can be discussed through the lens of systematic curriculum development (Van den Akker, 1998): connecting context and science concepts in a course-design framework (formal curriculum and its functioning in the operational curriculum), involvement and beliefs of teachers as key persons (perceived curriculum) and assessing students outcomes (attained curriculum).

**Strand 1: Science Learning, Understanding and Conceptual Change** *Metacognition and Processing Scientific Information* 2:45pm-4:15pm, Commonwealth 2

**Presider:** Mehmet F. Tasar

Ninth Grade Student Knoweldge Construction through a Critique-based Recursive Writing Activity in Argument-based Inquiry Approach

Sae Yeol Yoon, Unviersity of Iowa, saeyeol-yoon@uiowa.edu Claudia Patricia Aguirre Mendez, The University of Iowa Nurcan Keles, University of Iowa Brian M. Hand, University of Iowa

**ABSTRACT:** The purpose of this study was to explore students' development of understanding in science that emerged in writing samples when they were immersed in argumentation for learning science, and writing was used as a critical element of argumentative practice. This study also explored the role of critique in students' argument-based expository writing. In a critique-based recursive writing activity, fourth grade students provided critique on ninth grade students' writing of a unit of Force and Motion, and based upon the critique, ninth grade students rewrite their ideas. Exploratory sequential mixed methods research design was used. In the qualitative phase, analytical frameworks was developed to explore students' knowledge development. In the quantitative phase, pre-experimental designs was employed to examine ninth graders' pre- and post- writing samples and fourth graders' critique, which was used as the intervention. The results suggest that first, argumentation helps them to practice both roles of knowledge constructor and critique; and second, writing as learning tool as well as argumentative tool promotes student knowledge construction. With this in mind, a

critique-based recursive writing activity effectively encourage ninth grade students to further develop knowledge, as well as to think about how they learn.

#### *Thinking about Graphs: The Semiotics of Visual and Textual Representations* Michelle Whitacre, University of Missouri-St. Louis, michelle.phillips77@gmail.com

Rose Davidson, University of Missouri-St. Louis

**ABSTRACT:** This study explores how students make sense of information provided in both linguistic and visual forms in order to inform how students learn and understand graphical literacy practices. A think-aloud protocol and qualitatively-based coding scheme were used to examine a group of female high school students' approaches and meaning-making strategies as they read and responded to two multi-line graphs and accompanying texts that incorrectly described what the graphical data depicted. A total of sixty-one students completed the task. Using purposeful sampling, thirty students were chosen for individual interviews, and a focus group comprised of a subset of participants discussed their own results and that of their peers. Responses were analyzed for degree of student understanding of the relationship between the graphed variables. Results suggest that students privileged the text over the data presented on the graph and focused primarily on graphing conventions rather than analyzing the relationships between variables. Additionally, when allowed to engage in talk around their comprehension, students were able to offer more nuanced and critical assessments of their interpretations. This has important implications for the ways we both teach and assess students' graphical literacy.

The Effect of 5E Learning Cycle Model Supported with Metaconceptual Processes on 7th Grade Students' Understanding of Moon Phases

Ebru Ezberci, Kastamonu University, ebru.ezb@gmail.com

Nejla Yuruk, Gazi University

Gulfem Dilek Yurttas, Gazi University

**ABSTRACT:** The aim of this study to search the effect of various teaching methods (traditional instruction method, 5E learning cycle model, and 5E cycle learning model supported with activities promoting metaconceptual process) on the understanding of 7th grade students about the phases of the Moon. The workgroup of the study was composed of 82 7th grade students of a primary school in Turkey. The study was carried out on 3 different groups. The 5E learning cycle model and the 5E learning cycle model supported with metaconceptual processes were applied in experimental groups and the traditional teaching method was applied on the control group. When analyzed, F values estimated in consequence of ANCOVA analysis made are found statistically significant for both pre-test (covariant) and teaching method. Being found significant for F value pertaining to pre-test (F (1.78) = 23.75; p<.05) indicates that students' conceptual understanding on the phases of the Moon, prior to teaching processes, is revealing a variance at statistically significant level. It is stated that teaching method supported with activities revealing metaconceptual processes creates the difference in ensuring meaningful learning in students, in comparison to traditional instruction on the phases of the Moon that is carried out in control group.

# A Review of Research on Metacognition in Science Education: How is Metacognition Defined and Taught? Anat Zohar, Hebrew University, anat.zohar1@mail.huji.ac.il

Sarit Barzilai, University of Haifa

**ABSTRACT:** This study reports partial results from a large review study whose goal is to map the current state of research in the field of metacognition in science education. We conducted a systematic analysis of 178 studies published in peer-reviewed journals in the years 2000-2012 and indexed in the Eric database. The present study focuses on three research questions: (1) what components of metacognition are being studied; (2) what instructional methods are used to teach metacognition; and, (3) what is the status of research that addresses in- and pre-service teachers' knowledge and professional development in this area. The findings show that the development of learners' metacognitive knowledge is receiving less empirical attention than the development of their metacognitive skills. The studies use a wide range of instructional practices for fostering learners' metacognition. The most prominent practice is the use of metacognitive cues and prompts in the course of instruction. There are very few studies of teachers' knowledge and professional development regarding metacognition. No studies of the development of pre-service science teachers were found. The implications of the findings for teaching and learning metacognition in science education are explored and suggestions for future research are raised.

#### Investigating the Role of Integrated Knowledge and Declarative Knowledge in Preparing Students for Future Energy-Related Learning

Jeffrey Nordine, Trinity University

**ABSTRACT:** Energy is one of the most fundamental and far-reaching concepts in science and is a ubiquitous concept in everyday life as well. While scientists use the energy concept to make sense of cosmological phenomena or analyze relationships within ecosystems, non-scientists frequently make energy-related decisions that include choosing types of food to eat, automobile to buy, or household appliance to install. Because energy is such a useful concept in both scientific and non-scientific settings, it is important to understand the conditions necessary for students to translate their classroom understanding of the energy concept to make everyday energy-related decisions. While much is known about how students understand energy in a classroom setting, very little has been done to investigate whether and how students become prepared to use their understanding of energy to guide future learning and approach real-world energy problems. In most real-world problems, people have insufficient knowledge to approach a meaningful problem and must learn more in order to formulate solutions. In this study, we explore how students' knowledge of energy concepts and their ability to meaningfully connect between concepts impacts their preparedness to continue learning about energy in a real world, information-rich setting.

#### Strand 2: Science Learning: Contexts, Characteristics and Interactions Engaging Students in Authentic Scientific Practice and Motivation

2:45pm-4:15pm, Fort Pitt **Presider:** Eduardo F. Mortimer

Elementary Students Engaged in Science Practices through a Planetarium Fieldtrip Julia Plummer, Pennsylvania State University, jdp17@psu.edu

Kim J. Small, Upper Dublin School District

**ABSTRACT:** The Framework for K-12 Science Education recommends that children learn science through an integration of core disciplinary ideas, science practices, and cross-cutting concepts. Our work explores methods of supporting children in learning astronomy in ways that integrate science practices, such as observation, and cross-cutting concepts, such as patterns. Students in 1st grade (N=36) participated in a sequence of two classroom lessons and a planetarium visit. Interviews assessed students' conceptual understanding and scientific reasoning using evidence-based representations on: the Moon's appearance, apparent daily motion, and change in lunar phases. Our work illustrates successful methods of integrating a planetarium fieldtrip with classroom-based lessons in ways that improve the ways students integrate the Framework's three dimensions. Analyses revealed significant improvement in students' reasoning about each of the three areas, but also revealed challenges in how students compared models with phenomena and application of temporal information in their representations.

Investigating Student Interest in the Context of Engaging in Authentic Science Practices

Laura B. Schneider, University of Georgia, laurasch@uga.edu

Barbara A. Crawford, The University of Georgia

Ayelet Baram-Tsabari, Technion

Daniel K. Capps, University of Maine

Jaclyn Murray, University of Georgia

Dongmei Zhang, The University of Georgia

**ABSTRACT:** Interest is an influential motivator that helps students feel a connection to content. This is vital since declining enrollment levels in science and technology are often attributed to lack of interest (Jenkins & Nelson, 2005). A qualitative approach was used to determine how an authentic paleontological project contributed to students' science interest. Forty interviews of 7th and 9th graders were conducted with students from different geographic areas and from different backgrounds, including English Language Learner (ELL) students. A theme that emerged was best practices in science like working in groups, using technology, using inquiry, and creating authentic investigations could foster or suppress student interest. Feeling helpful was found to be central to bringing meaningfulness to the project enriching a

sense of relatedness with classmates and scientists. Student interest in the project could be divided into two categories: interest in the process of authentic science and interest in the science content of paleontology. This study suggests that classroom and contextual factors, as well as teaching practices play a role in interest. This study has implications for researchers, teachers, and curriculum developers related to engaging all students, in particular ELL students and students from underrepresented populations, in science.

### The Role of Motivational Factors in Science-Related Career Aspirations and Expectations Wondimu Ahmed, University of Akron wahmed@uakron.edu

**ABSTRACT:** This study examines how motivational factors (self-concept, enjoyment, attainment value and utility value) predict science-related career aspirations and expectations using a nationally representative, ethnically diverse sample of 5611 15-year-old students in 166 schools in the USA. The findings showed that motivational factors, particularly the value components of motivation, namely, enjoyment, attainment value and utility value are important predictors of science-related careers aspirations and expectations even after controlling for SES and science achievement. Nevertheless, the findings also showed that the motivational factors do not seem to operate in same fashion for male students as they do for female students. Moreover, the findings also showed that the role of motivational factors in predicting careers aspirations was somewhat moderated by ethnicity.

#### The Regional Science Fair: Students' Motivation for and Perception of their Participation

Kathleen A. Fadigan, Pennsylvania State University, kxf24@psu.edu

Penny L. Hammrich, Drexel University

David M. Majerich, Georgia Institute of Technology

Ashanti Obamwanyi, Pennsylvania State University

**ABSTRACT:** This case study provides insight into a highly popular, yet scarcely studied learning environment – the science fair. This study provides a detailed description of factors that motivate students to participate in a tri-state, regional science fair as well as their perceptions of their participation. A total of 301 students in grades 6-12 completed a survey during the 2011 annual science fair. Results indicate that learning new things, having fun, and preparing for the future are the top reasons that motivate students to participate in the science fair. Teachers, parents, and the students themselves are most frequently the individuals who provide the motivation or encouragement to participate. The majority of students positively perceive their participation.

### Strand 4: Science Teaching--Middle and High School (Grades 5-12): Characteristics and Strategies Integrating Science with Other Disciplines in Middle and High School

2:45pm-4:15pm, Duquesne **Presider:** Tirupalavanam G. Ganesh

#### Using Mathematics in Physics Lessons in Upper Secondary Class

Stephanie Trump, RWTH University, trump@physik.rwth-aachen.de

Andreas Borowski, University of Potsdam

**ABSTRACT:** Empirical studies like TIMSS III or PISA reveal that students lack in deeper understanding of mathematics. Furthermore, they have great difficulties in applying mathematical knowledge to physical problems. The importance of these results has to be taken seriously - with regard to the fact, that mathematics is known as the language of physics. Considering these, this study focuses on the questions: "What mathematics is required in physics in upper secondary class?" and "How is mathematics used for physical problems?" Therefore, we systematically analyzed N=878 textbook tasks of all relevant physics topics of secondary class. Furthermore, we conducted a think-aloud study with N=30 physics PhD stu-dents. The results show that contrary to expectations most of the required mathematics is taught in secondary class (students age range of 10-15). Furthermore, the application of mathematical and physical knowledge. These results demonstrate which mathematical concepts and procedures can be taught interdisciplinary on the one hand and helps creating goal oriented new interdisciplinary tasks on the other hand.

Impacts of a Middle School Mathematics-Science Integration Program

Luisa McHugh, Stony Brook University, luisamchugh@mac.com

Angela M. Kelly, Stony Brook University

**ABSTRACT:** Contemporary research suggests that in order for students to compete globally in the 21st century workplace, pedagogy must shift to include the integration of science and Mathematics. This research study conducted at a large suburban school in New York examines students' attitude toward integration and achievement on science assessments in an integrated 8th grade science classroom compared to students in a non-integrated classroom Using data from an established Math Infused Science Program (MISP), results indicate that student's ability to understand the mathematical concepts were better in the experimental group than the control group. The current research the principal investigator is analyzing is to see if there are similarly statistically significant findings in science achievement in an integrated classroom. Integration addresses the national standards: National Council of Teachers of Math (NCTM), National Science Teachers Association (NSTA), American Association for the Advancement of Science (AAAS), and the National Research Council (NRC). The future educational goals will continue to be a push toward integrating mathematics and science to improve literacy as governed in the Common Core Standards. It remains imperative that in order to reach this desired goal, teachers need to be highly skilled at all levels of integration.

*The Wicked Problem of Integration of Curriculum Materials with Embedded Multimedia Simulations: Recognizing Teacher Professionalism* 

Catherine E. Milne, New York University, cem4@nyu.edu Ruth N. Schwartz, Quinnipiac University Steve Yavner, New York University Tzuchi Tsai, New York University Jan Plass, New York University Bruce Homer, CUNY Graduate Center Trace Jordan, New York University Anna G. Brady, New York University

**ABSTRACT:** We report a qualitative study examining teacher integration of a curriculum sequence that incorporated interactive multimedia simulations designed to support learning of kinetic molecular theory and associated topics in high school chemistry classrooms. Analyzing integration as a wicked problem, we explore how four teachers, with their 222 students, implemented the curriculum units. Wicked problems are complex, and resist simple solutions. Using data including teacher web logs, student log files, and teacher exit interviews, we explore how different teachers incorporate the same materials into their pedagogical practice, highlighting the role of teacher professionalism in the process of curriculum integration.

The Meme-ing of STEM at a STEM-centric Middle School

Meena M. Balgopal, Colorado State University, Meena.Balgopal@colostate.edu

Laura B. Sample McMeeking, Colorado State University

John Howe, Preston Middle School, Fort Collins, CO

Scott Nielsen, Preston Middle School, Fort Collins, CO

Tracey Winey, Preston Middle School, Fort Collins, CO

**ABSTRACT:** Is STEM a single construct or just an acronym? We studied what administrators, teachers and students at a middle school believe STEM is. To examine how ideas proliferate through populations we grounded our study in memetic theory, which describes how socio-cultural units spread through cultures. We asked two open-ended questions and analyzed (through inductive coding and Chi Square tests) survey responses from 755 students and 55 teachers and a focus group transcript of four administrators. For "What is STEM?" student responses were significantly more likely to be centered on school while teachers discussed STEM in the context of themselves (self) and school ( $\chi 2$  (2, N = 755) = 29.20, p < .0001). For "How does STEM impact your life?" student answers were significantly more likely to center on the impact of STEM within the context of school compared to teachers, who were more likely to discuss STEM within the context of self—how STEM improved their teaching ( $\chi 2$  (2, N = 698) = 15.77, p = .0004). Administrators said STEM helps people "make the world a better place" yet made no personal connections. The science education community must examine how STEM is interpreted in schools as its popularity increases.

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

Identity Development in College Science Teacher

2:45pm-4:15pm, Heinz **Presider:** Erica Blatt, College of Staten Island, CUNY

*Exploring a Professional Meeting for Undergraduate Female Physics Majors: Can One Weekend Make a Difference?* 

Gayle Buck, Indiana University, gabuck@indiana.edu Mary Mills, Indiana University

Jianlan Wang, Indiana University

Xinying Yin, Indianan University Bloomington

**ABSTRACT:** Female students from across the United States attended one of six simultaneously occurring three-day regional meetings for undergraduate students in physics. We gathered the experiences of these participants through preand post-surveys and focus group interviews. The findings reflect the impact of such an experience, as well as how the various aspects of the experience fostered or hindered this impact. We found that the majority of the participants felt encouraged by the other students or faculty present at the conference. They also believed the conference had a positive influence on their ideas about graduate school. With this, they demonstrated an increased sense of confidence in their ability to continue in physics. Although most of the conference activities were noted to be valuable to some of the students, the field trips to national labs, tours of modern research labs and the minority women socials were agreed to be extremely valuable. The degree of focus, however, on graduate school and women's issues generated mixed reactions among the participants. This study demonstrates that such an experience can make a significant impact, as well as provides future facilitators of similar professional meetings with understandings on how to design women in science experiences that meet different needs.

### Are Career Aspirations in Alignment with Career Attainment Patterns Among Science and Engineering Doctoral Recipients?

Deborah S. Barry, Center for Advanced Study of Teaching and Learning- Higher Education University of Virginia, dsb9u@virginia.edu

Amy K. Swan, Center for Advanced Study of Teaching and Learning- Higher Education University of Virginia John W. Tillotson, Syracuse University

**ABSTRACT:** This study utilized Social Cognitive Career Theory (SCCT) to identify aspects of the doctoral education process that are predictive of the likelihood of certain career aspirations among science and engineering doctoral candidates and career attainment among science and engineering doctoral recipients by utilizing nationally representative datasets: the National Research Council's Assessment of Research Doctorate Programs student survey and the National Science Foundation's Survey of Earned Doctorates. The purpose of this study was to investigate the relationship between doctoral program experiences and career aspiration and attainment patterns of two samples of doctoral candidates and recipients in the fields of chemical engineering, neuroscience, and physics. This research utilized multinomial logistic regression modeling, identifying several aspects of doctoral education that act as predictive measures of doctoral candidate career aspirations and attainment in the targeted science and engineering fields, including the primary type of funding received by students. This finding is in alignment with the SCCT performance model, since funding for doctoral students in STEM fields is often based on ability or past performance and determines the types of experience students gain while in graduate school.

# *Female Science Education Graduate Students' Conceptual Ecologies: A Collective Case Study of Multiculturalism and Urbanity*

Phillip A. Boda, Columbia University: Teacher's College, pab2148@tc.columbia.edu

**ABSTRACT:** Teachers' beliefs don't always translate into practice and teachers' pre-education belief structures often drive responses toward diverse stimuli they encounter, particularly in multicultural settings. Researchers need to study how teachers' cognize their beliefs and describe their conceptual ecologies. Science teacher research has focused on shifting multicultural beliefs of equitable teaching and learning rather than overall cognitive ecologies that influence belief

accretion and the restructuring process. Instead of solely studying the impact an Urban and Multicultural Science Education course had on beliefs, this study also focused on describing how the course influenced the conceptual ecologies of three female graduate students. In this collective case study, triangulated data sources generated conception statements that were then concept mapped. A hierarchal categorization model was used to define the participants' belief alignments in terms of ontological categories. Subsequent analysis was done to describe shifts within and between ontological categories alongside belief changes. Initial findings suggest that beliefs of education and culture shifted alongside ontological categorization. This description of teachers' conceptual understandings of multicultural science education shows promise for use to promote more efficacious conceptual change toward equitable teaching and learning.

#### Strand 6: Science Learning in Informal Contexts Designing Science Competitions to Promote 21st Century Student Outcomes 2:45pm-4:15pm, King's Garden 3 Presider: Kathryn Stofer

Can a National Project-based Competition Enhance Students' Motivation to Learn Chemistry? Yael Shwartz, Weizmann Institute of Science, yael.shwartz@weizmann.ac.il Yamit Sharaabi-Naor, Weizmann Institute of Science Miri Kesner, Davidson center of Science Education

**ABSTRACT:** The interest, attitudes and motivation of students towards science learning decreases over time, especially during middle school years. In order to overcome this, two leading approaches have been applied - the contextbased approach, and Project-based learning (PBL) in a framework of a national competition named ""Chemistry, Industry, and the Environment in the eyes of the individual and society. In this study we evaluated whether the national competition indeed promotes students motivation for chemistry learning. We evaluated the motivation of the participants in the national competition and the motivation of participants in a similar project that took place in a single school. The comparison took into account the projects' nature and students characteristics regarding their intrinsic motivation for chemistry subject in general. We found that the National project increases students' motivation to learn chemistry while a similar project that takes place in school does not have the same affect. Nevertheless, we noticed a small decline in interest along the duration of the project. Once again, this research provides additional evidence to the complexity of motivational processes.

#### Success on a Losing Robotics Team

Nathan R. Dolenc, University of Virginia, nrd3fp@virginia.edu

Xiaoqing Kong, University of Virginia

Robert H. Tai, University of Virginia

**ABSTRACT:** Large scale robotics competitions bring together teams of various backgrounds, resources, and abilities. The odds of winning one of these competitions are low. However, students dealing with adversity and the hardship of losing in robotics competitions may lead them to possessing a stronger appreciation toward science and engineering. This research follows six high school students on a losing robotics team to understand how they interpret the robotics competition landscape in which they participate, how they view success on their team, and why they keep returning to compete despite always losing. Despite facing imminent defeat, the students develop mature outlooks of the competition environment, continue to solve complex problems, and focus on having fun with their peers.

Fostering and Characterizing Young Talents in Science - Design and Evaluation of a Competition Day Janet S. Blankenburg, Leibniz-Institute, blankenburg@ipn.uni-kiel.de

Tim N. Höffler, Leibniz-Institute for Science and Mathematics Education

Heide Peters, Leibniz-Institute for Science and Mathematics Education

Ilka Parchmann, Leibniz-Institute for Science and Mathematics Education

**ABSTRACT:** Science Olympiads and science fairs are effective instruments to encourage talented students. However, at most schools competitions are not an integrated element. In order to encourage and motivate more students to participate,

we designed a competition day with representative science competition tasks for students in 6th grade. The theoretical basis for the day's design are self-determination theory (Deci & Ryan, 2000) and an adapted version of Holland's RIASEC-model (1997). To learn more about students' reasons for participating in contests and examine whether this day may change those, we conducted an evaluative questionnaire-study with students at the age of 12 (N = 550). The study takes place from August 2013 until February 2014. Expected results are students' reasons for and hindrances against participating in respect to social relatedness, autonomy and competence. The pre- and post-results will be available at the time of the conference. A pilot study with 12-year-old students (N = 102) showed several participation influencing factors and significant predictors as well as gender differences.

Strand 7: Pre-service Science Teacher Education *Preservice Teachers' Self-efficacy and Attitudes* 2:45pm-4:15pm, Sterlings 1 **Presider:** Sarah Michaels

#### A Case Study of a Pre-Service Teacher with Positive Science Attitude and Science Teaching Self-Efficacy Mahsa Kazempour, Penn State Berks, muk30@psu.edu

**ABSTRACT:** This qualitative case study aimed to focus on the experiences and subsequent science and science teaching beliefs, attitudes, and self-efficacy of an elementary pre-service teacher, Heather, with extremely positive attitude and high self-efficacy. For this particular population of pre-service teachers, possessing a high science teaching self-efficacy alone is not sufficient to assume reform-based beliefs and teaching practices. This study was unique in that it concurrently explored the relationship between attitude, beliefs, and self-efficacy before and after the course. Initially, Heather's attitude and self-efficacy with respect to science and science teaching were closely interrelated and a product of her own intrinsic interest in science and her unique K-12 experiences. Her beliefs appeared to have been shaped by both her actual science experiences and what she had witnessed in the classrooms. Heather's course experiences shaped her post beliefs about science and science teaching, which altered her attitude and confidence.

# Identifying the Sources of Self-efficacy in a Science Content Course for Preservice Elementary Teachers Deepika Menon, University of Missouri, Columbia, MO, dm2qc@mail.missouri.edu Troy Sadler, University of Missouri, Columbia, MO

**ABSTRACT:** Self-efficacy beliefs that relate to teachers' motivation and performance have been an important area of concern for preservice teacher education. This qualitative study investigated the factors that influenced preservice elementary teachers' science self-efficacy beliefs in a physical science content course. Participants included twenty-five preservice elementary teachers enrolled in Spring 2013 semester. Data collection included implementation of STEBI-B as pre-test, two semi-structured interviews with nine participants, classroom observations and artifacts. Post-hoc analysis of the STEBI-B data was used to select three participants belonging to each group representing low, medium and high initial levels of self-efficacy beliefs. Findings suggest that despite of the nature of prior science experiences preservice teachers previously had, exposure to a course that integrates relevant content along with modeled instructional strategies can positively impact self-efficacy beliefs. While some course elements such as active learning experiences and teaching models seemed to impact all groups positively, the low group participants were particularly influenced by the multiple representations of the content and the course instructor as a role model. One implication from this study is that science educators could include elements within science content courses to potentially support preservice teachers with varied initial levels of self-efficacy.

### Developing Self-Efficacy Through the Use of Cloud-Based Collaboration in an Elementary Science Methods Course

Gregory M. Benedis-Grab, Teachers College, gbenedisgrab@theschool.columbia.edu Felicia Moore Mensah, Teachers College, Columbia University

**ABSTRACT:** This mixed methods study suggests that utilizing a cloud-based collaboration in a blended learning environment can be beneficial to elementary preservice teachers (PSTs) in a science methods course. The study presents an innovative approach to a methods course design including a constructivist orientation, a focus on reflection, and a

cloud-based collaborative tool to digitally extend learning beyond the traditional limits of the classroom. Teacher selfefficacy, which has been identified in the literature as instrumental to elementary science teacher development is the focus of teacher development in this study. By analyzing the data from the cloud-based collaboration this study explores how the intervention impacts the learning of PSTs. Using a grounded theory methodology we have constructed an understanding of the intervention and present emergent findings about how the PSTs have utilized the blended learning approach of the course. In the process they have demonstrated growth in science teaching self-efficacy and technology self-efficacy. The use of the collaborative tool served to document and support this growth. Specific examples of this growth are presented from one of the PSTs to illustrate and give insight into the process. This study provides useful insights into the design of science methods courses for elementary PSTs.

## Pre-service Teachers' Self-efficacy and Attitudes toward Learning and Teaching Science in a Content-based Biology Course

Cindi Smith-Walters, Middle Tennessee State University, cindi.smith-walters@mtsu.edu

Heather L. Barker, Middle Tennessee State University

Thomas Brinthaupt, Middle Tennessee State University

Brent J. Linville, Middle Tennessee State University

**ABSTRACT:** Research suggests that the teaching of science is approached with hesitation by many Pre-K-8 teachers. Our university is unique in that it requires a content knowledge-based, pedagogy heavy life science course for preK-8 preservice teachers in lieu of the traditional science methods course. This combination lecture/laboratory approach is presented via proven teaching strategies for science. Findings are presented from our study that examined pre-service teachers' responses to a science teaching questionnaire, a science learning questionnaire, and a middle grades PRAXIS confidence survey administered at the beginning and end of each semester. Results show an overwhelmingly positive and statistically significant difference in all areas measured. Our presentation will explore the effect of active learning, research-based pedagogies, and contextual factors in a biology content course on the self-efficacy and attitudes of preservice teachers. We will also draw conclusions to guide teacher preparation programs in the development of high quality science courses.

#### **Strand 8: In-service Science Teacher Education**

## *Related Paper Set – If We Support Them Will They Stay? Studying Online Mentoring for Beginning Science Teachers*

2:45pm-4:15pm, Birmingham

#### **Discussant:**

Julie A. Luft, University of Georgia

**ABSTRACT:** This paper set discusses research from three different institutions related to the use of online induction to promote the development of beginning secondary science teachers' reform-based practices, reflective practices, and teacher leadership. This research explores how appropriately designed online induction programs can provide sustained interaction, which helps beginning teachers not only survive but thrive during their first years in the classroom. Paper 1 explores how online mentoring facilitates beginning teachers' knowledge and understanding of their role as a reform-based teacher through interactions with online mentors. Paper 2 provides a design-based research analysis of the structure of our online induction program and the integration of Web 2.0 tools such as video annotation. Paper 3 explores the development of teachers' reflective practices within the online induction program described in paper 2 through the use of video annotation tools. Paper 4 explores the development of teacher swithin an online induction program.

Online Mentoring Program and Beginning Secondary Science Teachers

EunJin Bang, Iowa State University, ejbang@iastate.edu Sissy S. Wong, University of Houston Jonah B. Firestone, Washington State University-Tricities Julie A. Luft, University of Georgia Development of an Online Induction Program Joshua A. Ellis, University of Minnesota, ellis228@umn.edu Gillian Roehrig, University of Minnesota Justin McFadden, University of Minnesota Tasneem Anwar, University of Minnesota

Exploring Transformation of Beginning Science Teachers' Reflective Practices Tasneem Anwar, University of Minnesota, anwar013@umn.edu Gillian Roehrig, University of Minnesota Joshua A. Ellis, University of Minnesota Justin McFadden, University of Minnesota

Developing Teacher Leaders Using Adopted Personas in an Online Induction Support System Samuel J. Pollizi, Kennesaw State University, sjpolizzi@gmail.com Greg Rushton, Kennesaw State University Michelle Dean, Kennesaw State University Donna J. Barrett, Georgia State University

Strand 8: In-service Science Teacher Education *Professional Development and Teacher Classroom Practice* 2:45pm-4:15pm, King's Garden 5 **Presider:** Irene U. Osisioma

Statewide Implementation of the Critical Features of Professional Development and Impact on Teacher Outcomes

Carla C. Johnson, Purdue University, carlacjohnson@purdue.edu

Toni A. Sondergeld, Bowling Green State University

**ABSTRACT:** This is a study of a Race to the Top funded statewide implementation of Desimone's (2009) Core Conceptual Framework for professional development and associated impact on teacher quality and beliefs regarding the teaching of science. This large-scale study included 252 participants who submitted digital recordings of their teaching prior to, during, and at the end of the 18 month professional development program. Teachers also completed the Local Systemic Change Teacher Questionnaire and the Survey of Enacted Curriculum survey. Repeated measures ANOVA and t-tests revealed significant gains on all measures for participants. Implications for the field of science education, as well as research on effective professional development models will be discussed.

Changes in Teachers' Classroom Practices and Students' Perceptions of Science Resulting from Participating in Continuous Professional Development Program

Saouma B. Boujaoude, American University of Beirut, boujaoud@aub.edu.lb

Rola Khishfe, American University of Beirut

Sahar K. Alameh, American University of Beirut

**ABSTRACT:** The purpose of this study was to investigate the effect of a professional development (PD) program that used inquiry- and context-based science education, the nature of science, and dialogic teaching, as well as raised awareness about gender issues in science careers on teachers' practices and students' perceptions of science. The PD model included workshops and continuous support to teachers by the researchers. Design-Based Research was the methodology used in this study. Three teachers and 120 grades 6 and 7 students participated in the study. Data sources included a questionnaire, focus groups conducted before, during, and after the study, and videotapes of the classrooms of the teachers. Data were analyzed qualitatively and qualitatively. Evidence from analyzing the videotapes of students' responses in the focus groups showed that the classes became more dialogic and that there was an increase in the conceptual discourse. Analyzing focus group data showed that students started relating classroom science to everyday

activities, were involved in hands-on/mind-on activities and discussions and in groups suggesting that the classroom became more learner-centered. Finally, questionnaire results indicated that there was no significant change in gender role stereotypes and students were less confident in the ability of science to solve all problems

Effects of an NGSS-focused Professional Development on Elementary Teachers' Self-Efficacy and Teaching Practice

Emily J.S. Kang, Adelphi University, emilykang2@gmail.com Corinne Donovan, Adelphi University Mary Jean McCarthy, Adelphi University

**ABSTRACT:** With the recent release of the Next Generation Science Standards, there is a pressing need for sustained science professional development (PD) for teachers, particularly elementary school teachers. This study explores the effects of a PD program with 2nd grade teachers within one high needs suburban school district. The aims of this study are two-fold: 1) to explore the strengths and struggles of implementing an in-class coaching and modeling intensive PD around teaching science aligned with the NGSS, and 2) to explore the changes in self-efficacy and NGSS-focused teaching practice. This paper reports on early findings as part of a 2-year investigation on the effectiveness of the PD on helping the teachers transform their science teaching practice.

Effects of Formal and Informal Support Relationships on Experiences and Practices of First-year Science Teachers

Lori M. Ihrig, Iowa State University, lihrig@iastate.edu

Michael P. Clough, Iowa State University

Joanne K. Olson, Iowa State University

**ABSTRACT:** Programs to support new teachers are assumed to be crucial during induction years. However, new teachers' establishment and engagement in formal and informal support relationships may vary depending on alignment of supports to new teachers' beliefs about practice. The purpose of this multiple case study is to explore how an entire cohort of graduates of an intensive reform-based secondary science teacher education program engage in support relationships and the relationship that exits, if any, between new teachers' engagement in support relationships, experiences, and teaching practices during their first year of teaching. Semi-structured and informal interviews were conducted, lessons and interaction patterns were observed, and classroom artifacts were collected. Preliminary analyses indicates that participants were effectively socialized into their TEP and found value in research-based practice promoted by their TEP. However, when participants became novice teachers and their significant superordinates did not understand, value, or promote research-based practice, novices' implementation and development of research-based practices was undermined. This paper explores why some participants in this study were able navigate the directives and sanctions of their superordinates that were not aligned with effective practice, and others could not.

#### Strand 10: Curriculum, Evaluation, and Assessment

**Development and Validation of Concept Inventories** 

2:45pm-4:15pm, Smithfield **Presider:** Per Morten Kind

Improving upon the Chemical Concepts Inventory: Towards a State-of-the-Art Summative Assessment Instrument in Chemistry

Emily J. Borda, Western Washington University, bordae@wwu.edu

Mihwa Park, University at Buffalo

Xiufeng Liu, State University of New York at Buffalo (SUNY)

**ABSTRACT:** Chemistry lags behind some other scientific disciplines in the availability of valid and reliable summative assessment instruments to measure the effectiveness of educational treatments. Although the Chemical Concepts Inventory (CCI) has been used for such purposes, studies show that it can be improved to measure interventions more sensitively and accurately. Here we describe the analysis of a new instrument, the Chemical Concepts Questionnaire (CCQ), which was created by adding items to the CCI and developing sub-scales, or dimensions, that measure smaller

constructs within the overall construct of conceptual understanding in chemistry. We used Rasch modeling to determine several properties of the instrument and its dimensions, including its internal consistency, dimensionality, and fit between item difficulty and person ability. Though our analysis reveals some misfitting items and gaps between item difficulty and person ability, we are encouraged by slightly improved unidimensionality of the instrument overall; that is, its improved ability to measure the overall construct of conceptual understanding in chemistry. We will discuss the CCQ and the initial results of our analysis, along with future steps to improve the instrument based on these results.

## The Population Thinking Concept Inventory (PTCI): Measuring Introductory Biology Student Understanding of Selected Evolution Concepts

Mike U. Smith, Mercer University, smith\_mu@mercer.edu

Ryan M. Walker, Mississippi State University

Randolph S. Devereaux, Mercer University

Rebecca M. Price, University of Washington, Bothell

Kathyrn E. Perez, University of Wisconsin at La Crosse

**ABSTRACT:** Population thinking is a foundational basis for understanding evolutionary change in populations. In this study we present the conception, development, and testing of a new concept inventory, the Population Thinking Concept Inventory (PTCI), that measures understanding of four essential concepts of population thinking. The tested version of the PTCI consisted of eight two-tiered multiple-choice item pairs and one single item. Repeated field-testing employed introductory biology students at two universities. Introductory-level students (n=198) at two universities participated in the final testing of the PTCI. One item pair was removed because it was negatively correlated with other item pairs. The Cronbach alpha reliability of the resulting measure was 0.69. Principal components analysis of this version resulted in a single-component solution which accounted for 31.9% of the measure variability. These data suggest that the PTCI is a valid and reliable instrument for measuring student understanding of the principles of population thinking and the prevalence of common conceptual difficulties related to population thinking. The structure of the PTCI also lends itself to classroom use as diagnostic question clusters or clicker questions.

# *Efficacy of Two Types of Multiple-Choice Items to Diagnose Year 8 Students' Understanding of Heat and Temperature Concepts in the Classroom*

#### Hye-Eun Chu, Nanyang Technological University, hyeeun.chu@gmail.com

**ABSTRACT:** The purpose of this research is to investigate an efficient type of instrument to assess Year 8 students' conceptual understanding of heat and temperature before or after their instruction. Two different types of instruments were used in this study: Type 1, consisting of multiple-choice items with open-ended justifications and Type 2, consisting of two-tier multiple-choice items. In the Type 1 items students selected a correct response to each multiple-choice item and provided a free-response justification for their selection. In the Type 2 items, students selected a correct response from the first tier consisting of 4 – 5 content answers related to the question and the reason for their choice from the second tier to justify their selection of the first tier response by selecting one of the 4 - 5 reasons provided. Each of the instruments was administered to two separate cohorts of 173 and 143 Year 8 students of similar achieving ability. Findings indicated that Year 8 students were better able to show their understanding in the two-tier multiple-choice items. Also, both types of instruments provided similar information about students' alternative conceptions. Hence, two-tier multiple-choice items are more suitable for eliciting Year 8 students' understanding of science concepts.

Strand 10: Curriculum, Evaluation, and Assessment Innovative Approaches to Assessment 2:45pm-4:15pm, Brigade Presider: Christina S. Melki

Assessing Student Learning Through Scientific Humor: The Views and Practices of a College Biology Instructor

Francine Wizner, Albany University, imnotfran@hvc.rr.com Alandeom W. Oliveira, University at Albany, SUNY **ABSTRACT:** This study explored how scientific humor is integrated into exam problems developed by a college instructor to assess student learning outcomes in a genetics course. Specifically, we examined how scientific humor (content-embedded humor) was viewed and produced by a professor in course examinations. Through a qualitative, indepth exploration with a dual analytical focus on humorous views and practices, we provided a detailed depiction of the professor's humor-based science pedagogy. It was found that the professor viewed humor as a pedagogical strategy that effectively integrated scientific meanings and social meanings. Translation of these views into practice led to the development of humorous science problems with increasing degrees of cognitive complexity: identification, classification, and analogy. The significance of this study is that it underscores the content-embedded nature of scientific humor as well as its potential as a tool for interpersonal management of student emotions. It is argued that the perception of humor as merely a source of amusement and entertainment in the science classroom is too simplistic, and serious consideration should be given to the pedagogical role of humor in science instruction.

#### Development and Validation of a Three-tier Water Cycle Diagnostic Test for Pre-service Teachers Dannah L. Schaffer, University Of Missouri - Columbia, dlszh3@mail.missouri.edu Lloyd H. Barrow, University Of Missouri - Columbia

**ABSTRACT:** The first goal of this study was to develop and validate a three-tier diagnostic test to determine pre-service teachers' (PSTs) conceptual knowledge of the water cycle. For a three-tier diagnostic test, the first tier assesses content knowledge; in the second tier, a reason is selected for the content answer; and the third tier allows test-takers to select how confident they are in their answers for the first two tiers. The second goal of this study was to diagnose any alternative conceptions PSTs might have about the water cycle. The Water Cycle Diagnostic Test (WCDT) was developed using the theoretical framework by Treagust (1986, 1988, & 1995), and in similar studies that developed diagnostic tests (e.g., Calean & Subramaniam, 2010a; Odom & Barrow, 2007). The final instrument consisted of 15 items along with a demographic survey that examined PSTs' weather-related experiences that may or may not have affected the PSTs' understanding of the water cycle. The WCDT was administered to 77 PSTs enrolled in science methods courses. Analysis of the PSTs' responses demonstrated acceptable reliability, difficulty indices, and discrimination indices. Analysis indicated the majority of the PSTs had a limited understanding of the water cycle with 49 potential alternative conceptions.

#### Evaluation of Clicker Use and Student Success

Christina S. Melki, Indiana University, csmelki@indiana.edu

#### Meredith A. Park Rogers, Indiana University

**ABSTRACT:** Studies have examined students' and instructors' feelings toward clicker use, however, none have conclusively determined their efficacy. This study used mixed methods to elucidate clicker efficacy with regards to student performance on summative assessments (i.e., tests). To do so, we conducted semi-structured interviews with professors and students, observed each class session, and analyzed students' exam grades. From the data, we found that while the instructors viewed the purpose of clickers in similar ways, their implementation was different. Also, while there was not a significant difference in performance between topics addressed and not addressed with clickers, the types of questions asked with clickers compared to the test did have some impact on student performance. Students also appreciated the use of clicker and viewed different types of questions asked as being useful for their learning. These findings indicate that determining clicker efficacy involves much more than a quantitative analysis of students' exam performance. The method of clicker implementation and the questions asked also must be considered when determining whether they are effective tools for formative assessment in classrooms. Implications and suggestions for further study of the factors involved in clicker efficacy will be discussed.

### Physics Teachers' Diagnostic Accuracy in the Use of Concept Maps to Diagnose Students' Difficulties Heiko Krabbe, University Duisburg-Essen, heiko.krabbe@uni-due.de

Siv Ling Ley, University of Duisburg-Essen, Physics Education (Didactics)

Hans Ernst Fischer, University Duisburg-Essen

**ABSTRACT:** While there is quite a lot of research investigating the use of concept mapping as a scientific assessment tool, little is known about its power as a diagnostic tool for teachers in school and potential impact on diagnostic accuracy. This study presents concept maps allied with a detailed analysis strategy for physics teachers to use as a diagnostic instrument during lecture series. Diagnostic accuracy of the teachers is assessed by their ranking of students compared

with the students' ranking in a multiple-choice competence tests. Four groups of teachers are compared that differ in the provided diagnostic tools (concept maps (yes/no), evaluation sheet (yes/no)) for the ranking. It can be shown that concept mapping is worthwhile for formative assessment purposes during lecture series. This paper embraces quantitative statistical analysis techniques, so also offers insight into applying these methods for classroom use.

#### Strand 10: Curriculum, Evaluation, and Assessment

Related Paper Set – Using the Framework to Guide Evaluation of Curriculum Materials in Diverse Urban Middle Schools

2:45pm-4:15pm, Rivers

Presider: Christopher J. Harris

Discussant: Richard A. Duschl, Penn State University

**ABSTRACT:** It is widely expected that the Framework for K-12 Science Education and the Next Generation Science Standards (NGSS) will influence science education for years to come. This paper set explores the efforts of a research team that is using the Framework and recently released NGSS to study the efficacy of a middle school science curriculum in a diverse urban school district. The curriculum, with features that align with the new standards, presents an early opportunity for researchers to study implementation, including impact on learning outcomes and instructional practice, using measures of science teaching and learning that take into account the proficiencies implied in the Framework and NGSS. The four related papers in this set focus on (1) designing assessments that integrate content and practice, (2) examining the role of classroom discourse in supporting students' participation in science practice, (3) studying teachers' implementation of curricular units designed to engage students in science practice, and (4) exploring teacher sense-making of new standards via professional development. Together, these papers are important for moving us toward increased understanding of how to meaningfully study and support teaching and learning in diverse classrooms that will be trying to implement the next generation of science curriculum materials.

Using the Framework to Guide Evaluation of Curriculum Materials in Diverse Urban Middle Schools Christopher J. Harris, SRI International, christopher.harris@sri.com

Using the Framework to Design Assessments of Modeling in Physical and Earth Science Angela H. DeBarger, SRI International, angela.haydel@sri.com Joseph S. Krajcik, Michigan State University Christopher J. Harris, SRI International

The Role of Productive Talk in Supporting Student Participation in Scientific Modeling Savitha Moorthy, SRI International, savitha.moorthy@sri.com Cynthia M. D'Angelo, SRI International Christopher J. Harris, SRI International Carrie-Anne Sherwood, University of Michigan Carrie Allen Bemis, University of Colorado - Boulder Tina M. Stanford, SRI International

Using Log Data to Analyze Teacher Implementation of Framework-aligned Curriculum Cynthia M. D'Angelo, SRI International, cynthia.dangelo@sri.com Savitha Moorthy, SRI International Carrie Allen Bemis, University of Colorado – Boulder Carrie-Anne Sherwood, University of Michigan

Evaluating Teacher Professional Development for Implementation: Teacher Sensemaking and Impacts on Practice Carrie Allen Bemis, University of Colorado – Boulder, carrie.bemis@colorado.edu Cynthia M. D'Angelo, SRI International William R. Penuel, University of Colorado Samuel Severance, University of Colorado

Strand 11: Cultural, Social, and Gender Issues *Examining Cultural Tensions* 2:45pm-4:15pm, Benedum **Presider:** Bryan Shao-Chang Wee

#### YPAR and Peer Teaching to Subvert Systemic Racism in Science Learning

Takumi C. Sato, Virginia Polytechnic Institute and State University, takumi@vt.edu

**ABSTRACT:** The high school students in this critical ethnography are all youth of color with STEM aspirations and members of a community center where this project took place. Youth participatory action research (YPAR) provided the research tools to expose racism in science learning opportunities. YPAR is an emancipatory methodology often used to confront and transform social inequities. The youth-led research indicated youth of color were less likely to encounter engaging science practices with an over reliance on lectures and worksheets in the science classroom. The youth took action by teaching their younger peers a three-lesson science unit on food and nutrition. By planning and teaching a science unit, the youth improved the science learning opportunities for their middle grades peers and addressed a relevant concern in the community about food and nutrition. In addition, planning the unit enabled the youth to conduct all of the activities before teaching the unit. Thus, the youth supplemented their own science learning. YPAR provided an empowering opportunity to challenge racism along their STEM trajectories and fight for social justice. This project invites science educators to consider how to transform science learning in ways that sustain STEM aspirations among youth of color.

#### In Critical Solidarity: Decolonizing Science Education Research

#### Jean R. Aguilar-Valdez, St. Olaf College, aguilarv@stolaf.edu

**ABSTRACT:** This study counters traditional methodologies within science education research that often view communities and participants as research subjects, and research knowledge to be generated for the benefit of the academy. A year-long research endeavor with Latina/o undocumented science students in a Title I high school is presented as an example of utilizing a critical, qualitative, decolonizing approach: working in solidarity with research participants, as mutual agents for social change. Testimonio methodology (Urrieta, Kolano, & Jo, in press) helped create a safe space for speaking truths to power for those experiencing injustices and building solidarity towards pushing back against the political, educational, and social struggles these students reveal through their brave voices. This approach draws on Linda Tuhiwai Smith's (1999) and Marcos Pizarro's (1999) notions of decolonization of research methodologies through participant's ownership of research knowledge and through researched relationship, strong bonds were formed between the author and the students, as interests unify for educational and political change in solidarity with participants towards more equitable access to science education and a change in state and educational policies that limit these students' aspirations towards a future in science.

# African American Boys as Science Scholars: Prospectives from Teachers of Boys of Color Shari Watkins, University of Delaware, swatkins@udel.edu

**ABSTRACT:** To better understand African American boys' experiences with success in learning science, the elements of a science scholar, as conceptualized by one current and two former science teachers in a middle grade charter school for African-American boys, are examined and recognized. The teaching practices used to define their scholarship are identified and compared with literature-based culturally relevant practices for science teaching and learning. Utilizing interviews as the primary data source for this qualitative case study, science scholar definitions, examples of model science scholars and teacher's pedagogical practices in the science classroom, are analyzed to construct a description of African American boys as scholars in the science classroom.

Influence of a STEM camp on Underrepresented High School Students: Using Exploratory Factor Analysis Geeta Verma, University of Colorado Denver, geeta.verma@ucdenver.edu

Anton Puvirajah, Georgia State University

Lisa Martin-Hansen, California State University, Long Beach

**ABSTRACT:** Underrepresentation of minorities in STEM professions, including STEM education professions at universities and schools is a significant moral, economic, and strategic issue that has been of part of various conversations and initiatives across the United States for several decades. One of many such initiatives is the Academy for Future Teachers (AFT) program within which the current study is situated. In the study presented here, we describe the validation process that was undertaken on an instrument developed to measure AFT participants' science related attitudes and their education and career trajectories related to STEM. In addition we use the validated instrument to draw certain conclusions about the participants and the impact of the AFT program on them. We also propose a model for predicting students' notions about the importance of science. The study and the derived instrument will be useful for those interested in examining the manifestation of science agency through programs that occur in informal settings.

#### **Strand 12: Educational Technology**

*Spatial Thinking and Affect in Science Education* 2:45pm-4:15pm, King's Garden 2 **Presider:** Bridget T. Miller

Examining the Enactment of Web GIS on Students' Geospatial Thinking and Reasoning and Tectonics Understandings

Alec M. Bodzin, Lehigh University, amb4@lehigh.edu Qiong Fu, Lehigh University Denise M. Bressler, Lehigh University Farah L. Vallera, Lehigh University

**ABSTRACT:** Spatially-enabled learning technologies may enhance science learning by adding an emphasis on geographic space, visualization, scale, representation, and spatial thinking and reasoning skills. We developed a series of Web GIS investigations that use features designed to promote geospatial thinking skills and enhance tectonics learning. This study investigated how the Web GIS investigations improved urban middle school learners' geospatial thinking and reasoning and understandings of tectonics concepts. Twelve grade 8 middle level science teachers in four urban schools implemented the Web GIS tectonics investigations with 1,124 students. Data included a tectonics content knowledge and geospatial thinking and reasoning pre- and posttest achievement measure. Thirty-three classroom observations were conducted during the enactment. Paired-sample t tests for the entire assessment, the tectonics content subscale and the geospatial thinking and reasoning subscale revealed statistically significant gains from pretest to posttest (p < .001) with large effect sizes. Mixed design ANOVAs indicated significantly higher gains over time for males than females and for the upper level academic track than other tracks, p < .05. The findings provide support that geospatial thinking and reasoning related to a science content area can be learned with appropriately designed learning activities with Web GIS.

Fully Iterative versus Partially Iterative Visuo-Spatial External Representations of Abstract Physics Concepts Satyugjit Virk, Teachers College, suthbills@hotmail.com

John B. Black, Columbia University

**ABSTRACT:** Students often have trouble visualizing abstract physics concepts. The hypothesis of this experiment is that students presented with a complete, dynamic visualization to depict the abstract concepts of voltage and current will perform better than students reading text and diagrams for these concepts. Here, graduate students (N=53) who performed guided exercises on a circuit where electrons were animated and a neon blue sphere which represented potential energy changed in size and current as the electrons encountered each resistor and wire in a series circuit (experimental 1) were compared to students who performed guided exercises on a circuit where only the first few wires/resistors had the electron potential energy sphere visualization (experimental 2) and students who read a text passage with diagrams on the same material (control). Significant increases in learning were found for the fully animated circuit condition over the text and diagrams condition on measures of definitions, a compare/contrast chart, multiple choice and drawing questions, and over

the partially animated condition for the compare/contrast chart. This demonstrates how hard it is for students to visualize abstract concepts, like voltage in a circuit on their own, and the power of fully visualizing such concepts using animated spatial metaphors.

Changes in High School Science Student Affect Through Serious Educational Game Design and Development Len Annetta, George Mason University, lannetta@gmu.edu

Richard L. Lamb, Washington State University

David B. Vallett, University of Nevada Las Vegas

Rebecca Cheng, George Mason University

**ABSTRACT:** Infusing innovative technology in a project-based learning paradigm is not a new approach to science learning. With the release of the Next Generation Science Standards call for inclusion of more engineering design principles, this study reports results from an NSF project in which high school students designed and created education video games. This study sought to understand the nature of the links between affective, cognitive, and inventory measures between groups of high school students who designed and developed SEGs versus a peer group that created a non-technology science project for a service learning requirement. 434 high school students from two mid-Atlantic states participated over three years in the project. Analysis of Variance testing on affective measure of interest (p<0.001) and efficacy (p<0.001); cognitive measures of creativity (p<0.001), spatial visualization (p<0.001), and mental rotation abilities (p<0.001); and inventory measures of STEM career awareness (p<0.003) and 21st century skills (p<0.001) were compared with a peer comparison group. These results suggest that the use of the XXXX model as a means to increase affect, STEM career interest, and STEM skills has matured and is ready for implementation at scale.

Assessment of Student 21st Century Skills Using Science Based Serious Educational Games

Richard L. Lamb, Washington State University, Richard.Lamb@wsu.edu

David B. Vallett, University of Nevada Las Vegas

Len Annetta, George Mason University

Rebecca Cheng, George Mason University

**ABSTRACT:** The science education community has entered a new era in assessment. The recognition of the changing face of science competition away from developed nations, such as, England, Canada, France, Germany, and Japan, to the fastest growing economies in the world such as China and India has generated a need for a new framework for assessment of science skills. One possible way to meet this requirements for the changing model of assessment is through real-time (computer adaptive) cognitive diagnostic assessments using 21st Century Skills as a framework. Results of this study identify three underlying cognitive attributes and four tasks responsible for science processing and other related constructs. The authors also explore the implications of this identification for teachers and students for assessment purposes.

Strand 13: History, Philosophy, and Sociology of Science

Symposium – Indigenous Knowledge, Nature of Science, and Scientific Inquiry: Can the Three Coexist in the Science Classroom?

2:45pm-4:15pm, Sterlings 2 & 3 **Presider:** Ian Binns

#### **Discussants:**

Judith S. Lederman, Illinois Institute of Technology, Ledermanj@iit.edu Ian Binns, University of North Carolina, Charlotte Eleanor Abrams, University of New Hampshire Meshach Ogunniyi, University of the Western Cape, South Africa Larry D. Yore, University of Victoria, Canada Chilung-Fen Yen, Providence University, Taichung Taiwan Bryan Brayboy, Arizona State University, USA
**ABSTRACT:** The research literature on nature of science occasionally discusses world views and its potential impact on students' understandings of science and nature of science. Indigenous knowledge is an example of a culturally-based world view that can impact students' views about nature of science. In some countries (e.g., South Africa) indigenous knowledge is a mandated part of the science curriculum, but whether attention to indigenous knowledge is required, the students in many countries possess strong traditions of indigenous knowledge. This symposium will provide perspectives on indigenous knowledge emanating from numerous countries. Presenters will discuss how indigenous knowledge is presented within the context of a science classroom and what impacts, if any, inclusion of indigenous knowledge has on the learning of science and understandings of nature of science

#### **Strand 14: Environmental Education**

Symposium – Climate Change Education: Policies and Practices

2:45pm-4:15pm, King's Garden 4

Presider: Sarah J. Carrier

**Presenters:** 

Charles W. Anderson, Michigan State University J. Randy McGinnis, University of Maryland Barry Golden, University of Tennessee Elizabeth Walsh, San Jose State University

**ABSTRACT:** While the science community recognizes that climate change is occurring and is very likely caused by human activities, public views of climate change have varied and often remain divided along party lines (Mayer, Adair, & Plaff, 2013). An obvious approach to inform public understanding is through formal (K-14) and informal education efforts, yet educational research studies reveal that students and their teachers continue to have misconceptions about global warming and climate change The proposed symposium will consist of four distinguishes presenters who each bring years of research on climate change education. Presenters' research will include: 1. presence of climate change in the Next Generation Science Standards, 2. efforts to encourage climate scientists' communication and global implications of policies about climate change with an emphasis on social justice issues, 3. climate change education professional development efforts with teacher educators relating to impacts on teacher education policies, and 4. status of climate change using evidence. Audience discussions will follow.

#### **Plenary Session #1**

#### Confronting the Contraditions of Globalization for Science Education and Educators

4:30pm – 5:50pm, Ballroom 1

Presider: Lynn A. Bryan, Purdue University

Keynote Presenter: Susan Robertson, University of Bristol, United Kingdon

**ABSTRACT:** This keynote address engages with the following question: what does 'globalization' mean for education in general, and for the teaching of science, and for science education in particular. In short, it means a great deal! I will be arguing that there are contradictory developments afoot, and ones that we need to engage with as educators, if we are to fully understand their full implications. Technological developments now enable an opening up of a vast array of resources through which we can learn about our worlds, about each other, of our different scientific traditions, and shared concerns. Yet the dominance of the global competitiveness discourse in education tends to narrow teaching and learning - especially in the sciences - into activities that can be assessed, compared and ranked globally - in turn closing down those possibilities that are opened up by a more interconnected world. We also need to deabte what is at stake when the international agencies - such as the OECD - set agendas that strongly prefer particular pedagogical approaches to teaching and learning, and ask what this means for disciplinary basis of science teaching, on the one hand, and for the capacity for learners to more fully engage with core scientific knowledges, on the other.

### Monday, March 31, 2014

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

**Equity and Ethics Committee Sponsored Session** Jhumki Basu and Hedy Moscovici Scholars Symposium – Curriculum, Assessment and Learning **Environments to Enhance Science Teaching and Learning** 8:30am-10:00am, Commonwealth 2 Presider: Felicia M Mensah, Columbia University **Presenters:** Deborah Roberts-Harris, University of New Mexico Deb Morrison, University of Colorado at Boulder Julie C. Brown, University of Florida Emily A. Dare, University of Minnesota Deb Morrison, University of Colorado at Boulder Vanessa Dodo Seriki, University of Houston-Clear Lake Christopher G. Wright, University of Tennessee **ABSTRACT:** Five scholars and last year's recipients of the Basu Scholars Award and the Hedi Moscovici Teaching Award present exciting and compelling research that spans many areas of science education, including teacher education, teacher professional development, formative assessment, curricula, and science content. These scholars bring diverse educational perspectives that will shape science education. In this session, they present new approaches to help us understand challenges and successes of science teachers, students, and programs.

Strand 1: Science Learning, Understanding and Conceptual Change *Reasoning Patterns in Learners' Scientific Explanations* 8:30am-10:00am, Benedum **Presider:** John R. Ruppert

#### Profiles of Relationships between Content and Systems Reasoning

Cheryl Lyons, Columbia University, cal2154@tc.columbia.edu

Ann E. Rivet, Teachers College Columbia University

**ABSTRACT:** There is emerging empirical and theoretical support in science education for fostering the development of science reasoning and practices alongside content understanding, as opposed to the perspective that reasoning develops after a certain threshold of content mastery has been achieved. However, existing research on systems thinking has focused on universal skills and neglected the role of content or conceptualized a progression in which content mastery precedes reasoning. This study focused on describing individual variations in the ways that 8th and 9th grade students reason about changes in a system over time to investigate the relationship between this reasoning and the students' demonstration of content. We found that the relationship between content and reasoning was nuanced when students demonstrated at least a moderate level of content. Four profiles of this relationship emerged which warrant different instructional support. This work has implications for science educators and developers of curriculum and assessment.

The Role of Perspective Taking Skills in Children's Explanations of Astronomical Phenomena

Cori Bower, The Pennsylvania State University, cbower@psu.edu

Julia Plummer, The Pennsylvania State University

Lynn Liben, The Pennsylvania State University

**ABSTRACT:** This study investigates the role of spatial reasoning, particularly perspective taking abilities, in how children learn to explain spatially complex astronomical phenomena. Understanding of many astronomical phenomena

studied in elementary and middle school require shifting between an Earth-based description and a space-based explanation. Children's explanations for seasonal constellations (SC) were investigated for this project as limited prior research has focused on children's explanations for this phenomenon. Children at a one-week summer astronomy camp were interviewed about celestial motion. Their SC explanations were coded for: depth of explanation, use and integration of frames of reference (Earth-based and space-based), and use of gesture. A more sophisticated understanding of SCs would be evident through explaining the connection between these frames of reference. Results indicate that children with higher spatial perspective taking abilities also have more scientific explanations of SCs, make more connections between frames of reference, and gesture more frequently. Overall, well-developed spatial abilities, particularly perspective taking, serve as a strong foundation to learn spatially complex science content, such as those learned in astronomy. Findings suggest that educators and curriculum developers address the key role of spatial reasoning ability in science education to foster this type of reasoning.

A Framework for Analyzing High School Students' Understanding of Complex Human Body Systems Zohar Snapir, Ben Gurion University of The Negev, Israel, zohar.snapir@gmail.com Catherine Eberbach, Rutgers University Orit Ben Zvi Assaraf, Ben-Gurion University of the Negev ISRAEL Cindy E. Hmelo-Silver, Rutgers University Jaklin Tripto, Ben Gurion University of the Negev Beer Sheva, Israel Miriam Amit, Ben Gurion University of the Negev Beer Sheva, Israel ABSTRACT: Science education is increasingly focused on the instruction and learning of complex systems. In this paper, we establish a baseline of student understanding of the complexity of human body systems. To trace the learning trajectories of high school students, we adapted and expanded upon the Component-Mechanism-Phenomena model (Quellmalz, Timms, Silberglitt, & Buckley, 2012). The tool for data collection in this study was the Repertory Grid technique that can help identify the components and processes of a system that students understand. This is a preliminary study about how high school students begin to develop an understanding of human body systems. As the first part of a three-year longitudinal study, we coded and analyzed the personal constructs of eighty-five 10th graders at the start of the school year. Coding considered relations between components, mechanisms, and phenomena. Findings suggest that students tend to describe the locations and properties of components, as well as identify simple mechanistic relations between components and processes. In addition, few students refer to phenomena-the problem context-and then in terms of overall behaviors or properties. These results suggest that students at this stage present novice understanding of the human body as complex system.

Reasoning Patterns of Nigerian Students In Explaining Biological Phenomena

Uchenna M. Nzewi, University of Nigeria-Nsukka, starnzewi@yahoo.com

Nnenna Ezechi, Rnugu State Collrge of Rducation, Enugu

Apollonia A. Nwosu, University of Nigeria, Nsukka, Enugu State.

**ABSTRACT:** According to Southerland et al (2001), students in their explanation of biological phenomena reason alongside any combination of the following categories /patterns:(i) Anthropomorphic, (ii) Teleological, (iii) Mechanistic proximate; (iv) mechanistic ultimate (v) pre-determined (vi) Blended and (vii) Don't know. While the teleological and mechanistic ultimate reasoning patterns are scientific in outlook, the others are not. These prior conceptions are greatly related to the students' cultural and social worldviews about these natural phenomena. This study was aimed at finding out the various categories of reasoning patterns used by Senior Secondary students while explaining biological phenomena; and also the percentage of SS3 biology students that gave shifting explanations even after instruction. 352 students (116 males and 176 females) in eight intact classes from 2 co-educational schools responded to the "Students Reasoning on Explanation of Biological phenomena" (SREBP) developed by the researcher. SREBP has seven question prompts which are pictures of different biological phenomena labelled plates A to G. Students responses were captured and categorised into various reasoning categories. Results showed that Nigerian students employed all reasoning patterns/categories identified by Southerland et al (2001) in explaining biological phenomena in genetics and evolution.

Analysis of Students' Models of Electric Interactions and Atomic Structure

Kristin Mayer, Michigan State University, mayerkri@msu.edu

Joseph S. Krajcik, Michigan State University

**ABSTRACT:** A model of the atom that is based on an understanding of electric interactions can serve as a powerful tool for explaining and predicting phenomena across disciplines. Unfortunately, students generally have a simple, incomplete model of the atom and do not use electric interactions to explain or make predictions about how atoms or molecules interact with each other. Scientific modeling is a key practice across science disciplines. In science, models are useful for explaining and making predictions about phenomena by depicting relationships between various components or variables involved in a variety of observations or interactions. Scientific modeling is a complex practice and it is important to study how students develop their understanding of scientific modeling in a variety of domains since the practice cannot be separated from the content. In this research we analyzed students' models of electric interactions and atomic structure and their responses to interview questions to determine how well students were able to use their models to make predictions and explain phenomena. We found that some students developed rich models, but many students did not include repulsive interactions in their models and could not relate their models of atomic structure to evidence.

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

Symposium – New Models of Professional Learning to Support Teachers in Realizing NGSS in Classroom Teaching

8:30am-10:00am, King's Garden 4 **Presider:** Brian J. Reiser **Discussant:** Elizabeth A. Davis **Presenters:** Jean Moon, Tidemark Institute Sarah Michaels, Clark University Abraham Lo, Northwestern University Christina Krist, Northwestern University Michael Novak, Park View School, Morton Grove, IL and Northwestern University Maria C. Simani, University of California Riverside Katie Van Horne, University of Washington Tana Peterman, University of Washington Philip L. Bell, University of Washington **ABSTRACT:** The Framework for Science Education and Next Generation Science Standards

**ABSTRACT:** The Framework for Science Education and Next Generation Science Standards (NGSS) promise to have a profound effect on science learning and teaching — if the vision and substance of these documents can penetrate the classroom door. This vision requires a radical departure from typical approaches of science teaching and learning, demanding a central role of science and engineering practices in which students develop key explanatory models through investigation and apply them to make sense of phenomena. Yet teachers need to develop pedagogical approaches to support students in science practices such as argumentation and modeling, and for orchestrating the classroom discourse that underlies these practices. This symposium explores (1) the challenges of supporting teacher learning to implement the Framework and NGSS, and (2) several early interventions designed to help teachers change their practice in alignment with this vision. We consider four interventions that vary in their structure for learning and support, including formal university courses for teachers, district sponsored teacher study groups, and projects involving curriculum implementation or adaptation. The approaches are all grounded in attempts to engage teachers not only in learning about these reforms, but in actively grappling with issues of how to bring them into their own practice.

#### Strand 2: Science Learning: Contexts, Characteristics and Interactions Symposium – Science/Environment/Health – Towards a Reconceptualization of Three Critical and Interlinked Areas of Education 8:30am-10:00am, Fort Pitt **Presider:** Justin Dillon **Presenters:** Alla Keselman, National Library of Medicine Justin Dillon, King s College London Marcus Grace, University of Southampton, UK Cláudia Faria, University of Lisbon, Portugal Francine Pinhão, Universidade Federal do Rio de Janeiro, Brazil **ABSTRACT:** The aims of science education include attracting students to science-related careers and imparting the knowledge, attitudes, and skills necessary for informed citizenship and for daily life. Attaining these goals requires a curriculum that students perceive as engaging and relevant to their lives. Traditionally, the environment and health received relatively little attention in science education research and were afforded little time in the science curriculum. However, recent years have been marked by an emerging appreciation of both the environment and health as invaluable

contexts for educating future scientists and non-scientists. This symposium, comprised of the contributors to the special issue of the International Journal of Science Education, entitled "Science|Environment|Health," will address important conceptual and practical considerations, relevant to bringing environment and health into science education. Presentations will be focused around four explicit arguments for the greater prominence of environment and health in science education: 1) relevance to informed citizenship, 2) potential for awakening interest for science, 3) ability to promote scientific literacy, and 4) encouragement of critical approaches to science. In addition to supporting the four arguments, presenters will also discuss enablers and challenges of integrating science, environment and health education research and practice.

#### Strand 2: Science Learning: Contexts, Characteristics and Interactions Scientific Drawings, Infographics, and Other Representations 8:30am-10:00am, Heinz

Presider: Kim Sadler, Middle Tennessee State University

# Students' Interpretations of Evolutionary Trees: When Relationships Contradict Prior Knowledge Laura R. Novick, Vanderbilt University, laura.novick@vanderbilt.edu Kefyn Catley, Western Carolina University

**ABSTRACT:** Science is an important domain for investigating students' responses to information that contradicts their prior knowledge. Previous studies of this topic communicated such information verbally. The present research used diagrams, specifically trees (cladograms) depicting evolutionary relationships among taxa. In two studies, we examined the effects on tree thinking in college and high school students of cueing conflicting prior knowledge by assigning different sets of taxa to the branch tips for cladograms illustrating a particular nested structure. For each of three cladogram pairs, one set of taxa targeted a common misconception about relationships among familiar living things, whereas the other was relatively unfamiliar to students. We asked structurally identical questions about the cladograms in each pair. Both groups of students had significantly lower accuracy for the cladograms with "misconceptions" than unfamiliar taxa. Although college students did better when the cladograms with unfamiliar taxa came first, suggesting they adopted a strategy for the first set that they maintained subsequently, tenth graders were unaffected by presentation order. A coding of students' explanations for their answers indicated that responses to diagrammatically presented information that conflicts with prior knowledge are similar to responses to such information presented verbally. Implications for biology education are discussed.

Early Learners' Multiple Representation in the Context of the Science Writing Heuristic Approach Claudia P. Aguirre-Mendez, The University of Iowa, claudiapatricia-aguirre-mendez@uiowa.edu Sae Yeol Yoon, Unviersity of Iowa Nurcan Keles, University of Iowa Deborah L. Linebarger, University of Iowa Brian M. Hand, University of Iowa

**ABSTRACT:** The purpose of this study was to evaluate the effectiveness of language-rich learning approach guided by the Science Writing Heuristic (SWH) on young children's use of multimodal representations in their science writing including the number of content ideas across both written text and pictures and the degree of cohesiveness between these text- and picture-based representations. Across first through third grade four elementary public schools located within a Midwestern school district, there were 369 students and 19 teachers who took part in this study. A quasi-experimental design was used, and data analysis indicated that while there were no significantly better able to cohesively integrate text with picture content. In addition to the overall benefits conferred by using the SWH approach, the results also highlighted the importance of experience in implementing it. Specifically, as teachers' experience using SWH increased beyond one year, students' odds of creating cohesive and connected representations between text and picture content increased significantly. One important implication of this research is that using an SWH approach in early elementary grades is not only feasible but also quite promising in promoting scientific literacy.

#### Aspects of Quality Science Infographics: Experts' Perspective

#### Engida Gebre, University of Colorado Boulder, engida.gebre@colorado.edu Joseph L. Polman, University of Colorado Boulder

**ABSTRACT:** Teaching young adults about using and creating science infographics creates considerable challenge for teachers and practitioners as there is no guide to determine the quality or effectiveness of artifacts and to scaffold students' performance in the learning process. In this study we address this challenge by developing components of quality science infographics that can be used in instructional settings. Using a total of six infographics developed by professionals and made available online, we gained insight from 10 experts in the areas of science, graphic design, and learning sciences on their thinking about graphic and information design related to science. Each participant was provided with two infographics and was asked to think-aloud, appraise, and suggest modifications to each artifact. Inductive analysis of transcripts using constant comparison method resulted in five super-ordinate categories, some with sub-categories, representing aspects of quality infographics. The identified categories can be used as inputs in teaching and learning about the use and creation of science infographics.

Contextualizing Science in Life through Science News Infographic Design and Publication

Joseph L. Polman, University of Colorado Boulder, joseph.polman@colorado.edu

Engida Gebre, University of Colorado Boulder

Cynthia Graville Smith, Saint Louis University

**ABSTRACT:** STEM information and arguments in public media use diverse and novel representational forms requiring competencies rarely taught in school. Science education in schools tends to focus on students' possible development as "future scientists", rarely demonstrating how science can be relevant outside careers for personal or community concerns that are part of their everyday lives. In this paper, we present affordances and constraints of a learning environment involving adolescents in critiquing and authoring authentic science news infographics. In a formal high school and an out of school learning environment, young adults chose topics, searched for data, organized the data, created infographics, shared them for external and peer review, and worked on revisions for possible online publication. Analysis of student activities, interviews, and the artifacts they produced show that a) young adults contextualize science topics to personal and/or societal concern, b) infographics are a potential instructional tool to develop students representational competence and science literacy, and c) students develop critical ability to address the question of "so what?" in their work and the work of others. The study has relevance for science teachers and researchers who work on designing environments for developing young adults' science literacy and representational competence.

#### Strand 4: Science Teaching--Middle and High School (Grades 5-12): Characteristics and Strategies Investigating the Effect of Various Inquiry Approaches on Student Learning 8:30am-10:00am, King's Garden 5 Presider: Shelly Micham

# Use of Physics Simulations in Whole Class and Small Group Settings: Comparative Case Studies A. Lynn Stephens, University of Massachusetts, lstephens@educ.umass.edu John J. Clement, University of Massachusetts

**ABSTRACT:** This study investigates student interactions with simulations, and teacher support of those interactions, within naturalistic high school classroom settings. Two lesson sequences were conducted in 19 physics class sections; some sections were taught in a whole class discussion setting and matched sections were taught in a small group setting. Unexpected quantitative findings led to comparative case studies to investigate why small group students using physics simulations in a hands-on fashion had done no better than students in the matched whole class discussions. Comparative analyses of videotapes and student activity sheets revealed that 1) in a majority of matched sets, more time was spent on key concepts in the whole class discussions; 2) small group discussions spent no more time than did whole class discussions in addressing student conceptual difficulties; 3) more episodes providing support for using visual features of the simulations were observed in whole class discussions; and 4) no small group students in the lower level physics sections showed any evidence along several parameters for having utilized the visual features. A mixture of whole class and small group discussion is recommended. Teacher interviews yielded several suggestions for the design of instructional simulations to facilitate whole class voting and prediction-making.

# Improving Students' Chemical Literacy Level on Thermochemical and Thermodynamics Concepts through Context-Based Approach

#### Ceyhan Cigdemoglu, Atilim University, ccigdemoglu@atilim.edu.tr

#### Omer Geban, Middle East Technical University, Faculty of Education

**ABSTRACT:** The aim of this study was to delve into the effect of context-based approach (CBA) over traditional instruction (TI) on students' chemical literacy level related to thermochemical and thermodynamics concepts. Four eleventh grade classes with 118 students taught by two teachers from a public high school in 2011 fall semester were enrolled in this particular study. Each teacher had an experimental and a control group. These classes were assigned randomly as experimental and control groups. The experimental groups were treated with CBA, control groups were treated TI. Items developed to assess students' chemical literacy level related to thermochemical and thermodynamics concepts were administered to as a post-test at the end of the implementation to both groups. Students' responses to chemical literacy item scores were analyzed by Analysis of Covariance (ANCOVA). The results revealed that CBA was superior to TI on improving students' chemical literacy level. The findings imply that CBA, as discussion platform of concepts through real-life experiences, have potential to increase students' chemical literacy level on abstract and difficult concepts.

#### Implementing Project-Based Learning in a New STEM-Focused Secondary School

Tamara Holmlund Nelson, Washington State University Vancouver, tnelson1@vancouver.wsu.edu David Slavit, Washington State University Vancouver

**ABSTRACT:** STEM-focused secondary schools are proliferating in the U.S. in response to a call for a more STEM literate workforce and citizenry. Inclusive STEM schools employ a non-exclusive admissions process to broaden the participation of students traditionally underrepresented in STEM courses and career pathways. In this analysis of data from the first year of a new, inclusive secondary STEM academy, we focus on the design and implementation of project-based learning, a common curricular approach in STEM schools. We look specifically at the factors that impacted teachers' implementation of interdisciplinary projects, what supported their learning about project design and student engagement, and the resulting impacts on student outcomes. We found that the teachers, carefully hired for their content-area expertise, had little experience with or understanding of project-based (PB) learning. This and a lack of support for curriculum development had a significant impact on the individualized rather than interdisciplinary nature of the projects and an initially overwhelming student workload. However, students reported they valued the PB approach as it applied to

complex, real-world situations. Teachers recognized the need to develop fewer and more authentic projects and stated that they fell short in realizing some of their goals for students.

# Effects of Science Inquiry Practices on Diverse Seventh Grade Students' Science Achievement and Attitudes Hanna Kim, Northeastern IL University, h-kim17@neiu.edu

**ABSTRACT:** The goal of the study is to examine participating students' science achievement and attitude changes after inquiry-based activity experiences. Thirty seventh grade students explored the harmful and helpful effects of ultraviolet (UV) rays on the human environment using their own scientific methods. They were encouraged to define problems, develop models, plan and carry out investigations, analyze data using mathematical thinking, engage in evidence-based arguments, and communicate obtained information. These processes are mainly known as inquiry-oriented approaches (NRC, 2000) and also defined as the science and engineering practices in the next generation science standards (Achieve, 2013; NRC, 2012). Individual students designed their own experiments by choosing different materials to test for the best protector of UV light. The dependent variable was the change in color of the UV beads as a result of the exposure to sunlight, especially UV light outside. The Science Exploration Sheet (SES), which measured their scientific achievement, showed that 92% of students were able to answer their own questions using their own scientific models. However, pre-and post-attitude surveys revealed that there was no significant change in students' attitudes about science/scientists after the inquiry intervention (p < .05).

#### Strand 6: Science Learning in Informal Contexts Making a Difference? Impact of Out-of-School Learning Experiences on Interest in STEM 8:30am-10:00am, Rivers Presider: Kathleen A. Fadigan

*Out-of-School STEM Learning in Germany: Can We Catch and Hold Students' Interest?* Burkhard Priemer, Humboldt-University, priemer@physik.hu-berlin.de

Christoph Pawek, German Aerospace Center Berlin

**ABSTRACT:** Visits to informal learning facilities such as museums, science labs, zoos etc. are popular in school practice in Germany. With regard to students' interest in science positive effects are ascribed to these learning settings. However, is there empirical evidence that supports this view? This talk summarizes ten years of research done in Germany that investigated students' situational interest in science in the context of informal learning. Most of the eight studies included in the review were published in German only and hence escaped international attention. Nevertheless, the results are not specific to Germany but of international relevance. It is our aim to present theses results and discuss them in an international science education context.

Authentic Experience in an Industrial Out-of-School Lab: Impacting the Image of Physics and Career Orientation

Susanne Wessnigk, IPN Kiel, s.wessnigk@ipn.uni-kiel.de Manfred Euler, professor

**ABSTRACT:** Facing the increasing lack of a skilled workforce due to the declining interest of students in science and technology, several approaches have been proposed to promote science learning and to raise the quality of science education. One of these approaches focuses on out-of-school laboratories. Most of these labs were mainly established in the noughties to promote scientific educational processes. Initially, these learning laboratories were conceived from a scientific point of view to foster students using scientific methods. However, the focus has recently shifted to economic issues and career orientation, often resulting in project work. By now, out-of-school labs have become part of the education innovation and contribute to the technological and scientific education process in Germany. This study investigates how one of these newly founded labs affects students' image of physics and career orientation in science. The industry oriented lab has extended out-of-school learning experiences with potentials, perspectives and the demands of an industrial company. Our results show successful image changes of physics. Moreover, positive effects on career orientation are evident.

Research on Impacts of University-Based Biotechnology Teaching Laboratories on Teacher Professional Development and Student Outcomes

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Angela M. Kelly, Stony Brook University

Kristen La Magna, Stony Brook University

Daniel Moloney, Stony Brook University

R. D. Bynum, Stony Brook University

**ABSTRACT:** The biotechnology teaching laboratories (BTLs) were developed to give middle and high school students an opportunity to work with practicing scientists on modern experiments based on rigorous content. Pre-service and inservice teachers have been involved in preparing and teaching the labs. The purpose of this research was to report the impacts of the BTLs on three key groups of stakeholders: middle and high school students, pre-service teachers, and inservice teachers. Quantitative and qualitative data were compiled from surveys of students and their teachers, as well as interviews with BTL instructors. Data have indicated that this program increased students' confidence, science knowledge, and interest in science. Teachers reported strong correlation between the BTL curricula and school-based course material and were highly satisfied with the program. Pre-service teachers have refined their skills in pedagogical content knowledge in biotechnology, classroom/laboratory management, ability to assess prior knowledge, and time management. In-service teachers who accompanied their students have deepened their content knowledge by observing scientists engaging in cutting-edge research techniques. Both teachers and students have gained an appreciation for critical questions in current biotechnology research, improving their scientific literacy and understanding of recent advances in the field.

Using Self-Determination Theory to Understand Students' Experiences at an Informal Science Learning Center Kendra J. Michaud, University of Maine, kendra.michaud@maine.edu

#### Daniel Capps, University of Maine

**ABSTRACT:** One of the major goals of informal science learning centers is to promote interest in science. In this study we examined how student experience at an informal science learning center was impacted by the 'job' or task they were asked to complete. We administered a 24-item survey to 448 student visitors immediately after they completed a simulated mission to space. Data were collected using a personal response system. We used tenets of self-determination theory in order to better understand student experience at the science center. Results indicate that jobs offering students a greater sense of relatedness, competence, and autonomy were viewed as more satisfying than other jobs. Additionally, students viewed some jobs as being more science related than others. Unfortunately, the job students viewed as being the most science learning student experience at informal science learning centers through a theoretical lens like self-determination theory may provide useful information for centers as they design and carry out their programming.

#### Teacher Involvement in Field Trips and Its Impact on Learning Outcomes

Nirit Lavie Alon, Technion, nirita@spni.org.il

Tali Tal, Technion

**ABSTRACT:** We studied 28 field-trips to natural environments aiming to understand how teachers and guides view their relationships prior to and during the field-trip? how do teachers function in field-trips facilitated by environmental-educators? And what is the relationship between teacher involvement and the learning outcomes? Data included observations, interviews with teachers and guides and 392 student questionnaires. We found that a minority of guides and teachers believe they should collaborate in carrying out the educational activity. They believe in coordination prior to the field-trip and in teachers giving technical help. We identified two main teacher involvement patterns: technical-assistant and active mediator in the social and/or cognitive domains. About half of the teachers acted as technical assistants. The professional guides did not recognize mediation of the teachers in the social domain, which could point to their insufficient understanding of possible roles teachers can play in field-trips to the outdoors. We found significant difference in students' self-reported outcomes with respect to teacher involvement, with higher reported outcomes in three domains: cognitive, social and behavioral of teachers who were more involved in enacting the field-trip.

#### Strand 7: Pre-service Science Teacher Education Learning and Teaching with Scientific Practices 8:30am-10:00am, King's Garden 3 Presider: Mark Olson, Oakland University

Developing the Next Generation of Science Teachers: Examining Self-efficacy Development for Teaching Engineering Practices

Amanda M. Gunning, Mercy College, agunning@mercy.edu Meghan E. Marrero, Mercy College Jessica Riccio, Columbia University

**ABSTRACT:** In light of the new Next Generation Science Standards [NGSS] (Achieve, 2013), science teachers will now be charged with explicitly integrating engineering practices into their curricula. But are our teaching candidates ready to meet this new challenge? How can we prepare them? This small, preliminary study examines the experiences of teachers in two graduate science education courses. Two cases are drawn to explore how teachers' and teacher candidates' self-efficacy develops during experiences that incorporate engineering practices into their coursework. The framework used for this study to examine teacher beliefs and behavior is Bandura's (1997) theory of self-efficacy, and data is analyzed through his four modes of self-efficacy development. As this study continues, early findings indicate that teachers are able to develop some self-efficacy for incorporating engineering practices into their instruction, even through small, in-course interventions. We share our findings to contribute to the dialogue on how best to build teachers' self-efficacy for including engineering practices.

#### Preservice Elementary Teachers' Ideas about Scientific Practices

#### Amy R. Ricketts, Penn State University, arr217@psu.edu

**ABSTRACT:** Recent reform documents call for teachers to implement scientific practices, crosscutting ideas and disciplinary core ideas into their science teaching. As a first step toward this goal, teachers must construct sophisticated ideas about scientific practices. Unfortunately, preservice elementary teachers commonly have naive understandings of science content and practices. Extensive prior research on children's "misconceptions" in science highlights the persistence of students' ideas and their influence on future learning, reminding us of the importance of assessing preservice teachers' ideas about scientific practices. Teacher educators must first assess what ideas their students hold, to effectively select materials and design experiences that work with and challenge these persistent ideas. Teacher educators who are informed about their students' ideas are in a better position to help their preservice teachers construct more sophisticated understandings about scientific practices. This study investigates what ideas about scientific practices elementary preservice teachers construct, by analyzing several different artifacts they created during an elementary science teaching methods course. Findings support prior studies in terms of preservice elementary teachers' difficulty with the practice of analyzing data, but challenges the findings of others in terms of their ideas about the social nature of science and the purpose of constructing and using models.

## The Effects of Explicit Instruction on Modeling on Pre-service Science Teachers' Understanding of Scientific Models

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Mehmet Aydeniz, The University of Tennessee

Mustafa Sami Topcu, Yildiz Technical University

Nejla Atabey, Mugla Sitki Kocman University

**ABSTRACT:** The purpose of this study was to explore the effects of explicit instruction on pre-service science teachers' understanding of scientific models and modeling. The participants were 35 pre-service science teachers from an eastern European country. Intervention consisted of exposing students to model-based instruction in a methods course for eight weeks with an explicit focus on modeling as a scientific practice. Participants' understanding of scientific models and modeling was measured through pre and post tests. The instrument consists of five open-ended questions that focused on various aspects of scientific modeling. The results show that while explicit instruction resulted in some improvement in participants' understanding of models and modeling, the improvements were not significant. In our discussion we talk

about the potential role of authentic modeling experiences as a way to help pre-service science teachers to develop a robust understanding of scientific models and modeling.

#### Strand 8: In-service Science Teacher Education Science Teacher Leadership and Reform 8:30am-10:00am, Sterlings 2 & 3 Presider: Matty Lau, New York Hall of Science

### A Grounded Conceptual Model of High School Science Chairs' Instructional Leadership

Jeremy S. Peacock, Monroe Area High School, peacock.jeremy@gmail.com

**ABSTRACT:** Ongoing reforms in science education call for a major shift in instructional practice, and science department chairs represent an important potential source of instructional leadership to support this change. However, department chair practice in science instructional leadership is not well understood and not well used in schools. This study built on a previous comparative positioning analysis of interview narratives from exemplary science chairs to construct a grounded conceptual model of these chairs' instructional leadership practice. The model indicates that chairs enacted leadership within five interrelated domains, and that chairs' practice was constrained by their leadership context. In particular, chairs' positioning within the school leadership hierarchy and the pervasive focus on school accountability heavily influenced chairs' practice. Chairs more often positioned their leadership within a discourse of school improvement than a discourse of science education reform. Important implications for research and practice in the field are discussed in light of the goals of science education reforms.

A Longitudinal, District-wide Social Network Analysis of the Impact of Science Teacher Leaders Matthew M. Schroyer, University of Illinois, schroye2@illinois.edu Fouad Abd-El-Khalick, University of Illinois at Urbana-Champaign

Anita M. Martin, University of Illinois

Caroline Haythornthwaite, University of British Columbia

**ABSTRACT:** This 3-year longitudinal study, funded by the National Science Foundation, engaged K-12 science teachers in an intensive PD program aimed at enhancing science content knowledge and pedagogical repertoire, and helping them develop leadership and entrepreneurial skills and habits of mind. Its goal is to nurture entrepreneurial teacher leaders who innovate in their classrooms and disseminate innovations in their districts toward reform-oriented science teaching modalities. The study aimed to (a) document extant teaching and learning networks, (b) observe how they changed over the life of the Project, and (c) track entrepreneurial teacher leaders and their impact within these networks. A rural Midwestern school district participated in the study by completing online surveys from 2011 to 2013. Respondents indicated whether they had learned from others about science teaching and learning, and three other subject areas. Using social network analysis, this study found teacher leaders initially were similar to peers in terms of number of ties and influence. Yet after receiving entrepreneurial PD, teacher leaders forged more ties with peers, took on greater roles as information brokers, and became more central to the science teaching and learning network.

Science Teacher Leadership: Learning From a Three-year Leadership Program

Julie A. Luft, University of Georgia, jaluft@uga.edu

Janey Kaufmann, Scottsdale Unified School District

Larry R. Plank, Hillsborough County Public Schools

Susan Koba, Science education consultant

Shannon Dubois, The University of Georgia

**ABSTRACT:** Teachers are professional learners and leaders. They seek to understand how their students are learning, they participate in programs that provide them with new instructional skills and curricular materials, and they engage in programs that help them participate in their community. This study follows a science teacher leadership program over a three-year period of time. There were approximately 30 participants per year. The teachers who participated in the program came from two different states in the United States. Interviews, documents and surveys were used to follow the development of the program and the professional growth of the participants. The qualitative and quantitative analysis

reveals that: not all participants became teacher leaders, there were different levels of difficulty associated with the presented leadership skills and knowledge bases, there are some essential knowledge bases associated with teacher leadership, the follow-up program varied between sites, and teachers engaged in leadership in different ways. The results also revealed that the follow-up part of the program was essential for teacher leadership development. For those in science teacher education, this study contributes to the void of research in this area and it suggests that science teacher leadership should be an option for professional development.

Strand 8: In-service Science Teacher Education *Teachers Noticing and Impacting Student Learning* 8:30am-10:00am, Brigade **Presider:** Jeffrey Nordine

Working with Teachers to Observe What Four Year Olds Know and Can Do in Science Mary E. Hobbs, University of Texas at Austin, maryhobbs@utexas.edu Robert Williams, University of Texas James P. Barufaldi, University of Texas at Austin

**ABSTRACT:** Researchers discuss outcomes and implications from a four-year study focusing on what four year olds know and can do in science. Twenty-four prekindergarten teachers from diverse backgrounds and teaching in a variety of settings, including classrooms where students are culturally and economically diverse, worked with a team of university mentors on this NSF funded project. The overall research design included extensive classroom observation by teachers of children's ability to learn science processes and content, and intensive professional development and mentoring support for teachers to learn science. The nature of our research into what four year olds know and can do necessitated our being assessors of children's abilities rather than teachers, and our experiences over time transformed our beliefs regarding answers to our other two research questions: What core STEM ideas should be stressed in prekindergarten/kindergarten science learning activities? What professional development practices best support the teaching of complex STEM concepts and processes to young learners? Working collaboratively with teachers, we conducted group and individual research, learning not only what four year olds know and can do but simultaneously reframing our own practice. We summarize our own "awakening dialogues" in this paper.

## Science Teachers' Modeling of Teaching Based on Their Own Interpretations of Student Thinking Nam-Hwa Kang, Korea National University of Education, nama.kang@knue.ac.kr

**ABSTRACT:** The purpose of this study was to examine science teachers' modeling of teaching physics concepts based on their interpretations of student thinking. Participants included 16 secondary science teachers (5 females) who had 5 to 16 years of teaching. The teachers were given four scenarios that had a test item or a lab set up in a middle school context and a student answer or response to the situation. They were asked to (1) interpret student thinking in each scenario and (2) describe their planning of teaching moves to address student ideas. The findings about teachers' framing of student thinking highlighted three different foci of teachers' analysis of student thinking: knowledge gap, reasoning, and sources of misunderstanding. The focus on knowledge gap apparently had a straightforward connection to the teaching move that attempts to fill the gap. The second focus was more complicated in that they planned to use different kinds of counter evidence to confront student reasoning, while details of how to use it were left out. The third framing was related to the most sophisticated teaching move because the teachers planned to reason with students about their thinking process. Contributions and limitations of the study are discussed.

Examining How Professional Development Builds Secondary Science Teachers' and Their Students' Understanding of Secondary Research Jamie N. Mikeska, ETS, jamiemik@yahoo.com Suzanne M. Wilson, Michigan State University James Short, American Museum of Natural History Suzanne Elgendy, American Museum of Natural History **ABSTRACT:** Research has suggested key features of professional development (PD) that likely result in transforming teachers' beliefs, knowledge, and practices. However, these design principles leave open the question of how teachers learn and the field would benefit from rich examples of teachers' PD learning across contexts. To our knowledge, for example, there is scant research that interrogates teachers' learning about secondary research (SR) and limited examples of students engaged in SR in classrooms. Thus, this study targets what happens in PD sessions and middle school classrooms as teachers and students learn about and use secondary data sets. In this study, we used interpretive case study methodology to discern how PD facilitators developed teachers' understanding about SR, and how these teachers engaged their students in SR. Findings point to the importance of building learners' understanding of the variables in secondary data sets; key strategies included contextualizing the problem, conducting similar data collection methods, observing scientists engaged in data collection, and explicitly discussing the nature of the scientists' work. This study contributes to the field's understanding of how to promote teachers' learning about scientific investigation in PD, and how teachers translate this learning to their practice.

#### Science Teacher Noticing: Evaluating Secondary Science Teachers Attention to Student Learning Meredith Houle Vaughn, San Diego State University, mhoule@mail.sdsu.edu Donna L. Ross, San Diego State University

**ABSTRACT:** Teachers' noticing has emerged within the mathematics education community as a focus of research and professional development (Sherin, Jacobs, & Philipp, 2011). In this proposal, we describe the development of a noticing instrument to capture science teachers' attention to student thinking and use the instrument to describe patterns in noticing from 16 exemplary secondary science teachers selected for a five-year teacher leader professional development program. Overall teachers tended to focus on classroom structures and factual information, but were limited in their analysis of the richness of student thinking.

#### Strand 9: Reflective Practice *Reflective Practices in Pre- and/or In-Service Science Teaching* 8:30am-10:00am, Duquesne **Presider:** Shirley A. Simon

#### Developing Preservice Teachers' Reflective Capacity to Analyze their Teaching Practice Kimberly A. Lebak, The Richard Stockton College, kimberly.lebak@stockton.edu

**ABSTRACT:** This proposal builds upon previous work on using video to increase the reflective capacity of preservice science teachers by including the use of a valid observational framework, The Framework for Teaching to structure viewing of videos in peer groups. Preservice teachers taught and videoed inquiry based demonstration lessons, viewed videos with peers, and then wrote reflection papers. Reflection papers from two groups of preservice science teachers were coded and compared. Findings included viewing videos with a common language of effective teaching as defined by the Framework for Teaching provided opportunities for preservice science teachers to develop greater reflective capacity to analyze effective teaching practice.

## Awakening Science Teachers/Educators' Awareness of the Cultural Values of Indigenous Meshach Mobolaji Ogunniyi, University of the Western Cape, mogunniyi@uwc.ac.za

**ABSTRACT:** In an attempt to make science relevant to students' daily lives, the new science curriculum in an African country requires science teachers to integrate school science with indigenous knowledge (IK). In pursuance of this aim the study exposed a group of 13 science teachers and 10 science educators (henceforth, subjects) to a dialogical argumentation instruction (DAI) for a period of two years. DAI provided the subjects with ample opportunities for discourse. Based on the data derived from completed worksheets and video recordings of classroom discussions, DAI was found to: (1) promote the subjects' interest in the cultural values of IK; (2) motivate them to want IK to be included in the science curriculum; (3) facilitate their conceptions of IK as a legitimate way of knowing and interpreting phenomena; (4) enhance their perceptual shifts from an initial negative to positive view of IK as a valuable cultural asset with great potential to promote and awaken their sense of self and social identity.

# Transition to Science Teacher Educator: Tensions Experienced while Learning to Teach Lesson Sequencing Heidi L. Wiebke, Indiana University, hwiebke@indiana.edu

Meredith A. Park Rogers, Indiana University

**ABSTRACT:** A self-study methodology was employed to investigate how to support elementary preservice teachers in developing a coherent sequence of five science lessons. Leach and Scott's (2002) four lesson planning components were used to devise a series of lessons to provide preservice teachers with additional support and guidance. For data analysis Berry's (2007) six tensions teacher educators may encounter when studying their practice were used. Data sources in which these tensions were applied as a coding framework included preservice teacher artifacts, an audio-recording of preservice teachers planning a lesson sequence, personal journal entries, and collaborative journal entries. Findings indicate the tension of telling and growth gradually developed during a three week experience where the preservice teachers' learned how to design a sequence of five coherent science lessons. Further reflection with a critical friend indicated this tension of telling and growth was enticed by two other tensions: confidence and uncertainty, and planning and being responsive. These findings suggest that novice teacher educators need explicit instruction on how to prepare preservice teachers for science teaching to reduce potential tensions. Implications regarding this issue will be shared in the paper.

### Strand 10: Curriculum, Evaluation, and Assessment

Assessing Science Proficiency 8:30am-10:00am, King's Garden 2 Presider: Cari F. Herrmann Abell

*Evaluating the Promise of an Intervention that Helps Students Understand Chemical Reactions in Living Systems* 

Cari F. Herrmann Abell, AAAS/Project 2061, cabell@aaas.org Jean C. Flanagan, AAAS Project 2061 Caitlin Klein, AAAS Project 2061

Jo Ellen Roseman, American Association for the Advancement of Science

**ABSTRACT:** Students often have trouble understanding biology ideas because they lack an understanding of underlying chemistry ideas. To help provide students with a better foundation, we collaborated in the development of a curriculum intervention that applies chemistry ideas to both living and non-living contexts. Nine eighth grade teachers participated in the field test during the spring of 2013. Three of the teachers had used an earlier version of the unit in the spring of 2012. The other six teachers were randomly assigned to either implement the unit or continue teaching the targeted ideas using "business as usual" practice. A pre- and post-test were administered and the data were analyzed using Rasch modeling and the racking and stacking methods. The results showed that, overall, the students who participated in the intervention made statistically significant gains compared to the students receiving traditional instruction. Additionally, the difficulty of the majority of the assessment items decreased from pre-test to post-test as a result of the intervention, indicating that the unit successfully targeted most of the ideas. Together, these results suggest that the unit may be more effective in improving students' understanding of the targeted ideas than traditional instruction.

Validation of New Chemistry Instruments that Assess Three Aspects of Science Proficiency

Anna M. Strimaitis, Florida State University, anna@bio.fsu.edu

Patrick J. Enderle, Florida State University

Jonathon Grooms, Florida State University

Victor D. Sampson, Florida State University

**ABSTRACT:** According to the Next Generation Science Standards, the goal for science education is for all students to become proficient in science. Students need to understand how to generate and evaluate scientific explanations, how scientific knowledge is developed, what warrants scientific knowledge, and how to participate in the practices of science. Unfortunately, assessing students' scientific proficiency continues to be challenging because typical paper/pencil, multiple choice type assessments are not adequate for assessing the many aspects of scientific proficiency. New validated assessment instruments, therefore, are needed in order to use a multifaceted approach to assessing students' current levels

of scientific proficiency and how each student develops different aspects of science proficiency over time. This paper describes the validation of three new instruments used within a larger study to measure students' scientific proficiency in high school chemistry. The Chemistry Content Knowledge Assessment, the Chemistry Writing assessment, and the Chemistry Performance Task satisfied tests of translational validity, content validity, discriminant validity, concurrent validity, and inter-rater reliability. These three new assessments provide valid and reliable measures of what students know and can do, which are important outcomes of science instruction in high school chemistry classrooms.

### Two Perspectives of Reading Adapted Scientific Articles: Cognitive and Practical Versus Metacognitive Zehavit Kohen, Technion, zehavitk@tx.technion.ac.il

Liora Saar, Technion-Israel Institute of Technology

Yehudit Judy Dori, Technion-Israel Institute of Technology

**ABSTRACT:** Reading scientific articles is vital in science teaching in order to prepare independent life-long learners who can read, analyze and understand new texts independently. The current study investigates the influence of integrating metacognitive skills in a chemistry context on reading adapted scientific articles from two perspectives: cognitive and practical versus metacognitive. 672 high schools chemistry students participated in this study. Participants were randomly divided into one experimental and two comparison groups (I and II) based on the number of adapted scientific articles (5 in the first two and 1 in the third) they read and the extent of their usage of a metacognitive tool, which guides the students to monitor their understanding for improving meaningful comprehension of adapted scientific articles after reading them. Findings revealed that using the metacognitive tool resulted in an improvement of declarative metacognitive knowledge regarding mapping reading strategies, of procedural metacognitive knowledge regarding the understanding of adapted scientific articles and a relationship between these two types of metacognitive knowledge. The current study highlights the importance of high-school students' awareness to the way they monitor their scientific articles will be discussed at the conference.

### Multimodal Representations in Senior Biology Assessments: Twelve Years of Public Examinations in NSW Australia

Wilhelmina Van Rooy, Australian Catholic University, Wilhelmina.VanRooy@acu.edu.au Eveline Chan, University of New England, NSW Australia

**ABSTRACT:** This study investigates the use of multimodal representations to test for biological understanding in the NSW Australia final secondary school public examination. It forms part of a larger Australian study concerned with the impact of disciplinary and technological innovations on learning, particularly molecular genetics where much knowledge is represented in modalities other than, or in conjunction with language, traditional text and visual representation. The availability of digital technologies and their affordances for learning and teaching of senior high school biology now makes it realistic for examiners to include new and novel representations into assessment tasks. A qualitative analysis of 12 years past biology examinations based on the systematic identification and collation of multimodal representations was undertaken from 2001 - 2012. Findings indicate that despite the ready availability of digital representation in classroom learning and curriculum materials, and evidence of high students engagement with ICT, high stakes written examinations do not make use of such resources. As a consequence students are disadvantaged because their in-depth knowledge and understanding of biological concepts is not effectively demonstrated through traditional pen-paper tests. A move towards online, interactive examinations might be one way to ensure that assessment format reflects classroom learning styles.

Strand 11: Cultural, Social, and Gender Issues *Equity and Power* 8:30am-10:00am, Sterlings 1 **Presider:** Lynn D. Dierking

Harnessing Affinity towards Biology to Support Diversity in Physics Vashti Sawtelle, University of Maryland, College Park, davisvas@gmail.com Julia Svoboda Gouvea, University of California, Davis Chandra Turpen, University of Maryland, College Park

**ABSTRACT:** Access to a professional community of scientists must start from exposure to, participation in, and developing an affinity towards a variety of scientific practices. In this work we explore how a female biology student with an initial negative orientation toward physics grows to see herself as capable and willing to engage in the scientific practices of the discipline. In this work we will examine case study data of a student who initially describes herself as hating physics, but shifts in her appreciation for physics. We triangulate across data sources to build an understanding of how this student's relationship with physics shifts. We draw attention to ways that this shift may have been influenced by the ways our physics for life science majors course develops connections between the disciplines. We argue that harnessing students' affinity towards biology may be a way to support diversity in introductory physics classrooms.

### Differences Within: A Comparative Analysis of Women in the Physical Sciences Katherine P. Dabney, Virginia Commonwealth University, kdabney@vcu.edu

#### Robert H. Tai, University of Virginia

**ABSTRACT:** The majority of existing science, technology, engineering, and mathematics (STEM) research studies compare women to men, yet a paucity of research exists that examines what differentiates female career choice within the physical sciences. This study examines the following question: What prior motivation and background factors are associated with and differentiate women that enter and persist in chemistry or physics doctoral programs? This question is analyzed with logistic regression analyses using variables from the Project Crossover Survey dataset through a subset of female physical science doctoral students and scientists (n = 1,137). Significant variables that positively predict a career choice in chemistry or physics among women include content specific high school and undergraduate academic achievement and positive undergraduate experiences. Findings point towards what public policy and research should examine in order to retain women in the fields of chemistry and physics. 0 false 18 pt 18 pt 0 0 false false false /\* 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-parent:""; mso-padding-alt:0in 5.4pt 0in 5.4pt; mso-para-margin:0in; mso-para-margin:bottom:.0001pt; mso-pagination:widow-orphan; font-size:12.0pt; font-family:"Times New Roman"; mso-ascii-font-family:Cambria; mso-ascii-theme-font:minor-latin; mso-hansi-font-family:Cambria; mso-hansi-theme-font:minor-latin; mso-hansi-font-family:Cambria; mso-hansi-theme-font:minor-latin; https://doc.org/link.ac/link

## Making it Better for Students through LGBTQ-Inclusive Science Teacher Education: A Programmatic Case Study

#### Mary Hoelscher, University of Minnesota, hoel0039@umn.edu

**ABSTRACT:** This case study of a post-secondary science initial license program (SILP) at a large-public university begins by exploring the confluence of policies, experiences, and voices that permitted the program to pursue lesbian, gay, bisexual, transgender, and queer (LGBTQ)-inclusion. The study then explores the pedagogical strategies employed by the SILP including: individual-identity self-study; facilitated small group discussions; reflective journaling; curriculum analysis; case-study writing; and traditional course readings and lectures. The program was found to be LGBTQ-accepting according to the Continuum of LGBTQ Inclusion. The primary strength of the program was the continuous integration of LGBTQ-related topics throughout the SILP. The primary weakness of the SILP was its lack of assurance of support for LGBTQ-inclusion in science candidates' field placements. This study contributes to the development of exemplary practices for preparing science teachers' to engage in culturally relevant pedagogy as it includes LGBTQ-identified people and issues. This study suggests the need for more research regarding LGBTQ-identifying people and topics in science teaching and learning. Finally, this study suggests the need for policies that explicitly require the consideration of the needs of LGBTQ-identified students within SILPs.

Awaken a Dialogue: Race and the Experiences of Black Faculty in the Science Education Community Eileen R. C. Parsons, University of North Carolina at Chapel Hill, rparsons@email.unc.edu Domonique Bulls, University of North Carolina at Chapel Hill Mary M. Atwater, The University of Georgia Malcolm B. Butler, University of Central Florida Tonjua B. Freeman, The University Of Georgia

**ABSTRACT:** Numerous science education research studies examine inequality, inequity, and underrepresentation in STEM with respect to students and K-12 teachers. Very few studies investigate race. Even fewer studies have Black faculty in science education at the postsecondary level as subjects of interest. Using Critical Race Theory as a lens, this study investigated the following: How is race present in the experiences of Black faculty who teach, research, and serve in science education? Interview and questionnaire data provided by four Black faculty members, two tenured associate and two untenured assistant professors, in science education were subjected to interpretative and quantitative analyses, respectively. In spite of their various orientations to race as determined by the racial identity questionnaire, the findings indicated that race was present in their sense of marginalization and in the challenges they faced. These challenges included assignment and management of heavy administrative and service workloads and insufficient time to keep abreast in their fields and to prepare manuscripts for publication. The findings warrant a turn of the investigative gaze of the science education research community inward and to examine the challenges of the underrepresented within its ranks.

#### **Strand 12: Educational Technology**

*Scaffolding Frameworks and Strategies* 8:30am-10:00am, Smithfield **Presider:** Janice L. Anderson

Assessing the Implicit Scaffolding Design Framework: Effectiveness of the Build a Molecule Simulation Emily B. Moore, University of Colorado Boulder, emily.moore@colorado.edu Katherine Perkins, University of Colorado Boulder

**ABSTRACT:** This study assesses the effectiveness of an interactive computer simulation designed using the implicit scaffolding design framework. We first describe the implicit scaffolding framework, and how its principles were applied in the design of the Build a Molecule simulation. The goal of this simulation is to support students in integrating pictorial and symbolic chemical representations, and in interpreting and producing chemical formulas with coefficients and subscripts. We then present the results of a study involving three 5th grade classes (total N = 64) completing a Build a Molecule activity. Students were given pre, post and delayed post assessments. Significant increases – pre-post gains ranging from 23% to 78% – were found in the amount of correct responses to all assessment questions involving writing chemical formulas from molecule pictures or drawing molecules from chemical formulas. These results indicate that the Build a Molecule simulation supports students in interpreting and producing chemical formulas. This work provides evidence to support the effectiveness of the implicit scaffolding design framework – which can be applied in the design of educational simulations across disciplines and student age levels.

*The Effect of Scaffolded Strategies on Content Learning in a Designed Science Cyberlearning Environment* Cindy L. Kern, University of New Haven, ckern@newhaven.edu

Kent J. Crippen, University of Florida

Alice J. Corkill, University of Nevada, Las Vegas

**ABSTRACT:** Scientific inscriptions and argumentation are integral to generating and communicating scientific understanding as well as learning science. Previous research indicates that learners struggle to understand and learn science content represented in inscriptions. Furthermore, when learners engage in argumentation, learning science content becomes secondary to learning argumentation skills. This design-based research study is meant to inform the design and development of the 5-Featured Dynamic Inquiry Enterprise design framework (5-DIE) for cyberlearning environments and to advance theory associated with the difficulties learners have with scientific inscriptions and the consequences related to using argumentation to learn science content. The two learning strategies evaluated in this study were (1) self-

explanation prompts paired with a scientific inscription and (2) faded worked examples for the evaluation and development of scientific knowledge claims. Participants consisted of ninth and tenth grade students (age: 13-16 years; N=245) enrolled in a state-mandated biology courses. A three factor mixed model analysis of variance with two between factors and one within factor was used to evaluate the effects of the learning strategies on the acquisition and retention of content knowledge.

The Next Generation of Inquiry: Examining a Teacher's Scaffolding of Collaborative Technology during Inquiry Learning

Baki Cavlazoglu, Texas A&M University, bakicav@tamu.edu

Jennifer K. LeBlanc, Texas A&M University

Cheryl Ann Peterson, Texas A&M University

Carol L. Stuessy, Texas A&M University

**ABSTRACT:** Integrating technology in science curriculum is a crucial step towards empowering teachers to engage their students in authentic and relevant science practices (NGSS, 2013). Authentic scientific practices, such as inquiry, have been the foundation for science education research and science teaching (NRC, 2007) The next generation of inquiry calls for increased technology integration in science education (NGSS, 2013). As this shift in dialogue occurs, science teachers will need to understand how to orchestrate technology enhanced inquiry learning environments. Using a convergent mixed methods approach, our research examines how one middle school science teacher scaffolds collaborative technology tools, PlantingScience platform, during an authentic plant-inquiry activity. The PlantingScience platform engages students in authentic science practices through providing an online platform for collaborative technology through the inquiry cycle. Our results indicate as the teacher enacts more of a facilitator role in the technology enhanced inquiry learning environment as she scaffolds the use of collaborative technology through predominately process management scaffolding. We suggest future professional development focus on transforming teachers' role towards increased levels of sense making and reflection scaffolds when scaffolding collaborative technology.

### Strand 13: History, Philosophy, and Sociology of Science *Inquiry*

8:30am-10:00am, Birmingham **Presider:** Jonathan Francis Osborne

Scientific Question Generation in Secondary Chemistry Classrooms: An Empirically-Based Framework for Exploring Novelty

Allison Antink Meyer, Illinois State University, aameyer@ilstu.edu

Daniel Z. Meyer, Illinois College

**ABSTRACT:** This study explored the investigative nature of the scientific questions generated by three sets of secondary, U.S., chemistry students and the relationship between that nature and question novelty. The resulting categorization of investigation types is argued here as an alternative to Dillon's (1984) classification scheme and may be more epistemologically appropriate, as well as developmentally appropriate, to K-12 science classrooms. The investigation types are suggestive of at least two different dimensions of questions: 1) research questions, or those that frame discrete investigations and 2) scientific questions, or those that define research agendas. The prevalence of these types emerged as indicative of the type of classroom instruction students had experienced which in turn was indicative of the extent of the novelty demonstrated by each group. Despite the differences between the three groups, the most novel questions posed were those that would inform a descriptive study (Lederman, 1999).

How They Look and What They Do?: Chilean Students' Perceptions of Scientists and Scientific Work. Hernan L. Cofre, Pontificia Universidad Católica de Valparaíso, Chile, hcofrem@hotmail.com Paulina Bravo González, Pontificia Universidad Católica de Valparaíso

Corina Gonzalez-Weil, Pontificia Universidad Católica de Valparaíso, Chile

**ABSTRACT:** This paper describes image of scientists and scientific work of 363 secondary Chilean female students according to the Draw a Scientist Test (Chambers, 1983). The sample includes participants from 9 schools both private and public school, including a wide range of socioeconomic level (SEL). Students were asked to draw a picture of a scientist at work and to provide a written explanation as to what the scientist was doing. The drawings were analysed using Chambers (1983) 7 indicators of stereotype image, alternatives indicators and no stereotype indicators. The explanations were analysed looking for inquiry skill included in it. The results shown that the students usually present a stereotypical image of the scientist, nonetheless it was also found cases in which the scientist doing?" showed generally basic inquiry skills as observing and comparing. However it was also found in a lower frequency hypothesis formulation, and interpretation. The comparative analysis using SEL indicates some tendency difference mostly in narratives, with more integrative inquiry skill at high socioeconomic level. Implications for science education research in Chile are discussed.

### *The Status of "The Scientific Method": Why We Should Kill It; Why It's Not Dead Yet* Daniel Z. Meyer, Illinois College, daniel.meyer@mail.ic.edu

**ABSTRACT:** "The Scientific Method" is ubiquitous in its use, yet is also regarded as a fallacy by science education reformers. We aim to explore this schizophrenic status. We first lay out the various arguments against "the Scientific Method". These include the implied uniformity in science, philosophical shortcomings and the conflation of methodology and epistemology. We next use occurrences of "the Scientific Method" in science teacher practitioner journals to further explore the nature of this myth in actual practice. This includes examining the nature of its use, the appeal of its use, and the nature of support for its use. We outline several possible impediments to reform. There is a community problem, whereby the status of "the Scientific Method" seems to differ wildly in different science education communities. There is a family resemblance problem where both better terms are used without making clear the substantive difference and better substance is attached to "the Scientific Method" which reinforces traditional conceptions. We end recommendations for how to better address the problem. In particular, we argue that the wrong argument – that science has multiple methods – has been emphasized. The more fundamental, and perhaps palatable, argument is that it conflates methodology and epistemology.

# A Comparison of Scientists' and Preservice Teachers' Ideas about Justification and Anomalous Data in Science Renee S. Schwartz, Western Michigan University, r.schwartz@wmich.edu

**ABSTRACT:** Scientists must decide when to submit their work for review by the scientific community. This decisionmaking involves the recognition and ultimate reasoning of anomalous data, or those data that do not fit with expectations or current theory. Despite the role of anomalies in science practices, little research has explored how individuals understand anomalies and the justification of knowledge. This study explores (1) scientists' and preservice science teachers' ideas of how scientists know when to make their results public (needs for justification), (2) scientists' and preservice teachers' ideas of how scientists deal with anomalous data; and (3) how preservice teachers think students deal with anomalous data. Results indicate discrepancies between scientists and preservice teachers regarding the needs and process of justifying scientific knowledge; as well as how anomalies are handled and the role they play within scientific practices. Preservice teachers' tend to consider anomalies as mistakes, while scientists recognize their potential for driving theory change. Preservice teachers think anomalies in the classroom are mistakes, and that students either ignore or change date to fit expectations. The discrepancies in preservice teachers' and scientists' ideas are significant when considering the need for teachers to address scientific practices in their classrooms.

#### **Strand 14: Environmental Education**

*Community Contexts for Environmental Education* 8:30am-10:00am, King's Garden 1 **Presider:** Cassie Quigley, Clemson University

Broadening the Dialogue: Environmental Perspectives of Kenyan Teachers and Community Members Cassie Quigley, Clemson University, cassieq@clemson.edu James Dogbey, Clemson University Megan Che, Clemson University Jeff Hallo, Clemson University

**ABSTRACT:** This project engages key stakeholders in an economically and environmentally fragile region in Kenya in a unique, interdisciplinary, and integrative approach to understanding environmental sustainability from diverse perspectives. The aim of the present application is to investigate the current perspectives of local key stakeholders on the environment and sustainability and share these understandings among the local groups to generate a locally constructed meaning of environmental conservation and sustainabilityThe dichotomies between Western Modern Science (WMS) and Indigenous Knowledge Systems (IKS) have been documented for years in academia (Aikenhead, 2001; Barnhardt, Tippins, & Brandt, 2008; Brayboy & Castagno, 2008; Cajete, 2008; Cobern & Loving, 2000). However, western scientific communities are now recognizing the benefits and overlapping nature of IKS and WMS. The approach used in this study is a qualitative study of representative stakeholders' environmental perspectives utilizing digital images. The researchers analyzed the digital images and the accompanying narratives for themes. Two major themes emerged during the data analysis: How do we co-habit? and How do we modernize? This project challenges the current discourse regarding sustainability in sub-Saharan Africa by identifying, valuing, and including local perspectives regarding the environment and sustainability in efforts to conserve and preserve natural resources.

#### Linking School Science to Communities: A Systematic Literature Review

#### Xavier Fazio, Brock University, xavier.fazio@brocku.ca

**ABSTRACT:** Requiring students to be scientifically and environmentally literate requires them to be equipped to confront complex socioscientific or environmental issues that they will encounter as citizens. One way to deal with this challenge is to engage students in authentic and meaningful learning activities nested in their school communities. An interpretive scoping review of the literature is presented showing conceptual orientations of past studies, and research challenges that still need to be addressed. This presentation highlights a growing interest in formal science collaborations with schools from various community partners, and discusses the insufficient attention given to a detailed investigation of the phenomenon. The overarching themes of the literature about school science-community partnerships: types of science-community partnerships; outcomes of partnerships; implementation strategies. Overwhelmingly, studies in the review are descriptive empirical studies and were single case analysis. Future research requirements should include developing a theoretical framework drawn from activity theory. Researchers in science and environmental teacher education must be attuned to the realities of school-community partnerships, since science teachers have the opportunity to mediate and promote these partnerships. Nevertheless, little practical and theoretical guidance is currently available in this area. This presentation will help bring to the fore this important research topic.

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

#### Awards Committee Sponsored Session

Symposium – Reflections on Career Trajectories: 2013 NARST Award Recipients
10:15am-11:45am, Smithfield
Presider: Patricia Friedrichsen
Discussants:
Patricia Friedrichsen, University of Missouri, FriedrichsenP@missouri.edu
Lori A. Fulton, University of Hawaii at Manoa
Alandeom Oliveira, University at Albany, SUNY
Dale Baker, Arizona State University
ABSTRACT: The Awards Committee is sponsoring this session, highlighting the 2013 recipients of the Outstanding

**ABSTRACT:** The Awards Committee is sponsoring this session, highlighting the 2013 recipients of the Outstanding Doctoral Research Award (Lori Fulton), Early Career Research Award (Alandeom Oliviera), and the Distinguished Contributions to Science Education Through Research Award (Dale Baker). The recipients will give a brief overview of their research and reflect on influences on their career paths. Critical events and the role of serendipity in their careers will be discussed. Each of the recipients will share "lessons learned" and offer advice to beginning researchers.

Strand 1: Science Learning, Understanding and Conceptual Change

Elementary Level Modeling and Assessment

10:15am-11:45am, Sterlings 2 & 3 **Presider:** Per Morten Kind

Analyzing Fifth-Grade Students' Engagement in Scientific Modeling: Changes in Students' Epistemologies-in-Practice over Time

May Lee, Michigan State University, leemay1@msu.edu Christina V. Schwarz, Michigan State University Li Ke, Michigan State University

Joshua M. Rosenberg, Michigan State University

**ABSTRACT:** Instructional reform efforts to foster scientific literacy focus on helping students engage in understanding scientific content and practices. This paper describes the analyses from the second year of a multi-year design research study that explores how students construct and use models to represent physical phenomena to inform educators and researchers on ways to increase their engagement in meaningful scientific practices. Our research group interviewed two cohorts of 5th grade students before, during, and after instruction on a model-based unit focusing on evaporation and condensation. Focusing on how two students from the second cohort used their models to explain evaporation and condensation. This analysis allows us to build on our exploration of students' epistemologies in modeling.

Examining Elementary Students' Attention to Mechanism as They Engage in Scientific Modeling across Content Areas

Li Ke, Michigan State University, keli1@msu.edu Christina V. Schwarz, Michigan State University May Lee, Michigan State University

Joshua M. Rosenberg, Michigan State University

**ABSTRACT:** This paper investigates elementary students' epistemologies in practice focusing on the aspect of mechanism within scientific modeling by analyzing 113 5th grade students' embedded assessments across three modeling-based units. Analysis indicates that students' epistemologies in modeling about mechanism improved significantly between the first unit (evaporation) to the second closely-related unit (condensation), and retained their high levels of

attention to mechanism through the third unit (light). The findings also suggest that students may begin with a more descriptive approach of phenomena and then learn to think more deeply about the phenomena as well as become more aware of the goal of modeling to better understand how and why the phenomena occur. Finally, we discuss the implication of our work for future research with respect to modeling practice.

# Mapping Concepts to Systems: Fostering 3<sup>rd</sup> Grade Students' Use of Models to Explain Hydrologic Phenomena Cory T. Forbes, University of Nebraska-Lincoln, cory-forbes@uiowa.edu

Laura Zangori, Univrsity of Nebraska-Lincoln

Christina V. Schwarz, Michigan State University

**ABSTRACT:** To develop scientific literacy, elementary students should engage in articulation, negotiation, and revision of model-based explanations about the water cycle (NRC, 2012). However, scientific modeling remains underemphasized in elementary science learning environments and little past research has explored early learners' engagement in domain-specific modeling practices. We are engaged in research and development to investigate 3rd-grade students' model-based reasoning about water. In this proposal we present findings from the first year of the project. First, we developed and empirically-tested a learning performances framework that integrates science content (i.e., 'big ideas') and scientific practices (i.e., modeling). This learning performances framework a) grounds the iterative development of curriculum and assessment and b) lays the groundwork for future development of a learning progression for K-12 students' learning about water. Second, we report on the ways in which students engaged in model-based reasoning about water. While results indicate that elementary students generate mechanism-based explanations about water processes, findings from this study highlight the range of ideas evident in students' model-based explanations for water cycle "hidden" processes (evaporation and groundwater).

#### Strand 1: Science Learning, Understanding and Conceptual Change

Symposium – Integrating Crosscutting Themes, Practices, and Core Ideas: Learning Progressions in Earth and Space Sciences

10:15am-11:45am, Rivers

#### **Discussants:**

Charles W. Anderson, Michigan State University Scott McDonald, Pennsylvania State University Julia Plummer, Pennsylvania State University Ann E. Rivet, Teachers College Columbia University Cesar Delgado, University of Texas at Austin Kim Kastens, Education Development Center, Inc. Alice Flarend, The Pennsylvania State University KeriAnn Rubin, The Pennsylvania State University Megan Pickard, The Pennsylvania State University Meredith Bembenic, The Pennsylvania State University

**ABSTRACT:** Learning progressions (LP) describe how students' understandings grow in sophistication within big ideas in science across multiple years. This symposium explores one of the challenges with LP research: how to appropriately represent all three dimensions from the Framework for K-12 Science Education: scientific practices, crosscutting concepts and core disciplinary ideas. The symposium includes four learning progression research groups investigating aspects of science practices and crosscutting concepts within the context of core disciplinary ideas in Earth and Space Sciences (ESS). ESS is a particularly apt context in which to investigate and discuss issues of integration crosscutting concepts as the field investigates phenomena across the entire range of size scales, from incredibly small to unimaginably large (NRC, 2012). ESS is also a particularly good test case for studying the integration of scientific practices as it relies heavily on modeling full-scale Earth systems. The session will focus on integrating LPs around plate tectonics, the formation of the Solar System, spatial and temporal scales in ESS, and analogical reasoning with physical models.

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

Motivation, Contextualization, and Science Learning

10:15am-11:45am, King's Garden 2 **Presider:** Jeremy S. Peacock, Monroe Area High School

#### Science Learning and Levels of Contextualization

Michael Giamellaro, Oregon State University - Cascades, michael.giamellaro@osucascades.edu **ABSTRACT:** Contextualization in science education is conceptualized here as learning either with context (secondary contextualization) or in context (primary contextualization). Differences in these degrees of contextualization are examined theoretically and tested empirically. Using a pretest-posttest-interview design, the knowledge structures of 27 high school students participating in four different science immersion experiences were modeled using Pathfinder Networks (PFnets) and compared as a function of the average degree of contextualization students utilized during their experience (coded in interview data.) No statistically significant interaction was found. Sub-PFnets were also used to examine student conceptions of individual concepts pre to post (n = 357). ANOVA showed a significant difference in learning gains as measured by PFnet similarity to an expert referent: primary contextualization (24% gain), secondary (0%), no contextualization (7%), using degree of contextualization as a grouping factor, F(2, 357) = 6.9, p = .001,  $\eta 2$  = .061. These data suggest that primary and secondary contextualization should not be treated as the same process in research, instruction, or curriculum. They also suggest that primary contextualization has promise for building not only relevance and interest in science but deeper understanding of key concepts.

#### Why Study? Emphasizing Mastery Goals in the Science Classroom

Dana Vedder-Weiss, Weizmann Institute of Science, weissda@gmail.com

#### David L. Fortus, Weizmann Institute of Science

**ABSTRACT:** Employing achievement goals theory (Ames, 1992), this study aimed to characterize instruction perceived high and low in mastery goals emphasis, in elementary, middle and democratic schools. Taking the student perspective, data on teachers' instruction and goals emphasis was collected by students survey (N=1181) and interviews (N=69) from 5th-8th grade Israeli students. Survey replies were used to select nineteen interviews for further analysis. The selected interviews described the instruction of 5 science teachers perceived high or low in mastery goals emphasis. Analysis employed the TARGETS framework (Patrick, et al., 2001), combining theory-driven with data-driven approach. Results were mostly consistent with the TARGETS recommendations, although some contradictions were found. Results suggested that grouping and students' social interaction are not salient features in mastery goals emphasis while time and autonomy are. Concrete illustrations of classroom mastery-emphasizing practices in different school cultures are provided.

A Practical Measure of Motivation in Middle School Science: Validity Evidence for the E-V-C Scale

Joseph A. Taylor, BSCS, jtaylor@bscs.org Jeff Kosovich, James Madison University Chris Hulleman, James Madison University

Steve Getty, BSCS

Kenn Barron, James Madison University

**ABSTRACT:** This paper examines the factor structure and sensitivity of an instrument intended to measure student motivation for science. The results of the confirmatory factor analysis provide evidence that the factor structure of Expectancy, Value, and Cost is valid. Further, hierarchical linear modeling was used to test student motivation trajectories across the middle school years. These trajectories were generally flat and linear with some notable and statistically significant exceptions. Several statistically significant (though small in magnitude) trajectories were noted. Expectancy for the 7th grade science sample (B = 0.01, p = .049, proportion reduction = .013), and value for the 7th grade science sample both showed small positive linear slopes. These positive effects suggest that the applicable construct increases slightly every few months. Value for the 7th grade math sample and cost for 6th and 7th grade math and science as well as 8th grade science showed small negative linear slopes. As motivation factors have been associated with student achievement in other work by the authors, valid and sensitive measurement of motivation has important implications for evaluating motivation interventions as well as predicting student academic success.

Using a Self-Report Survey to Study the Effect of Teaching Practices on Students' Motivation David Fortus, Weizmann Institute of Science, david.fortus@weizmann.ac.il Dana Vedder-Weiss, Weizmann Institute of Science

**ABSTRACT:** We developed and used a self-report survey assessing teachers' mastery goals emphasis in different instructional dimensions to study the relation between particular instructional dimensions and adolescents' motivation for science learning, using HLM analyses. Data from 95 Israeli teachers was used to test the reliability of the survey scales. Data from 5th-8th grade students (N=1356), who studied science with 35 of these teachers, was used for the HLM analyses. Results suggest that students' motivation for science learning in and out of school are both predicted by their science teacher's mastery goals emphasis. In particular, practices that relate to the nature of tasks and to autonomy support emerged as most strongly associated with students' motivation.

#### Strand 4: Science Teaching--Middle and High School (Grades 5-12): Characteristics and Strategies Related Paper Set – Examining Teacher Knowledge and Practices in Enacting Learning Progression-Based Science Instruction

#### 10:15am-11:45am, Heinz

**ABSTRACT:** As the prominence and number of learning progressions for K-12 science education continues to grow, learning progression scholars are expanding their research focus to explore how teachers use learning progressions in classroom instruction. Effective use of learning progressions to support student learning depends on a complex array of teacher knowledge and practices, including knowledge of and facility with 1) learning progressions and associated big ideas and learning goals, 2) enacting formative assessment to elicit and understand students' ideas, 3) developing responsive instruction to address the ideas and experiences students bring to school, and 4) scaffolding students in learning to engage in scientific practices. This related paper set presents four papers about teachers' uses of learning progressions are neither commonly held nor easily achieved. The authors discuss teachers' successes and struggles as they learn to use learning progressions in classroom instruction. These papers provide a foundation for the design of professional development efforts responsive to the challenges science teachers face in building effective learning progression-based science instructional practices.

### Learning Progression-Based Teaching Strategies in Environmental Science: Teachers' Successes and Struggles in Implementation

Julie A. Bianchini, University of California, Santa Barbara, jbianchi@education.ucsb.edu Nissa R. Yestness, Colorado State University Katherine J. Nilsen, SmartStart ECS LaTisha M. Hammond, George Washington University Jiwon Kim, Michigan State University Sylvia D. Parker, University of Wyoming Alan R. Berkowitz, Cary Institute of Ecosystem Studies

Developing a Learning Progression for Formative Assessments Hui Jin, The Ohio State University, jin.249@osu.edu Michele Johnson, University of California, Santa Barbara Jinho Kim, University of California, Berkeley

Teachers' Use of Learning Progression-Based Formative Assessment in Water Instruction Beth A. Covitt, University of Montana, beth.covitt@umontana.edu Aubrey A. Cano, University of California, Santa Barbara Bess Caplan, Baltimore Ecosystem Study Sara Syswerda, Michigan State University Teachers' Uses of Learning Progression-Based Tools for Reasoning in Teaching about Water in Environmental Systems Kristin L. Gunkel, University of Arizona, kgunckel@email.arizona.edu Beth A. Covitt, University of Montana

Ivan Salinas, University of Arizona

#### Strand 4: Science Teaching--Middle and High School (Grades 5-12): Characteristics and Strategies Symposium – Reconceptualizing High School Chemistry Based on Authentic Practices

10:15am-11:45am, King's Garden 4
Presider: Hannah Sevian, University of Massachusetts, Boston
Discussants:
Joseph S. Krajcik, Michigan State University
Hannah Sevian, University of Massachusetts Boston
Vicente A. Talanquer, University of Arizona
Astrid M. W. Bulte, Utrecht University
Ilka Parchmann, University of Keil
Ron Blonder, The Weizmann Institute of Science
Deborah Herrington, Grand Valley State University
Marissa S. Rollnick, Wits University
Myunghwan Shin, Michigan State University
Tali Tal, Technion

**ABSTRACT:** Conventional approaches to teaching chemistry tend to present the discipline as a collection of facts and concepts. However, memorizing vocabulary, rules, and mechanics of using models does not give students "chemical lenses" that are core ideas in chemistry through which they can interpret and reason about issues and phenomena in the world around them. But, integrating the major purposes of the chemical enterprise can engage students in learning how to pose and answer questions that reflect authentic chemical concerns. To change tradition requires developing coherence across educational components and including all necessary stakeholders. The goal of this symposium is to highlight necessary elements of updating secondary chemistry education to orient toward the use of motivating contexts for chemical thinking. The symposium makes theoretical cases for chemistry as a technoscience that blends scientific pursuit with technological goals, and for why students' engagement in purposeful activity can provide motivation for learning chemistry. The symposium then considers main areas of activity that must be addressed in order to implement modern context into chemistry education, including teacher education, students' and parents' awareness, curriculum development, and standards and assessment. Discussion includes synthesis and challenges for next steps.

#### Strand 5: College Science Teaching and Learning (Grades 13-20) Poster Symposium – Chemistry Education Research (CER): At the Nexus of Disciplinary and Educational Approaches to Research

10:15am-11:45am, Commonwealth 2

**Presider:** Anne Loyle-Langholz

**ABSTRACT:** This poster symposium focuses on current research in the area of chemistry education in a targeted effort to bring new researchers into the NARST community with an interest in disciplinary-based educational research. The symposium is structured as a poster symposium to maximize engagement and discussion related to chemistry education research (CER). The topics address a variety of research approaches related to the teaching and learning of chemistry at the college level including work in assessment, learning progressions, classroom discourse, and chemistry research experiences for teachers. The diversity of approaches promises a rich discussion for the future of CER and the role of CER within the NARST community.

Collaborative Discourses and the Construction of Explanations with Haptic Technology in Chemistry Abdi M. Warfa, Metropolitan State University, moham227@gmail.com Gillian H. Roehrig, University of Minnesota Jamie L. Schneider, University of Wisconsin-River Falls

Rethinking Testing in Chemistry

Jamie L. Schneider, University of Wisconsin-River Falls, jamie.schneider@uwrf.edu Kirsten L. Murphy, University of Wisconsin-Milwaukee Arundendu Chatterjee, University of Wisconsin-River Falls

A Cross-Cultural Study of the Development of Understanding in Chemical Design Gabriela A. Szteinberg, University of Massachusetts-Boston, Gabriela.Szteinberg@umb.edu Hannah Sevian, University of Massachusetts-Boston

Integrating Scale as a Theme into Instruction in General Chemistry Jackie Trate, University of Wisconsin-Milwaukee, jtrate@uwm.edu Anja Blecking, University of Wisconsin-Milwaukee Peter Geissinger, University of Wisconsin-Milwaukee Kristen Murphy, University of Wisconsin-Milwaukee

*Characterizing Standardized Testing Practice in College Chemistry Education* Tom Holme, Iowa State University, taholme@iastate.edu

A Longitudinal Study of the Effect of College Students' Attitude, Self-Concept, and Motivation on their Achievement in General and Organic Chemistry Julia Chan, University of New Hampshire, jym8@unh.edu Christopher F. Bauer, University of New Hampshire

The Development of a Learning Progression on Energy for a General Chemistry Course Melanie M. Cooper, Michigan State University, mmc@msu.edu Michael W. Klymkowsky, University of Colorado Nicole M. Becker, Michigan State University

Tool Trouble: Challenges with Using Self-Report Data to Evaluate Long-Term Chemistry Teacher Professional Development Ellen J. Yezierski, Miami University, yeziere@miamioh.edu Deborah G. Herrington, Grand Valley State University

*Evaluation of Chemical Representation in Physical Chemistry Textbooks* James M. Nyachwaya, North Dakota State University, James.Nyachwaya@ndsu.edu Nathan Wood, North Dakota State University

Developing Assessment Items to Measure Students' Understanding of Multiple External Representations in Chemistry Stacey Lowery Bretz, Miami University, bretzsl@miamioh.edu

#### **Strand 6: Science Learning in Informal Contexts**

Looking Longitudinally at STEM Learning Outcomes in Out-of School Contexts 10:15am-11:45am, King's Garden 5 Presider: Leonie J. Rennie, Curtin University

#### *Cascading Influences: Long-Term Impacts of Informal STEM Experiences for Girls* Lynn D. Dierking, Oregon State University, dierkinl@science.oregonstate.edu Dale McCreedy, Franklin Institute Science Museum

**ABSTRACT:** Hundreds of STEM programs for girls are funded and implemented. There is short-term evidence that they can be influential, allowing girls to engage with STEM in everyday contexts, building capacity and confidence in science and influencing positive attitudes and future plans. Despite significant investment though, the field knows little about the long-term (5-20+ years) contributions such programs make. This retrospective study documented young women's perceptions of experiences in one of six programs and the ways in which they felt they influenced their lives. Three separate investigations were conducted, including a web-based survey. Analysis of survey findings (n=174), suggested that programs: (1) are memorable and salient; women recalled specific activities and experiences; (2) influenced women's attitudes and understanding of STEM, shaping future education, careers, leisure pursuits, and ways of thinking about what science is and who does it; and, (3) helped shape women's personal identities and life trajectories. Despite evidence of positive influences on views of science, data also revealed continued tensions in ways girls/women think about what counts as science, complicating their relationship to, and identification with science. Findings also pointed to the fact that society's focus on traditional "pipeline" metaphors, may be discouraging participation in STEM.

Declining STEM Interest in Adolescents: A Longitudinal Research Approach

Nancy L. Staus, Oregon State University, stausn@onid.orst.edu

John H. Falk, Oregon State University

Lynn D. Dierking, Oregon State University

Jennifer Wyld, Oregon State University

Deborah Bailey, Oregon State University

**ABSTRACT:** The decline in interest in science, technology, engineering, and mathematics (STEM) during adolescence has been well-documented, but is still not fully understood. Past studies have used cross-sectional data and focused on STEM interests at school. Our study takes a longitudinal approach to document STEM interest and participation trajectories of a cohort of middle school-aged youth from 5th through 8th grade to examine how a variety of community resources (including school) and out-of-school activities support STEM interest development. This mixed-methods study uses in-school questionnaires and in-home interviews to document youth interests in STEM topics, engagement in STEM activities, use of resources in the community, and how families and peers influence these interests and activities. We present the results from the first two years of the four-year project and discuss possible strategies for creating a more effective STEM education system that more successfully supports STEM learning for all.

#### Long-term Museum Programs and their Impact on Underrepresented Youth's Ability to Persist in Science Preeti Gupta, American Museum of Natural History, pgupta@amnh.org Jennifer Adams, Booklyn College- CUNY

Alix Cotumaccio, American Museum of Natural History

**ABSTRACT:** This study examines the experiences of youth who have participated in a continuum of museum-based science afterschool programs in an urban museum over a 7-year period. The overarching research question that guided this study was, "in what ways does long-term participation in out-of-school time (OST) science programs shape the interest, motivation and ability of disadvantaged youth to pursue and persist in STEM majors?" We used a narrative approach to data collection and analysis to develop stories and undercover themes about how these youth have built strong interests in STEM and related identities over the years, including how they navigated any challenges they encountered towards their pursuit of STEM interests. Findings from the study have great implications for the field as related to both program design and the nature of questions we ask about youth learning in informal environments.

#### Strand 7: Pre-service Science Teacher Education Socioscientific Issues in Preservice Teacher Education 10:15am-11:45am, Fort Pitt Presider: Sara Tolbert, University of Arizona

### In Debate and On Agreement: Preservice Teachers' Understanding and Evaluation of Climate Change Theories Asli Sezen-Barrie, Towson University, asezen@towson.edu

#### Hilal Aktamis, Adnan Menderes University, Turkey

**ABSTRACT:** The effects of climate change on different societies of the world are real and scientists have reached a consensus on the major role that humans play in this global change. Major scientific agencies are calling for climate-literate people who will make informed decisions about the earth we live in. Although the initiatives on educating the public and students are increasing as the effects of climate change are progressing, there are yet not enough studies on teachers' interpretations, understanding, or learning of how to educate the climate-literate generation. In this study, we worked with preservice teachers who will have an influential impact on educating climate-literate youth for our future. Our aim was to observe the way preservice teachers understand and evaluate climate change theories and how their evaluation of the theories changes when they construct evidence based arguments. We collected data from 21 preservice teachers who are working towards their degree in teaching science at the middle school level. The three data sources were: (a) Initial Ideas Questionnaire (b) Climate Change Debate Posters and (c) Argumentative Papers. Preservice teachers were introduced to climate change theories from the scientists and the skeptics for the data (a) and (b). The constant comparative analysis of this data showed the preservice teachers to be almost evenly distributed in supporting and not supporting the climate change theories initially (a & b) while the majority of the preservice teachers did not support the theories form the skeptics after the evidence based instruction as they could not find enough scientific evidence to support their initial ideas (c).

#### Preservice Science Teachers' Socioscientific Issues-Based Teaching Practice in Real Science Classrooms Mustafa Sami Topcu, Yildiz Technical University, msamitopcu@gmail.com Abdulkadir Genel, Mugla Sitki Kocman University

**ABSTRACT:** Despite a growing body of research on SSI in the literature, the question about how preservice science teachers (PST) can teach SSI in authentic science classrooms seem unresolved. In this study, we focused on 10 PST's SSI teaching practice examining their video-recorded lessons and lesson plans. An interpretive qualitative research approach was utilized in this study. In order to elicit PST's SSI-based teaching practices, lesson plans developed by PST and video-tape recorded lessons were used. One of the important findings of the present study was that none of PST considered moral perspective in their teaching. Another important finding of the study was that most of PST did not use media resources in their teaching and did not related SSI with media. Despite a significant place of risk analysis in SSI teaching, the risk analyses were very simple and superficial. All selected SSI were appropriate and the transition from unit topic to the SSI topic was mostly appropriate. However, the time allocated for teaching SSI was not sufficient. The arguments developed in the classrooms generally remained at simple level. Our suggestions regarding the findings of the study are presented in the discussion and conclusion section.

#### Earth, Air, Fire, Water: Teachers Talk about Environmental Science

#### Shawn M. Bullock, Simon Fraser University, sbullock@sfu.ca

#### Doug Hayhoe, Tyndale University College and Seminary

**ABSTRACT:** Concepts in environmental science has been getting increased attention in society, both as a result of media coverage and as a result of ongoing, often public, debates between climate scientists and climate skeptics. Teacher candidates were asked to articulate their knowledge and beliefs about topics in environmental science and climate change science in response to several questions that were developed based on existing literature in a focus group setting over thee years. Our analysis has revealed that participants moved freely between discussing concepts related to environmental science and more general concepts of environmentalism, sustainability, and social justice. In fact, many participants seemed to quickly gravitate toward issues of "green" citizenship by talking about recycling, consumerism, and conservation instead of talking about scientific conepts. Teacher candidates who participated in the research relied heavily on their prior significant life experiences (SLEs) when discussing concepts in environmental science, despite having

recently experienced relevant coursework. The paper concludes by asserting the importance of providing teacher candidates with meaningful opportunities to speak openly about their knowledge and beliefs about climate change science, for purposes of clarifying and consolidating their conceptual understandings through social interactions with peers and teacher educators.

### Preservice Science Teachers' Epistemologies and Efficacy regarding a Socioscientific Issue Seda Baltaci, Abant Izzet Baysal University, ahmetkilinc@ibu.edu.tr

Ahmet Kilinc, Abant Izzet Baysal University

**ABSTRACT:** Many countries have initiated to incorporate socioscientific issues (SSI) into their science education programs. However, current science teachers are not ready for these reforms and present weak efficacy beliefs for teaching these issues. Therefore, the purpose of this research is to uncover the nature of teaching efficacy beliefs about SSI. For better understanding these beliefs, we have also investigated epistemological beliefs that are a possible source of teaching efficacy. 382 preservice science teachers (PSTs) from three universities have constituted the sample. Questionnaires of epistemological belief and teaching efficacy for genetically modified (GM) foods have been administered. The results have showed that PSTs have held moderately high teaching efficacy beliefs. Their efficacy has particularly decreased in the case of teaching nature of science. Their epistemological beliefs have predicted teaching efficacy beliefs. At the end of the paper, we have suggested implications based on the importance of epistemologies in pedagogy of SSI and on practical issues for enhancing teaching efficacy beliefs.

#### **Strand 7: Pre-service Science Teacher Education**

#### Understanding Pre-service Teachers' Identity and Identity Development

10:15am-11:45am, Benedum

Presider: Meredith A. Park Rogers, Indiana University

#### Peer Interactions and Identity Development

Steven D. Wall, University of North Carolina at Chapel Hill, sdwall@email.unc.edu Janice L. Anderson, University of North Carolina at Chapel Hill

**ABSTRACT:** Methods coursework introduces pre-service teachers (PSTs) to experiences involving the culture and language of science teaching and learning. The goal of these courses is to produce an environment aimed at the development of skills and knowledge appropriate to teaching science at the elementary school level The process of developing these skills involves learning designed to expose students to new experiences that emulate good teaching while also drawing upon the PSTs' own experiences with science learning. To be effective in growth, what is needed are reflections and comments that are focused upon thinking about science pedagogy. Through postings and reflections that utilize blogging form of ongoing dialogue beneficial to development. Using PST input from a previous cohort in which PSTs indicate that minimal reflections are not because of the tool, we analyzed the communications and development of a unique cell of students to answer the question: How do the identity standards of members of a small cell group influence the development of science teaching identity among cell group members?

#### Gender Knowledge as an Important but Neglected Aspect of Pedagogy of Science

Annica Gullberg, University of Gävle, agg@hig.se

Kristina Andersson, Centre for Gender Research, Uppsala University

Anita Hussenius, Uppsala University, Centre for Gender Research

Anna T. Danielsson, Uppsala University

#### Kathryn Scantlebury, University of Delaware

**ABSTRACT:** In Sweden only one of 17 programs in upper-secondary school has a non-significant gender bias in student participation. Technical programs are almost exclusively chosen by boys, while girls chose nursing and child caring, that is students' academic interests are intertwined with their gender. Swedish school law requires that teachers explicitly counteract gender stereotypes. In this study gender theories has been integrated into science- and technology courses in teacher education programs to provide preservice teachers the opportunity to critically reflect upon how gender impacts the culture of science and technology and education. In an essay assignment, preservice teachers described and

reflected upon examples in their pre-school placements where gender was important. Two main themes emerged from the textual analysis of these essays : (1) children have a stable core identity and need to 'be who they are', or (2) children are a "jack-of-all-trades" with potential interests in a variety of subject matter topics and that these interests could be influenced by teachers. Our analysis showed the consequences that these views have on the preservice teachers' teaching and learning in science and technology. We will discuss issues that may promote, or hinder preservice teachers' development of strategies that challenge stereotypical gender patterns.

# Contextual Factors Shaping Teacher Identity and Agency among Non-traditional Science Teacher Candidates Gail Richmond, Michigan State University, gailr@msu.edu

#### Faith A. Muirhead, Michigan State University

**ABSTRACT:** In this paper, the authors take a grounded theory approach to the study of teacher agency, specifically considering how novice science educators write and talk about their efforts to advance equity in urban, high-needs schools. Drawing from a larger research project, we focus on a multi-year study of two novice science educators and incorporate social cognitive and sociocultural conceptions of agency to investigate how each of these educators interact with the content and contexts of their urban teaching placements. Using criteria for three critical constructs: professional identity, context, and agency, we propose that the contextual factors of a novice teachers' residency placement may either enhance or supplant their personal agency during the course of the year. Our work suggests a contribution of agency to longer-term teacher resilience. We assert that explicit attention during teacher preparation to how context might contribute to the ability of a beginning teacher to respond productively to change, ambiguity, and stress and serve as a foundation from which effective teaching can be built warrants further investigation. To that end we must find ways to increase the likelihood that preservice teachers demonstrate agency by preparing them in contexts which are likely to produce and sustain agency.

Strand 8: In-service Science Teacher Education Science Teachers' Experiences with Engineering 10:15am-11:45am, Duquesne Presider: Mehmet Erkol

Professional Development in Engineering with Science and Math Teachers: Fostering Conceptual Understandings

Christine G. Schnittka, Auburn University, schnittka@auburn.edu George E. Turner, Auburn University Randy W. Colvin, Auburn University Mary Lou Ewald, Auburn University

**ABSTRACT:** The BLINDED project is a 3-year teacher professional development (TPD) initiative designed to stimulate project-based STEM education throughout the state of Alabama. Through a targeted and intense professional development experience, 130 middle school science and math teachers learned how to implement engineering design into their existing science and math classes during year 1. By participating in three days of professional development, teachers who engaged in curriculum that reinforced engineering design, inquiry and experimental design, physical science concepts and applied mathematics, made significant gains in science content knowledge and attitudes toward engineering and self-efficacy to teach engineering. Teachers in this study have an increased probability of using engineering design-based projects with their students, and by diffusion across school districts, teachers across the state may be more likely to integrate STEM projects and ideas into their own formal teaching practices. As the Next Generation Science Standards are adopted by states, engineering will be a required component at every grade level. Results from this statewide study will inform the NARST community about best practices to engender significant gains in science understandings through engineering design activities.

Development of a Complex Systems-based Model for Enhancing Teachers' Understanding of the Nature of Authentic Science and Engineering Research

Annmarie R. Ward, Penn State University, arw192@psu.edu

Matthew Johnson, Penn State University Jenay Robert, Penn State University Leah Bug, Penn State University

**ABSTRACT:** This paper describes the development and initial implementation of a complex systems-based model for helping teachers understand the nature of authentic science and engineering research. This MASTER Model (Modeling Authentic Science, Technology, and Engineering Research) provides a novel approach that narrows the gap between teachers' limited authentic research experience and demands of reform documents for science teachers to use the practices of science to teach core ideas and cross cutting concepts. The MASTER Model included two components: 1) the MASTER Framework, a graphic representation of the systems nature of research, and 2) the MASTER Process, which consists of guidelines for implementation of the Model in a variety of teacher education and professional development contexts. Initial results of pre and post-focus groups, interviews, and lesson plan development demonstrate an increase in the systems thinking capacity of teachers as well as a better understanding of the interrelationships of major research projects and how that complexity can be represented and used in the classroom as a better alternative to the traditional Scientific Method.

A Multiphase Study Exploring Physical Science Teachers' Practices and Beliefs about Engineering Integration Emily A. Dare, University of Minnesota, dare0010@umn.edu

- Joshua A. Ellis, University of Minnesota
- Gillian H. Roehrig, University of Minnesota

**ABSTRACT:** As national reform documents (National Research Council, 2013) call for the integration of engineering into the K-12 science standards, the importance of understanding how engineering in currently being brought to science classrooms is apparent. This multiphase, mixed-methods study investigated the classroom practices and beliefs of high school physical science teachers following an intensive professional development on physics and engineering integration. The three phases of this study suggest that teachers new to incorporating engineering into their physical science classrooms often struggle to maintain focus on physics concepts and instead focus on the development of the "soft skills" needed by engineers, such as teamwork or communication. This study also indicates that classroom practices and beliefs may be related to whether or not the teacher has an undergraduate degree in physics, something that in not required in our state to teach physical science. Results from this study provide insight on obstacles current science teachers face as they begin to add engineering to the classrooms, and the research design provides an approach that may be used to investigate the impact of other factors on engineering integration deemed significant by professional development educators.

Engineering Awareness among High School Science, Mathematics and Technology Teachers Abeera P. Rehmat, University of Nevada, Las Vegas, rehmata@unlv.nevada.edu Janelle M. Bailey, Temple University

**ABSTRACT:** The challenge of preparing students for the global world created the impetus to develop and implement strategies that have the potential to improve STEM education in K-12 schooling. Yet despite the increase in support for STEM education, few teachers are integrating it into their instructional practices. This lack of integration could be due to teachers' lack of understanding and their pre-existing beliefs about STEM areas – particularly engineering. This quantitative study investigates current perceptions about engineering among 70 high school science, mathematics, and technology teachers and whether male teachers' perceptions regarding engineering differ than female teachers'. The analyses revealed that majority of the teachers believed that engineers have good verbal, math, and science skills. Teachers reported that they were familiar with design, engineering, and technology (DET) and agreed that it should be integrated in the K-12 curriculum. They showed an interest in learning about DET but indicated that lack of content knowledge and time are barriers associated with DET integration. Moreover, a significant difference between gender perceptions concerning engineering was found, with female teachers indicating greater confidence for integrating DET into their curriculum and greater preparedness to include DET activities in their science teaching than male teachers.

#### Strand 10: Curriculum, Evaluation, and Assessment

#### Nature of Science / Philosophy of Science

10:15am-11:45am, Brigade **Presider:** Martina Nieswandt, University of Massachusetts, Amherst

### Validation of the Views of Science and Education Scale (VOSE) for English Language Speakers Erin E. Peters-Burton, George Mason University, epeters1@gmu.edu

#### Toni A. Sondergeld, Bowling Green State University

**ABSTRACT:** The development of sophisticated thinking about the nature of science (NOS) has been a core goal of science education for many years. However, presently there is not large-scale baseline data available that reveal the landscape with respect to the developmental understanding of NOS. The purpose of this study is to validate a scale that has shown promise in Taiwan and has been used on a large scale, the Views of Science and Education (VOSE), originally written in Chinese, to determine if an English translation of the VOSE given to English language speakers has sound assessment properties. Rasch techniques were adopted for the analysis, as suggested by the VOSE author. The VOSE was administered to a variety of participants (N=224): 7th grade students (n=92, 41.1%), undergraduates participating in a geology course (n=84, 37.5%), in-service teachers (n=31, 13.8%), and scientists (n=17, 7.6%). Based on multiple scale analyses runs, it was determined that the original 5-point scale should be modified to a four point scale where Uncertain/No Comment responses were removed as missing data. The construct of NOS as measured by the VOSE was unidimensional. Further analysis deals with statistical and conceptual redundancies as well as the addition of more challenging items.

#### Aims and Values of Science: Implications for Curriculum Design and Assessment of Learning

Zoubeida R. Dagher, University of Delaware

#### Sibel Erduran, University of Limerick, Ireland

**ABSTRACT:** The purpose of this theoretical paper is to review contemporary scholarship in philosophy of science on the aims and values of science, and explore its implications for science curriculum policy and assessment of learning. We present a theoretical overview of some of the central epistemic aims and values of science. By aims and values, we refer to those epistemic criteria that guide the generation, evaluation and revision of scientific knowledge. Our research objective is to draw from the work of some contemporary philosophy of science perspectives that can inform science education research and practice. The key research questions are (a) what epistemic perspectives on scientific aims and values are useful for informing science education? and (b) how can these perspectives be transformed for use in practical educational contexts? The broader curricular context of this type of work is the recent policy calls for the inclusion of epistemic dimensions of science in science instruction (e.g. Eurydice, 2012; OECD, 2006). We illustrate some examples in application to curriculum and assessment by drawing on the Next Generation Science Standards that have recently been published in the United States. However our approach can provide an analytical framework that can be adapted and used by the international research and policy community to investigate how respective curricular documents relate to theoretical ideas on the aims and values of science.

#### A Nature of Science Instrument: Looking at Ways to Illicit and Capture Interrelated NOS Aspects Christian A. Carstensen, University of Illinois at Chicago, ccarst2@uic.edu Huseyin Colak, Northeastern Illinois University

**ABSTRACT:** Recent science education reform efforts have implicated nature of science (NOS) understanding as a key aspect of scientific literacy. Unfortunately, many K-12 teachers themselves struggle to adequately understand NOS concepts. Further complicating matters, assessing views of nature of science is difficult. This study proposes a revised nature of science questionnaire and rubric. Revision to previous instruments was needed due to three challenges: (1) previous instruments did not illicit useful participant responses for assessment, (2) provided unclear scoring guidelines, and (3) failed to capture the interrelatedness of NOS aspects across instrument items. We proposed the following solutions: (1) the instrument items were redesigned to prompt participants to more accurately reveal thinking, (2) we identified key concepts of seven NOS aspects to clarify scoring, and (3) we created a rubric that captured the interrelatedness of NOS aspects to clarify scoring, and (3) we created a rubric that captured the interrelatedness of NOS aspects to clarify scoring, and (3) we created a rubric that captured the interrelatedness of NOS aspects and contradictions. We believe that this revised instrument and associated rubric will be better able to capture participants' growth and understanding of NOS, provide more detailed profiles of participants'

understandings, and allow for greater comparison between individuals and groups. We will continue to assess the validity and reliability of the instrument and rubric.

#### Strand 11: Cultural, Social, and Gender Issues

Symposium – Structure-Agency Dialectic: Insights into Science Learning and Teaching of Historically Marginalized Youth in the US

10:15am-11:45am, King's Garden 1

#### **Discussants:**

Maria Varelas, University of Illinois at Chicago Heidi B. Carlone, University of North Carolina at Greensboro Felicia Moore Mensah, Teachers College, Columbia University Leah A. Bricker, University of Michigan Alberto J. Rodriguez, Purdue University John Settlage, University of Conneticut Pauline W. U. Chinn, University of Hawaii - Manoa Justine M. Kane, Wayne State University Maria S. Rivera Maulucci, Barnard College Megan Bang, University of Washington Jomo Mutegi, Indiana University, IUPUI Angela Calebrese Barton, Michigan State University Edna Tan, University of North Carolina at Greensboro Julianne Wenner, University of Illinois at Chicago

**ABSTRACT:** This symposium focuses on students and youth who have been historically marginalized in US schools and academic institutions in general, and in science specifically, and contributes to knowledge building regarding the relationship between identity construction and science learning and teaching. The session will bring together several scholars who have been conducting identity research to discuss ways in which a particular construct critical in such research, namely the structure-agency dialectic, is studied in science formal and informal settings, comparing and contrasting theoretical and methodological approaches and considering implications for science teaching and learning in and out of schools. In the spirit of the conference theme "Awakening Dialogues," the symposium will consist of conversations between presenters and between presenters and attendees. It will be in the form of an interactive poster session with three parts: (a) introduction; (b) dialoguing between presenters and poster visiting by attendees; and (c) whole-group discussion. Twelve research teams will share their work in this session, which, for part (b), will be paired up so that individual studies are used as springboards for conversation about similar and different ways in which the structure-agency dialectic is studied conceptually and methodologically.

#### Strand 12: Educational Technology

Learning Science Using Simulations

10:15am-11:45am, Sterlings 1 **Presider:** Richard L. Lamb, Washington State University

Learning and Engagement Effects of Embodied Interactions within an Immersive Science Simulation Robb Lindgren, University of Illinois Urbana-Champaign, robblind@illinois.edu Michael Tscholl, University of Illinois, Urbana-Champaign Emily K. Johnson, University of Central Florida Carolyn Glasshoff, University of Central Florida J. Michael Moshell, University of Central Florida **ABSTRACT:** Computer simulations have been shown to be effective instruments for teaching students about difficult concepts in science. Emerging interface technologies are expanding the manner in which learners can interact with these simulations, but the effects of these new interaction modalities on conceptual understanding and engagement have not been studied in great depth. We present a study where middle-school students learned about gravity and planetary motion in an immersive, full-body interactive simulation, and we compared their learning and attitudes about science with students using a desktop version of the same simulation. Results of the study indicate that enacting concepts and experiencing the laws of physics through one's body leads to significant learning gains and higher levels of engagement.

#### Meta-Analysis of Science Simulations for Learning

Cynthia M. D'Angelo, SRI International, cynthia.dangelo@sri.com

Daisy Rutstein, SRI International

Christopher J. Harris, SRI International

**ABSTRACT:** This paper describes the process and findings of a meta-analysis and systematic review of the literature of computer simulations related to science, technology, engineering, and mathematics (STEM) learning topics, focusing on the findings relating to science learning. Studies that met our search and inclusion criteria and that reported effect size measures or the data to calculate effect sizes were included in the meta-analysis. Important moderating factors related to simulation design, assessment, implementation, and study quality were coded, categorized, and analyzed for all the included articles. This review looked at studies that compared simulation-based instruction to non-simulation-based instruction as well as studies that compared two versions of simulation-based instruction to each other. Overall, 2,722 abstracts were reviewed, resulting in full-text retrieval of 260 primary research studies potentially suitable for the analysis. Through a thorough review of full-text documents, 201 studies were retained for further analysis, with 60 studies meeting all criteria. These 60 studies yielded 141 effect sizes. In the area of science achievement, simulations had a moderate to strong effect on student learning. The results show that simulations can have a significant impact on student learning and are promising tools for improving student achievement in science.

#### Science Teacher Questioning While Students Learn with Simulations

Robert C. Wallon, University of Illinois at Urbana-Champaign, rwallon2@illinois.edu

#### Barbara Hug, University of Illinois at Urbana-Champaign

**ABSTRACT:** The purpose of this exploratory study was to classify the types of questions a science teacher used to support students while they learned with a NetLogo simulation. Audio recording of a high school biology teacher's interactions with students was transcribed, and teacher questions were interpretatively categorized using Mortimer and Scott's (2003) framework. Teacher questions were also inductively categorized as primarily relating either to using the software or developing conceptual understanding. More authoritative rather than dialogic questions were used, especially when the teacher provided support for using the software. One implication is the importance for students to receive training on simulation software features so that the teacher can dedicate more time to developing conceptual understanding. This paper discusses other implications related to curriculum development and professional development, including the potential benefit of engaging teachers in an analysis of their own questioning types as a professional development activity.

#### Strand 12: Educational Technology

#### Web-based Learning Technologies

10:15am-11:45am, Birmingham **Presider:** Tamara L. Clegg, University of Maryland

Investigating Tutor-Student Interactions with a Digital Science Notebook Andy Smith, North Carolina State University, peter.andrew.smith@gmail.com Angi Shelton, North Carolina State University Samuel Leeman-Munk, North Carolina State University Courtney Behrle, North Carolina State University Elysa N. Corin, North Carolina State University

#### Eric N. Wiebe, North Carolina State University Robert Taylor, North Carolina State University Bradford W. Mott, North Carolina State University James C. Lester, North Carolina State University

**ABSTRACT:** Digital science notebooks can help address inconsistencies in classroom implementation of kit-based curriculum and traditional science notebooks by providing scaffolded support for students and a supportive structure through which teachers can guide instruction. Combining intelligent tutoring systems with digital science notebooks has significant potential to further enhance the scaffolded support of students as they learn science. To study different methods of student scaffolding, the research team developed the CyberPad, a digital science notebook that provides a rich, structured inquiry environment. This reported research focuses on investigating human tutors' interactions with students to explore methods of improving the intelligent tutoring scaffolding support for students. In this exploratory case study, Tutor and Student actions were recorded, coded, and categorized. Themes of coded human tutor interactions with middle school aged students using the CyberPad include that human tutors relied heavily on questions to diagnose and correct misconceptions and that participants rarely asked for help from the human tutors, though they reflectively expressed the desire to ask the intelligent tutor questions. Presented conclusions indicate how these initial findings inform the design of intelligent tutoring software that provide adaptive instruction and support of students engaging in different facets of scientific inquiry.

#### Effects of Web-Based Retrieval Practice Exercises on Plant Identification Performance

Niels Proctor, University of Florida, noproctor@ufl.edu

Pavlo D. Antonenko, University of Florida

Mihai Giurcanu, University of Florida

**ABSTRACT:** This quasi-experimental study extends the literature on the role of retrieval practice (Karpicke, 2012) in the context of using web-based retrieval exercises for an undergraduate course on local flora. In response to each species photo seen on the website, students could practice overt retrieval, by typing in a scientific name, or practice covert retrieval, by viewing the photos and moving on without typing an answer. This study examined the effects of retrieval practice enabled by this web-based content retrieval tool and, specifically, looked at the students' choice of retrieval practice mode and how it influenced plant identification performance. Web server logs and performance of weekly class quizzes served as data sources. A mixed effects ordinal logistic regression demonstrated that in addition to the expected influence of quiz complexity, variables associated with overt and covert retrieval were found to be significant predictors of students' plant identification performance. The main implication for practice is that web-based retrieval exercises provide learning benefits in science education and both covert and overt retrieval play an important role as predictors of learning performance.

### *EvoGrader: An Automated Online Formative Assessment Tool for Evaluating Written Evolutionary Explanations*

Minsu Ha, Stony Brook University (SUNY), minsu.ha@stonybrook.edu

Kayhan Moharreri, The Ohio State University

#### Ross H. Nehm, Stony Brook University (SUNY)

**ABSTRACT:** EvoGrader is a free, online, on-demand formative assessment service powered by Amazon's Elastic Cloud and run with LightSide Labs' open-source machine-learning tools. Currently, the web portal allows biology instructors to upload a response file (.csv) containing up to unlimited numbers of evolutionary explanations written in response to 86 different ACORNS instrument items. Within minutes, instructors receive detailed information about the concepts and misconceptions contained within each student response, as well as overall student (and sample) reasoning models. Graphs and visual models summarize responses, and downloadable files of response scores (in .csv format) are available. EvoGrader will be of interest to biology instructors teaching large classes who seek to emphasize scientific practices such as scientific communication and generating scientific explanations, and crosscutting ideas such as evolution and natural selection. A series of experiments are reported that demonstrate that EvoGrader is as accurate as having trained human scorers score the written responses, but does so in 99% less time and at no cost. The software architecture of EvoGrader is described, as it may serve as a template for other science educators interested in developing machine-learning portals for other core concepts within biology and across other disciplines.

"Evo in the News": A Tool to Enhance Students' Perceptions of the Relevance of Evolution Lynn M Infanti, Syracuse University, Department of Science Teaching Lemoyne College, Department of Biology, infantlm@lemoyne.edu

Jason R. Wiles, Syracuse University

**ABSTRACT:** This investigation evaluated the effects of the use of the "Evo in the News" section of the Understanding Evolution website on attitudes toward biological evolution among undergraduate students in a mixed-majors introductory biology course at a medium-sized, private research university in the American Northeast. In addition, this study looked at students' initial attitudes toward and their knowledge of evolution before beginning an introductory biology course. Attitudes and knowledge were measured using the Evolutionary Attitudes and Literacy Survey (EALS). We used a quasi-experimental design with pre-test/post-test comparison between a control group and a an experimental group. The control and experimental groups differed in that throughout the course of the semester, the treatment group was assigned pre-laboratory work using "Evo in the News" while the control group was assigned similar, traditional pre-lab activities. Post-course, the experimental group showed significant gains in their attitudes regarding the relevance of evolution. Additional findings included a significant correlation between positive attitudes toward evolution and knowledge of evolution. Also, significant correlations were found between both positive attitudes toward and knowledge of evolution and the students' level of achievement in the course.

#### **Strand 14: Environmental Education**

# Related Paper Set – Elementary Students' Understanding of Causal Concepts in Environmental Issues and the Next Generation Science Standards

10:15am-11:45am, King's Garden 3

Discussant: Catherine Eberbach, Rutgers University

**ABSTRACT:** The Next Generation Science Standards (Achieve, 2013) identify cross-cutting concepts intended to provide an organizational structure to understand the world and to connect core ideas across disciplines and grades. One of these is entitled "Cause and Effect." It focuses on such ideas as causes generate patterns, one can test for and explain change, correlational and causal patterns differ, and probabilistic/statistical patterns between potential causes and effects can indicate a causal relationship. This related paper set presents a studies investigating how elementary students structure particular causal concepts relevant to environmental education. The first two papers consider action-at-an-attentional-distance—the concept that it can be difficult to connect causes and effects that reside in separate attentional spaces. The third paper addresses distributed causality which involves causal agents that are distributed, often have uncoordinated intent, and whose actions result in emergent outcomes. The fourth paper addresses probabilistic causality which involves summing across cases statistically to see a causal relationship. Each of these causal concepts holds deep relevance for understanding our environment and the ways in which we struggle to make sense of its patterns. The papers address previous research and present new findings to further build our knowledge.

A Microgenetic Study of Students' Default Explanations of Action at an Attentional Distance Lynneth Solis, Harvard University, sls355@mail.harvard.edu Katarzyna M. Derbiszewska, Harvard University Tina Grotzer, Harvard University

Testing a Curriculum for Teaching Action at a Distance to Sixth Graders Maleka Donaldson Gramling, Harvard University, Maleka\_Gramling@mail.harvard.edu Lynneth Solis, Harvard University Katarzyna M. Derbiszewska, Harvard University Tina Grotzer, Harvard University

Fourth and Sixth Graders Conceptions of Distributed Causality Katarzyna M. Derbiszewska, Harvard University, katarzyna\_derbiszewska@harvard.edu
Lynneth Solis, Harvard University Maleka Donaldson Gramling, Harvard University Tina Grotzer, Harvard University

Comparing Paths: Bayesian Sequence Analyses in a Microgenetic Study of Student Learning Michael S. Tutwiler, Harvard University, mst216@mail.harvard.edu Tina Grotzer, Harvard University

### Concurrent Session #5 1:15pm – 2:45pm

Research Committee Sponsored Session *Poster Symposium – Sandra K. Abell Scholar Poster Session* 1:15pm-2:45pm, Commonwealth 2 **Presiders:** Julie A. Luft, University of Georgia Angela Calabrese-Barton, Michigan State University ABSTRACT: In this poster session, such will be able to most the owned.

**ABSTRACT:** In this poster session, you will be able to meet the graduate students who were selected to attend the 2013 Sandra K. Abell Institute for Doctoral Students in Washington, DC. The posters presented in this session represent the future of NARST, which is why all members should stop by and meet these emerging NARST scholars. Students will have posters on their research, which was contemplated and refined during the Institute, with the help of NARST members who served as research mentors. The Institute mentors included: Julie Luft, Angie Calabrese-Barton, Alicia Alonzo, Brian Reiser, Gale Seiler, Tali Tal, Jan van Driel, and Anat Yarden. Support for the Institute was provided by: NARST, Michigan State University, Create4STEM Institute, University of Georgia, and Leiden University.

Supporting ELL's Science Learning Through Multimodal Formative Assessment: Principles, Practices, and Possibilities

Preetha Menon, University of California, Santa Cruz, pmenon@ucsc.edu

Teachers' Practices about Chemical Reactions: Enacting Classroom Formative Assessment Dante Cisterna, Michigan State University, cisterna@msu.edu

Science Teachers' Understandings of Science Practices Before and after the Participation in an Environmental Engineering Research Experiences for Teachers (RET) Program Dilek Ozalp, University of South Florida, dilekozalp@mail.usf.edu

Students' Abilities to Critique Scientific Arguments Based on the Forms of Justification Amanda Knight, Boston College, knightam@bc.edu Katherine L. Mcneill, Boston College

*Identity Development of Science Teacher Leaders* Somnath Sinha, University of Missouri, ssqh9@mail.missouri.edu

Exploring Students' Perceptions of Teaching Episodes and the Subsequent Comparison to the Teachers' Expressed Intents Peggy Ward, University of Arkansas, pdward@uark.edu African-American Girls and Scientific Argumentation: Lived Experiences, Intersecting Identities and Their Roles in Constructing and Evaluating Claims Phyllis Haugabook Pennock, Western Michigan University, Phyllis.c.pennock@wmich.edu

Teaching to Their Cultures? Exploring the Connection between Four Science Teachers' Instructional Practices and Their Beliefs about Teaching African American Children Samantha L. Strachan, Morgan State University-Baltimore, sastr2@morgan.edu

*The Cultural Production of Creativity in Elementary Engineering Education* Tess Hegedus, The University of North Carolina, Greensboro, tahegedu@uncg.edu

*Examining the Relationship between Physical Models and Students' Science Practices* Alison Riley Miller, Teachers College, Columbia University, arileymiller13@gmail.com

*Elementary Students' Formulation of Explanations about the Water Cycle* Laura Zangori, Univrsity of Nebraska-Lincoln, laura-zangori@huskers.unl.edu

Understanding Roles of Assistive Technologies in Choice and Participation of Professionals with Disabilities in STEM Fields Heather A. Pacheco Arizona State University, pacheco.heather@gmail.com

The Global to Local Continuum: A Cross-National Comparative Study of Beginning Science Teachers' Cycle of Instruction in South Africa and the United States Shannon L. Dubois, The University Of Georgia, sdubois@uga.edu

Culturally Relevant Formative Assessment Practices in A Physics Classroom Jiwon Kim, Michigan State University, kimjiwo1@msu.edu

Making the Invisible Visible, a Pilot Case Study of Women in STEM Helen Douglass, University Of Colorado Denver, Helen.L.Douglass@gmail.com

Experienced Chemistry Teachers' Orientations to Teaching Science as Interrelated Sets of Beliefs Betul Ekiz, Middle East Technical University, Turkey, betulekiz@gmail.com

Investigating the Interaction between Pre-Service Chemistry Teachers' Content Knowledge and Pedagogical Content Knowledge Elif Selcan Kutucu, Middle East Technical University, Turkey, selcan.kutucu@gmail.com,

*Communicating Phylogeny: Evolutionary Tree Design* Teresa Macdonald, University of Kansas Natural History Museum, tmacd@ku.edu

The Construction of Views of Theory-Practice Relationships in an Undergraduate Science Education Program Gabriel Menezes Viana, Federal University of Minas Gerais, gabrielviana@ufsj.edu.br

*Understanding the Critical Role of a District Science Coordinator* Brooke A. Whitworth, University of Virginia, baw3tj@virginia.edu Knowledge Organization with Multiple External Representations in Computer Supported Collaborative Learning Environment for Arguing on Socio-Scientific Issues Bahadir Namdar, The University of Georgia, bahanamdar@gmail.com

Building Home-School Connections: Beginning Science Teachers' Practices for Communicating with Families Nena Bloom, Northern Arizona University, Nena.Bloom@nau.edu

*Emotions and How They Emerge in A Climate Change Course for Prospective Elementary Education Students* Elizabeth Hufnagel, The Pennsylvania State University, exh5064@psu.edu

#### Strand 2: Science Learning: Contexts, Characteristics and Interactions *Identity, Positioning, Relevance, and Engagement in Science Learning* 1:15pm-2:45pm, Fort Pitt **Presider:** Ellice Ann Forman, University of Pittsburgh

# Identity Work in the College Science Classroom: The Cases of Two Successful Latecomers to Science Phoebe A. Jackson, McGill University, phoebe.jackson@mail.mcgill.ca Gale A. Seiler, McGill University

**ABSTRACT:** Presenting the cases of two latecomers to science who successfully persisted through to graduation in their college science program, this paper asks what overarching cultural models are reproduced in the courses of the figured world of their science program and how do latecomers use the resources made available in their courses to advance their identity work towards science? Drawing from lecture and laboratory observations, teacher and student interviews, and student journals, it is shown that it is possible for latecomers to science to engage in successful identity work in their science courses. However, the dominant teacher-centered and sink-or-swim cultural models of learning in the figured world of the science program limited the resources available to latecomers to do so. This often resulted in them being positioned in the less powerful subject position of a good student, rather than good at, or interested in, science. The two cases suggest that the practices promoted by the concepts of active learning and social constructivist approaches to learning would help move away from these traditional cultural models. This would offer latecomers more resources with which to engage in successful identity work in their courses, thus affording their construction of inbound science identity trajectories.

## Youth Action Research in the Science Classroom: Implications for Youth's Identity Work Elizabeth Coleman, Loyola University Chicago, ecoleman3@luc.edu

**ABSTRACT:** This study examines youth's experiences while participating in a curriculum called Science Youth Action Research (Sci-YAR), which was designed to emphasize relevance and agency in order to promote youth's learning and facilitate their development as informed democratic citizens who use science as a tool to affect positive change in their lives and communities. This study aims to identify what components of the Sci-YAR curriculum youth find meaningful and to detail how youth experience and make meaning of their participation in the curriculum. In addition, this study investigates how the use of Sci-YAR as a curricular framework and instructional approach enables or constrains youth's identity work in service of critical science agency, so that youth might take action through their practices of science to bring about personal and social transformation.

### The Impact of Teacher Positioning of Students on Middle School Latina Girls' Engagement in Science Edna Tan, University Of North Carolina - Greensboro, e-tan@uncg.edu

Theresa A. Hegedus, University of North Carolina at Greensboro

**ABSTRACT:** This paper explores the impact science teachers' positioning of middle school Latina girls have on the girls' engagement with science and their developing science practices and agency, in formal school science and informal girls' science club. Research questions include 1) How are middle school Latina girls positioned by their science teacher in formal school science, and informal girls' science club? & 2) What are the affordances and constraints (e.g. roles and

resources) made available to girls' development and performance of science practices (i.e., how they engage in science) and their agency, as a result of teacher positionings? We focus on how two girls, Lizzy and Amberline are repeatedly positioned differently within the figured worlds of formal classroom ("traditional Latina girl", "good girl", "individual girl") and informal science club ("scientist", "problem solver", "team player"). We present the different modes of engagement with science Lizzy and Nadia performed. We present the processes of positioning through specific classroom and informal science episodes, and conjecture the relationships such processes of positioning have on the girls' developing science practices and senses of agency in science. Implications of teacher positioning with regards to middle school girls' engagement, and identification with science, are discussed.

#### *Mending the STEM Pipeline: Integrating Personal and Scientific Identities through Discourse* Amy E. Green, University of Maryland, amygreen@umd.edu

**ABSTRACT:** Despite intensive reform efforts, students are persistently and progressively dropping out of the "pipeline" intended to carry them through college and onto careers in STEM (science, technology, engineering, and math). Many scholars argue that a contributing factor to the leaks in the pipeline is the inability of many students to meaningfully integrate their personal identities with disciplinary identities. My research adds to this conversation by illustrating how students can engage in authentic science without needing to alter their discourse in ways they might find alienating." This paper reports the findings of a case study of first grade girls engaging in an informal scientific discussion. In order to recognize elements of students' everyday language as being legitimate tools for participation in science, I analyze the discourse for the ways it aligns with the dimensions of scientific proficiency in the Next Generation Science Standards. I claim that when the girls are given the agency to employ everyday language in science, dichotomies between scientific and everyday discourse begin to dissolve, opening the opportunity for their identities to become more authentically integrated

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

#### Models, Modeling, and Learning

1:15pm-2:45pm, King's Garden 5 **Presider:** Andy Cavagnetto, Washington State University

#### Collaborative Tangible Agent-Based Computation for Modeling Physics

 $Gokul \ Krishnan, \ Vanderbilt \ University, \ gokul.krishnan@vanderbilt.edu$ 

Pratim Sengupta, Vanderbilt University

**ABSTRACT:** In this paper, we seek to answer the following question: How can self-expression be supported in the science classroom using tangible and agent-based computation? To this end, this paper introduces ViMAP- Tangible, a new programming language and modeling platform that integrates sensor-based computation with ViMAP (Sengupta, 2011; Sengupta, Wright & Farris, 2012), a visual programming language that is designed specifically to support modeling domain-specific phenomena in physics and biology for elementary and middle school students. This paper also presents an activity system that was designed to introduce students to progressively deeper forms of abstraction and complex forms of modeling and report results from an exploratory study that shows how 4th and 5th grade students develop expertise in modeling kinematics, as they engaged in personally meaningful programming activities. Our analysis highlights how three key characteristics of our learning environment - collaboration, leaning activities that focus on user-centered design, and tangibility in the form of electronic sensors can integrate self-expression with modeling in the science classroom using visual programming.

### Facilitating Student Understanding of Dissolution Processes through Sociochemical Dialogs and Technology Use

Abdi M. Warfa, Metropolitan State University, moham227@gmail.com

**ABSTRACT:** Recent calls on science education reform recommend engaging students in the development and use of models, construction of explanations, and engaging arguments from evidence (NGSS, 2013). This study present analysis of student-teacher dialogical interchanges that highlight the role of teacher-initiated discourses on student understanding of solution chemistry. The study also highlights how teachers use technology in facilitating student discourse practices.

The analysis revealed that certain teacher moves, such as linking, communicative, re-orienting, and confirming were more successful than other moves in improving student conceptions of solution chemistry. The course instructor also used 3D technology the students were using to model the dissolution process to dissuade them from selecting misconceptions commonly found among chemistry students.

### How Teachers Support Students' Using and Building Models Using Computer--based Material? Jane J. Lee, Michigan State University, leejanej@msu.edu

#### Joseph S. Krajcik, Michigan State University

**ABSTRACT:** The purpose of this study is to investigate how teacher support students in building models using computer-based material and what affects their teaching practice. In this proposal, we selected two teachers and focused on their instructional moves in on one of their science classes. We collected various data and went through of recursive propose looking for patterns in one data source and confirming the pattern using other data sources. We found that teachers utilized the computer-based materials as a tool to connect various science ideas to help student build and revise their models. It was critical to help students link the interpretation of simulation data to the phenomena that they saw and apply these ideas to build or revise models. Using the feature of technology, teachers could check students' model in real-time and use them to led class discussion. From the class discussions, students could start to support one model over another and revisited their previous model for further development. From this study, we found that students' modeling can support students' engagement not only in the practice of building and revising modeling but in scientific practices such as argumentation, using of ideas and the sharing of ideas.

#### Capturing Teachers Engagement with Scientific Modeling

Jean Stevens, University of Maine, jean.stevens@umit.maine.edu

Lauren Barth-Cohen, University of Maine

#### Daniel Capps, University of Maine

**ABSTRACT:** In this study, we describe instances of high quality disciplinary based engagement with the scientific practice of modeling. We focus on two middle school teachers who were participating in a professional development workshop where teachers were asked to generate and revise models of different times period in our geologic history. There is evidence of the two teachers' engagement with the modeling task by how they exhibited an interest in digressions about scientific topics that had not been predetermined as part of the workshops curriculum. Using video and audio of the workshop, we used a bottom up grounded approach to analyze the data. This revealed several types of evidence for the teachers engagement, including their time on task, questions, and other verbal expressions. In addition we discuss the role of the workshop instructor in facilitating these teachers' engagement. Results include a series of hypotheses about the relationship between the teachers' and instructor's interaction.

#### Strand 3: Science Teaching--Primary School (Grades preK-6): Characteristics and Strategies Science Inquiry Practices in the Elementary Classrooms 1:15pm-2:45pm, Brigade

### Elementary Teachers' Adaptation of Investigation Questions across the Inquiry Continuum Mandy Biggers, Penn State University, msb33@psu.edu

**ABSTRACT:** Empirical evidence is mixed about whether student- or teacher-directed questions best promote student learning in science lessons. While some scholars argue that student-directed questions achieve the 'gold standard', others contend that a variety of questioning strategies should be used to help teachers engage in science instruction meeting the needs of learners. However, little research has been conducted on elementary teachers' conceptions of the inquiry continuum. Elementary teachers often struggle to translate their ideas into practice, and rely on their science curriculum materials. They need a great deal of support to develop robust understanding of the continuum, and to modify their science curriculum materials to best engage early learners in scientific practices across the continuum, specifically the practice of questioning. To address this gap in research, I asked: (1) In what ways do inservice elementary teachers adapt existing elementary science curriculum materials across the IC for the scientific practice of questioning? (2) How does the amount of scaffolding of an elementary science lessons' investigation question affect the overall quality of inquiry in the

lesson? and (3) How do inservice elementary teachers' ideas about the IC influence their adaptation of investigation questions from their science curriculum materials?

#### Inquiry Pedagogical Frames: A Heuristic for Science Teaching in Primary Classrooms Frederick T. Talaue, National Institute of Education, Singapore, frederick.talaue@nie.edu.sg Aik-Ling Tan, National Institute of Education

**ABSTRACT:** This study seeks to understand how teachers imagine the enactment of inquiry science as the intersection of policy imperatives, contextual features of the classroom, and their personal characteristics. We implemented an online survey that included six narratives collected from the field, featuring moments of breakdown within the process of appropriating inquiry-oriented teaching strategies. These vignettes were used as prompts to explore teachers' discourses on instructional planning and classroom learning that may be aligned with the ideals of an inquiry-based primary science curriculum. Based on an analysis of 200 survey responses, triangulated with an analysis of focus group discussion transcripts, we find that teachers of primary science had a moderately positive stance to teach through an inquiry-based approach. They typically indexed one or several themes to articulate their position and we used the notion of pedagogical frames to capture the interconnections between the themes' elements. Our findings converged with the competence-based model of inquiry science teaching, which theorize a complex set of competencies that become meaningful when contextualized to specific problems in practice. In our presentation we will discuss how our findings contribute to this model and its implications on reflective practice.

## Address Students' Inquiry or Follow the Lesson Plan? A Framing-Based Analysis of Elementary-School Science Loucas T. Louca, European University-Cyprus, Louca.L@cytanet.com.cy

**ABSTRACT:** Supporting inquiry in the science classroom is challenging, demanding that teachers monitor student thinking and respond appropriately. In this context, teachers often face the dilemma in choosing whether to follow potentially important student inquiry, but which might lead the discussion away from the lesson's objectives, or to disregard student ideas or reasoning which might be interesting but unrelated to the particular lesson objectives. The purpose of this video case study is to describe a detailed framing-based analysis of an 80-minute videotaped 6th-grade lesson in science. I investigated how a teacher framed the ownership of the lesson and how he "competed" with his students for that ownership. Findings suggest that in 57.9% of the discourse the teacher maintained control over the flow and the content of the conversation, even though he dominated only 26.3% of the discourse, whereas for 42.1% of the lesson the teacher and the students shared the responsibility of the discourse and its content. I discuss how the idea of "framing" as a methodological approach for analyzing videos of teaching can improve our understanding of the processes that teachers go through during teaching of science as inquiry, moving beyond approaches of simply describing teaching discourse.

### "Doing" Science in the Elementary School Classroom: Latour Analysis of Inscriptions Linking Classroom and Fieldwork

Kathryn A. Lanouette, University of California Berkeley, kathryn.lanouette@berkeley.edu Eric Berson, Stanford University

Kathleen E. Metz, University of California Berkeley

**ABSTRACT:** Research literature and NRC policy documents have identified a weak reflection of scientific knowledgebuilding practices in elementary science. Our pedagogical model seeks to address this challenge, scaffolding children's engagement in science by linking classroom and fieldwork. In this case study of third grade students, we use Bruno Latour's "cascade of representations" frame as an analytical tool to examine the link between a botanical garden's phenomenology and children's emergent constructs of limiting factors and variations in plant structures enabling fit in different environments. Our analysis is organized into four phases: framing of the question and motivation for the research; tools, the inscriptions they enable and the transformation thereof; focusing the class' "unified gaze" on a new "synoptic tableau" that has emerged from the transformations; and re-exploring the big questions that motivated the inquiry, through the perspective of the emergent big ideas. By providing children with multiple opportunities to interact directly with phenomena, to inscribe their observations, and to transform these inscriptions–both outside and inside the school walls–our analysis reveals a more synergistic relationship between phenomena and science classrooms, one that supports children iteratively building from their work in the field towards conceptual advancement of core scientific ideas.

### Strand 4: Science Teaching--Middle and High School (Grades 5-12): Characteristics and Strategies *Physical Science Knowledge in High School*

1:15pm-2:45pm, Sterlings 2 & 3 **Presider:** Muhammet Mustafa Alpaslan, Texas A&M

#### A Model-Observe-Reflect-Explain (MORE) Laboratory Module: Promoting High School Students' Molecularlevel Understanding of Dissolution

Linda Cummings, The Classical Academy, allegromus@gmail.com

Youngjin Song, University Of Northern Colorado

**ABSTRACT:** This study investigated the effectiveness of the Model-Observe-Reflect-Explain (MORE) Thinking Frame on promoting high school students' molecular-level understanding of dissolution. A chemistry laboratory module about the dissolution of salt and sugar in water was designed and implemented in high school chemistry classes. Two guiding research questions were: 1) what are students' molecular-level ideas about chemical compounds dissolved in water before the MORE laboratory module? and 2) how does the implementation of a MORE laboratory module affect student ideas of dissolution at the molecular level? Students' written explanations and drawings in their initial and refined models were collected. This data was analyzed both quantitatively using a coding scheme and qualitatively using a constant comparative method. Overall, the MORE laboratory module helped high school students improve their understanding of dissolution at the molecular level. Various alternative conceptions were identified throughout the study. Students' molecular-level ideas and models about dissolution are discussed under six themes: 1) substances exist as they are in water; 2) substances break into smaller species; 3) substances form bonds with water molecules; 4) substances do not dissolve; 5) other incorrect ideas and 6) no molecular-level ideas. Implications for teaching chemistry and using a MORE laboratory module are suggested.

## Advancing Tasks in Physics Education: Sharpening the Understanding of Scientific Experiments through Explicit Representational-Analysis-Tasks

Jochen Scheid, University of Koblenz-Landau, Germany, scheid@uni-landau.de

Andreas Mueller, JUFE (University of Geneva), Switzerland

Rosa Hettmannsperger, University of Heidelberg, Germany

Wolfgang Schnotz, University of Koblenz-Landau, Germany

**ABSTRACT:** Research in science education has shown that multiple representations are essential for an adequate understanding of scientific experiments and phenomena. A basic skill for efficient work with multiple representations is that students are able to generate coherent representations. However, students' level of representational coherence ability is low. It is a longstanding issue that students learn too little while doing science experiments, which usually involve implicitly multiple representations. Therefore, it is necessary to consider multiple representations and coherence in the future development of science education. To overcome these problems, Representational-Analysis-Tasks (RATs) were designed to focus on cognitive activation in connection with representations and physics experiments. In a field study, the comparison of a treatment dealing with RATs to a control group based on traditional tasks yielded a practically relevant effect on students' representational coherence ability and therefore students' understanding of science experiments (method: multilevel model for measuring changes: p < 0.001;  $\omega^2 = 0.09$ , n = 302). The methodological features of the above study are discussed (control measures, validity of instruments, etc.) as well as the significance of their results for theory and classroom practice, including their limitations, perspectives, and the outlook for the research of the next years.

### Secondary Science Students' Knowledge of Molecule Movement, Concentration Gradients, and Equilibrium through Multiple Learning Contexts

Sara P. Raven, Kent State University, sraven1@kent.edu

Julie M. Kittleson, University of Georgia

**ABSTRACT:** In education, the need to understand how students learn is imperative to both classroom management and educator research. In this study, I evaluated student knowledge of three related and important scientific concepts through different methods of assessment, framed by their use of curricular modules that feature 3-D computer environments of biological processes. In an attempt to characterize students' knowledge within a variety of learning contexts, I focused on

the experiences and evaluations of three case studies as they completed the modules, and sought to address the following question: How can students' knowledge of molecule movement, concentration gradients, and equilibrium be characterized in different learning contexts, including computer-based modules containing simulations? I qualitatively analyzed the work of three participants, coding the data for their understanding of scientific concepts, while also noting additional trends. Results from my analysis showed that, despite fairly consistent test scores and forced-choice question scores within the modules, the students maintained misconceptions related to molecule movement, concentration gradients, and equilibrium throughout the unit. These misconceptions not only affect students' learning of these concepts, but their future understanding of other key concepts, including chemical equilibrium, respiration, photosynthesis, and many other biological and chemical processes.

#### Strand 5: College Science Teaching and Learning (Grades 13-20) Engineering Pedagogies to Encourage Critical Thinking

1:15pm-2:45pm, King's Garden 2 **Presider:** Stanley M. Lo, Northwestern University

### Scientific Reasoning in relation to Content Learning among University Science and Engineering Students Lin Ding, The Ohio State University, ding.65@osu.edu

**ABSTRACT:** Besides the goal of increasing student content knowledge, many college-level science and engineering courses are also aimed at improving student scientific reasoning skills. It is broadly recognized that increased scientific reasoning is beneficial for content learning. However, what remains controversial is the extent to which content learning may impact scientific reasoning. Anchoring in the Neo-Piagetian framework of skill development in relation to knowledge acquisition, we investigated the variations in student scientific reasoning across different years and majors in top-ranked Chinese higher institutions. In total, 614 students from four years and two majors (science and engineering) participated in the study, representing students exposed to different amounts and domains of content learning. The Lawson Classroom Test of Scientific Reasoning (LCTSR) was used to quantitatively measure student reasoning skills. Results showed that there was little divergence in student performance on the LCTSR across year and major. This suggested that regardless of how long students had been in higher education or what they studied, their scientific reasoning measured by the LCTSR by-and-large remained constant. Results of this study call our attention to the status quo of undergraduate science and engineering education.

Engineering Student Metacognition during Dynamic Transfer in a Problem Solving Scenario

Adam Kirn, Clemson University, akirn@clemson.edu

Courtney J. Faber, Clemson University

Lisa C. Benson, Clemson University

**ABSTRACT:** Effective learning requires making connections between prior knowledge and new learning environments, and is often referred to as knowledge transfer. Assumptions that transfer occurs throughout the problem solving process and that each student perceives the transfer environment differently established the need to classify transfer as productive or unproductive. Given that teaching metacognitive skills can lead to improved transfer, we aim to identify how metacognition mediates transfer. Five engineering students solved a cellular mechanics problem that applied basic statics knowledge on a micro length scale. Interview transcripts from two students are presented. Coding schemes identifying evidence of dynamic transfer along with metacognitive regulation were used to evaluate students' responses. Both solutions showed connections between tools (prior knowledge and problem features), indicating that both students transferred knowledge to solve the problem. Each student identified similar tools; however their solutions were very different, indicating that coding for transfer alone could not differentiate between student experiences. A lack of planning was evident in a solution with unproductive transfer. In another solution, using more types of metacognitive regulation may have helped overcome knowledge limitations, resulting in productive transfer. Comparing cases demonstrates that tool selection and processes controlling tool usage are key aspects of productive transfer.

Assessing Dynamic Transfer of Knowledge during Engineering Problem Solving Using Teaching Interviews Courtney J. Faber, Clemson University, cfaber@clemson.edu

Adam N. Kirn, Clemson University

Randolph H. Hutchison, Furman University

Lisa C. Benson, Clemson University

**ABSTRACT:** Knowledge transfer has been regarded as one of the primary goals of education, and can be defined as the application of prior knowledge to novel situations. This study combines components from two current transfer frameworks to examine the dynamic construction of knowledge in a problem solving scenario from an actor-orientated perspective. Undergraduate engineering students were asked to solve a problem of appropriate difficulty that was in their discipline but involved a context that was new to them. They then participated in guided self-reflection (teaching interviews) to explain their problem solving processes. Qualitative analysis of student explanations of their problem solutions was conducted to assess student knowledge transfer using an a priori coding scheme. Two cases are presented that represent the richness of data that can be collected and assessed using the proposed methodology. Analyses of these two cases demonstrate how, during a teaching interview, students 1) interact with an instructor, 2) use fabricated and propagated knowledge to solve a problem and evaluate their answers, and 3) construct new knowledge while solving a problem. In addition to establishing an actor-oriented approach to examine the dynamic transfer of knowledge, this study characterizes how students transfer knowledge during a teaching interview.

#### Strand 6: Science Learning in Informal Contexts Novel Methods for Assessing Informal Science Learning

1:15pm-2:45pm, Benedum **Presider:** Jennifer Dewitt, King's College London

*Translating Existing Research into New Approaches for Evaluating Informal Science Education* Joy Kubarek-Sandor, Illinois Institute of Technology, kubareksandor@yahoo.com Stephanie Bohr, John G. Shedd Aquarium

**ABSTRACT:** For years, informal learning sites such as museums, zoos, and aquariums have conducted education evaluation. However, the degree of accuracy and acceptance of these evaluations has been widely debated, in part because of the dynamic and complex nature of contexts and audiences. Learners in informal settings are not subjected to the same contrived parameters for learning as in schools. Learners have diverse motivations and expectations. Learning outcomes may not be immediate enough to observe in the moment, nor may outcomes be readily assessed by a one-time exam. In addition to the challenge of accurately measuring learning at informal sites, often there is a lack of dedicated staff with expertise to do so. Yet, the demand to demonstrate what learning occurs is still very much present, even more so today as funds are scarce and funders ask to see return on their investment. So the question arises: what is your impact? To answer this question, this study investigated a research-based approach to evaluation of science learning in an informal setting. Findings of this study demonstrate this new approach has aided in building evaluation capacity within an informal science institution as well as establishing measures, instruments, and assessments to accurately do so.

#### Assessing Visitor Learning in Zoos and Aquaria: A Revised Framework

Chantal L. Barriault, Curtin University, chantal.barriault@postgrad.curtin.edu.au

**ABSTRACT:** The Visitor-Based Learning Framework has been used successfully to assess the learning impact of exhibits in science centres. The "Visitor Engagement and Exhibit Assessment Model", an extension of the framework, describes and predicts relationships between exhibits, visitors and observable learning behaviours. The framework and model have the potential to become practical learning and exhibit assessment tools for practitioners across informal science learning settings, including zoos and aquaria. This study examines visitor behaviour and dialogue in zoos and aquaria to build on the strengths of the Visitor-Based Learning Framework and to increase its validity and applicability across settings. The analysis of behaviours and dialogue as visitors interact with each other while observing live animal habitats in zoos and aquaria was based on a socio-cultural constructivist approach to learning and focused on finding evidence for the precursors to meaning making and learning. The findings of this study give us insights into the nature of learning in zoos and aquaria where a visitor's interaction with exhibits is less physical and involves more social and

reflective interaction. The revised Visitor-Based Learning Framework provides zoo and aquarium practitioners, and researchers with a valuable tool to assess the learning impact of live animal exhibits through observable behavioural indicators.

#### Strand 7: Pre-service Science Teacher Education *Preservice Teachers' Beliefs and Conceptions of Science and Science Teaching* 1:15pm-2:45pm, King's Garden 3 **Presider:** Robert H. Evans, University of Copenhagen

Investigating Possible Background Characteristics Affecting Science Teaching Conceptions Elif Adibelli, University of Nevada, Las Vegas, adibelli@unlv.nevada.edu

Hasan Deniz, University of Nevada

Mustafa Sami Topcu, Yildiz Technical University

**ABSTRACT:** The purpose of this study was two-fold: (1) comparing Turkish preservice and inservice science teachers' teaching conceptions and (2) exploring whether preservice and inservice science teachers' teaching conceptions change with the time. We found that preservice science teachers held more constructivist teaching conceptions compared to inservice teachers. Preservice teachers held less traditional conceptions of teaching as they spent more time in the teacher education program but their commitment to constructivist teaching conceptions did not change over the years in the teacher education program. Inservice teachers' both traditional and constructivist teaching conceptions did not change as their teaching experience years increased.

#### *Elementary Education Majors' Views on Evolution: Awakening the Dialogue on Elementary Education Models* Ronald S. Hermann, Towson University, rhermann@towson.edu

**ABSTRACT:** Elementary teachers play a crucial role in breaking the cycle of continued evolution controversy as they have the capacity to introduce science concepts and ideas at the same time students may first be presented with antievolution messages. However, the structure of elementary education programs and elementary schools may provide an additional barrier to breaking the cycle. This study compared elementary education majors' acceptance and understanding of evolution to other majors. The results indicate that the elementary education majors surveyed maintain a significantly lower acceptance and understanding of evolution as compared to other majors not tasked with teaching evolution in America's public schools. However, the results indicate that several of the elementary education majors surveyed maintain high levels of acceptance and understanding of evolution. Perhaps, a better way forward is to cultivate those students willing and able to teach evolution into elementary science education specialists. This research serves to awaken the dialogue on elementary education models by suggesting that a specialist model may remove a barrier to increasing acceptance and understanding of evolution. Further, a specialist model would provide a solution to the problem of trying to include more science content and pedagogy into current generalist teacher education programs.

Where is Science? An Exploration of the Places Student Teachers Associate with Science Learning

Anna T. Danielsson, Uppsala University, anna.danielsson@edu.uu.se

Kristina Andersson, Uppsala University

Annica Gullberg, University of Gävle

Anita Hussenius, Uppsala University

**ABSTRACT:** Working from a starting point that acknowledges the sense of place as important for educational experiences this paper is exploring what places early years and primary school student teachers associate with science as well as the affective dimensions they relate to these places. The aim of the paper is two-fold: to construct a conceptual framework to guide an exploration of student teachers' place-related science narratives and to employ this framework in an initial analysis of how different places are reflected in the student teachers' science learning narratives. The data from this paper comes from a written assignment, where the student teachers' (N=120) reflected on their science learning experiences science teaching and how those experiences had impacted on their relation to science today through a written essay. The paper reports on the initial development of a conceptual framework for exploring student teachers' place-related science learning narratives, drawing on the work by geographers Massey (2004) and Relph (1976), as well as some

preliminary analysis of student essays. The preliminary analysis shows that the student narratives often conflate science and nature, and many of the essays contrast experiences of insideness in places of nature and outsideness in the science classroom.

#### Dynamic Shifts within Belief Systems

Brian Scott Fortney, Texas Tech University, brian.fortney@ttu.edu

**ABSTRACT:** Much work has been done on teacher beliefs and General Systems Theory in the past 15 years, with advances in understanding change in teacher beliefs utilizing complex perspectives. In the recent decade, research has emerged that considers conceptual change from a complex perspective. We offer an interpretation of dynamic change in teacher beliefs utilizing Bertalanffy's General Systems Theory as an overarching framework that embraces disparate perspectives, presented through the construction of the belief structure of one preservice teacher, from a larger study.

#### **Strand 7: Pre-service Science Teacher Education**

*Teacher Preparation and Development for Inquiry-Based Learning Environments* 1:15pm-2:45pm, Rivers **Presider:** Phillip A. Boda, Columbia University

## *Preparing for Inquiry: Examining the Design of Model-based Inquiry Experiences by Preservice Science Teachers*

Ron Gray, Northern Arizona University, ron.gray@nau.edu

Allyson Rogan-Klyve, Oregon State University

**ABSTRACT:** The purpose of this study is to examine the specific challenges preservice secondary science teachers encounter when designing and implementing model-based inquiry (MBI) instructional units. Eight preservice secondary science teachers designed and implemented MBI instructional units during their teacher education program. Data sources including planning and classroom artifacts, classroom video, and post-instructional interviews were analyzed to determine specific difficulties encountered by the teachers. Findings indicate that the participants succeeded in utilizing models for pedagogical and cognitive purposes, but struggled with integrating the epistemic nature of models and modeling into their unit. In addition, their background knowledge of the concepts under study and of the role of models in the construction of those concepts were challenged, especially in the selection of appropriate phenomena and the construction of scientific explanations of those phenomena. The findings help elucidate the difficulties novice teachers have in implementing reform-based pedagogies as required by the new national science standards.

Using Research on Cognitive Discussion Strategies to Support Pre-Service Science Teachers' Model-Based Teaching Skills

Grant Williams, St. Thomas University, grantw@stu.ca

John J. Clement, University of Massachusetts

**ABSTRACT:** One of the eight core scientific practices identified by the Next Generation Science Standards to help learners construct understandings of abstract concepts is the development and use of models. In this study we focus on explanatory mental models which are internal cognitive representations of normally hidden mechanisms that can explain why phenomena in a system occur. Our group has studied the model-based strategies used by successful teachers in a wide variety and grade level of conceptually challenging K-12 science topics and we have converged on a set of twelve key cognitive discussion-based teaching strategies that are believed to support students' conceptual understanding of complex science topics. As a result, the most recent phase of our research has been the development and implementation of an eight-week model-based teaching unit for pre-service science educators that introduces these strategies. The unit also includes videotaped practice mini-lessons that are shared with the pre-service teachers and their classmates for analysis and evaluation. Evidence from pre, post, and delayed post surveys and interviews is presented that indicates how the unit positively impacts the way the pre-service teachers view their developing practice.

Collaborative Reflective Supervision: Scaffolding Preservice Science Teachers' Classroom Practice of Inquiry Jeerawan Ketsing, Kasetsart University, fedujwk@ku.ac.th

**ABSTRACT:** This paper extends research on how to support preservice science teachers' practice of inquiry in their actual classrooms. The case study aimed to examine the change in preservice teachers' practice of inquiry as a result of their participation in the collaborative action research (CAR) project as well as to explore factors that support and limit their practice of inquiry in a Thai classroom context. Through the analysis of multiple data sources, the study found that the CAR project was productive in affecting change in the novice teachers' inquiry teaching practice in real-life contexts. Crucial factors associated with the Thai culture that are likely to have both positive and negative impact on the development of preservice teachers are relationships among the project members and fear of thinking "outside the box" in designing learning activities. The paper calls for further discussions on how the basic elements of CAR could be integrated into preservice teachers' supervision model and how the crucial factors could be addressed to enrich a full classroom practice of inquiry.

Conceptual Change in Science Teacher Preparation: Collaboration between Scientist and Educator Will Stoll, Georgia State University, wstoll2@student.gsu.edu Brett A. Criswell, Georgia State University

Abdulkadir Demir, Georgia State University

**ABSTRACT:** A physics class for secondary science teacher candidates collaboratively developed and taught by faculty from the College of Education and the Department of Astronomy & Physics integrating physics content with a conceptual change pedagogical approach is the focus of this paper. Based on the first year results, the candidates show a growing awareness of the important role students' ideas play in the teaching and learning of physics. A major factor appears to be the candidates experiencing conceptual change firsthand in the class which produces within them a fresh perspective into what is involved in facilitating conceptual change. Another significant finding is the candidates identifying of the 'bridging' that occurred through the collaborative teaching of the course. The two faculty members created bridges between their two disciplines producing a fuller picture to the candidates of how physics content and pedagogy must be integrated. Candidates showed an increase in both their physics conceptual knowledge and their confidence in understanding of physics following the course. One limitation found was, despite a growing awareness of the importance of students' ideas and teaching for conceptual change, candidates did not display confidence in applying this to their own teaching.

#### Strand 8: In-service Science Teacher Education Examining Professional Communities

1:15pm-2:45pm, Sterlings 1

#### Unpacking the Noticing of Secondary Science Cooperating Teachers

Shelly Rodriguez, University of Texas, shelly.rodriguez@austin.utexas.edu

**ABSTRACT:** During a typical early field experience, cooperating science teachers interact with preservice teachers to observe and provide feedback. While cooperating teachers are influential in determining the kinds of practices that preservice teachers see, little attention has been paid to their professional growth. This case study focuses four secondary science cooperating teachers working with a nationally recognized STEM teacher preparation program. The study asks: 1. What do secondary science cooperating teachers notice as they observe preservice teachers enact lessons during an early field experience? 2. Does the act of noticing stimulate pedagogical reasoning? 3. What, if any, connections do secondary science cooperating teachers draw between what they notice and their own teaching practices? The findings show that the cooperating teachers primarily notice areas of general pedagogical reasoning. Finally, the data reveals that teachers draw connections that lead them to inquire into their current practice. Implications of this work include: the design of observation tools that direct teacher noticing to student learning in science, viewing cooperating teachers as learners, including metacognitive activities for cooperating teachers, and reorienting lesson debriefs toward a notion of classroom inquiry.

Enhancing Science Teachers' Understanding of Teaching Socioscientific Issues through Collaborative Action Research

Hyunju Lee, Ewha Womans University, hlee25@ewha.ac.kr Yeonjoo KO, Ewha Womans University

**ABSTRACT:** The study aimed to enhance science teachers' understanding of teaching SSIs and to promote their enactment of SSI instruction by adapting collaborative action research approach. Thus, we recruited two science teachers (Catherine and Jennifer) who wanted to address SSIs but had limited experience in teaching SSIs. The research questions included 1) what kinds of practical issues the teachers encountered when implementing SSIs, and 2) how their teaching practices and views on teaching SSIs had evolved over time? The primary data source was audio-tapes of regular group meetings containing information on the process of constructing or revising lesson plans and teachers' reflection. We also collected classroom video-tapes of teachers' SSI instruction and students' worksheets. The results indicated that when addressing SSIs in the classes Catherine and Jennifer encountered several challenges: 1) students' tendency of avoiding conflicts with peers, 2) amount of scientific knowledge to deliver, 3) management of students' moral conflicts, and 4) finding their niche in schools. As addressing SSIs, however, they gradually observed the benefits of implementing SSIs. Catherine found the potentials of SSI teaching for student character development. Jennifer observed noticeable changes in students' attitudes during SSI classes, which initiated her to reconsider her role as a teacher.

#### Supporting Science Teacher Learning and Development in Professional Learning Communities Cheryl A. McLaughlin, University of Florida, chermac72@ufl.edu

**ABSTRACT:** Professional learning communities (PLCs) are generally regarded as an effective approach to teacher development that could engender significant improvement in teaching and learning. Collaborative activities in PLCs mirror the way scientists work together to develop new knowledge, and are particularly valuable for science teachers who can draw from these experiences to improve the quality of learning for their students. The purpose of this qualitative study was to examine interactions within a PLC constituting middle school science teachers who were preparing to implement a reform-oriented curriculum, in order to determine the extent to which interactions contributed to their learning and development. Findings from careful analysis of the discourse generated as a result of the interactions, revealed that teachers used the PLC to 1) seek clarification for ideas that were not completely understood during formal instructional experiences, 2) share personal interpretations and adaptations of pedagogical innovations to which they had been introduced, and 3) refine understandings of important concepts as they attempted to close gaps in their knowledge base. Findings from our investigation uncovered the learning that occurred when our teacher participants collaboratively engaged in activities designed to improve their practice.

#### The Relative Influence of Professional Community on Changes in Science Teaching

Steven Mcgee, Northwestern University, mcgee@lponline.net

#### Linda C. Lee, Northwestern University

**ABSTRACT:** Previous research has shown that professional learning communities have the potential to be a powerful lever for continuous improvement in school settings. This research seeks to extend previous research by unpacking the characteristics of professional community that influence science teaching practice and focusing the research on neighborhood schools in an urban setting, where low student performance and high teacher turnover present barriers to professional community. All of the science teachers in a particular network of neighborhood schools in an urban setting were surveyed on the extent to which they participated in a variety of formal and on-the-job learning opportunities. The teachers also indicated the extent to which they changed their teaching practices in the previous year. The results indicate teachers engaged in a variety of professional community activities such collaborative discussions about curricula and student work and that these conversations statistically predicted the extent to which teachers changed their teaching practice in the previous year. Science educators who are supporting implementation of science curricula in urban settings would be well advised to consider how to support these ongoing conversations about their curricula and resulting student work products.

Tracing Professional Learning: Research Supporting the NSTA Learning Center Darren Cambridge, American Institutes for Research Albert Byers, NSTA ABSTRACT:

Strand 10: Curriculum, Evaluation, and Assessment Curriculum Reform and Enactment

1:15pm-2:45pm, Duquesne **Presider:** Jim Ryder, University of Leeds

A Framework for Anchoring Analogical Reasoning Activities to the Chemistry Laboratory Experience Mitchell Bruce, University of Maine, mbruce@maine.edu Shirly Avargil, University of Maine Alice Bruce, University of Maine Francois Amar, University of Maine

**ABSTRACT:** This NARST paper explores a sequence of curriculum strategies and theories that form a framework for understanding how anchoring analogical reasoning activities to the chemistry laboratory experience can help students make connections between macroscopic observations and submicroscopic representations, and then use these representations when designing experiments. One of the key aspects of student learning in the laboratory that we have focused on is the transition between making lab observations and designing experiments, which for most students is very challenging. The theoretical basis for introducing analogy into laboratory work is the recognition that making the connections between the macroscopic and atomic domains inherently involves analogical reasoning. There are two prominent ways that chemists use analogical reasoning in lab. First, when looking at macroscopic chemical phenomena and representing it at the atomic level. Second, when thinking at the atomic level during analysis, in order to design macroscopic experiments to test understanding. Our framework seeks to understand these two analogical processes. The overall goal of exploring the framework is to understand how to successfully transition students from making lab observations to designing experiments, through a representation building analogy activity.

#### *Chemistry Teachers' Implementation of Science Curriculum Reform: A Perspective from Turkey* Fatih C. Mercan, Bogazici University, fatih.mercan@boun.edu.tr

**ABSTRACT:** In Turkey, as part of science curricular reform, the secondary school chemistry curriculum was renewed in 2008. However, there is limited research investigating chemistry teachers' enactment of the new curriculum. This study aimed to identify and describe teachers' views about the implementation of the chemistry curriculum. The participants were 31 teachers working in 27 different schools in Istanbul. Data were collected using semi-structured interviews, analyzed using constant comparative method. The data showed that 65% of the chemistry teachers considered the goal of chemistry teaching as preparing students for the university entrance examinations, 55% of the teachers said that their teaching methods remain unchanged, and 81% of the teachers said that they did not do experiments in their classes. The data also showed that for the teachers the university entrance exams were the real criterion for assessment, and they stressed the need for the alignment of the content and format of these exams with the chemistry curriculum. The results imply that the university entrance exams and other high stakes tests must be considered in any curricular reform and that these tests can be deployed as tools to facilitate science curricular reform.

## Teachers' Experiences of Externally Driven Science Curriculum Reform: A Review of Empirical Studies Jim Ryder, University of Leeds, j.ryder@education.leeds.ac.uk

**ABSTRACT:** The science curriculum undergoes a constant flow of differing reform initiatives in many countries. Furthermore, the enactment of these reforms within schools rarely reflects the intended outcomes of the designers. This review analyses what we know from empirical studies of the experiences of teachers in the enactment of externally driven school science curriculum reform. 'Externally driven' signals a focus on studies involving teachers who have not necessarily 'bought in' to a curriculum reform initiative. The review includes studies examining teachers' experiences of systemic, mandatory curriculum reform, and other studies focusing on local curriculum reform activities. These studies draw upon differing theoretical perspectives. Many studies focus on individual teacher knowledge and beliefs; a teacher agency perspective. Other studies explore how teachers' experiences are conditioned by social and institutional structures within and beyond the school workplace; a structure-agency perspective. Other review themes include: the practice of lines of authority in teachers' work; teacher autonomy and professionalism; and teacher identity. The review addresses the NARST conference theme by seeking to 'awaken dialogues' that consider the extent to which the education research community is giving sufficient attention to the daily working practices of teachers, particularly those teachers who are not closely linked with university education departments.

#### *Clarity and Understandability of Two Modeling Langugaes in a Large-scale Project-based Information Systems Engineering Course*

Niva Wengrowicz, Technion-Israel Institute of Technology, nivawen@technion.ac.il

Dov Dori, Technion-Israel Institute of Technology

Yehudit Judy Dori, Technion-Israel Institute of Technology

**ABSTRACT:** Model-based systems engineering is an emerging approach to coping with the complexity of systems via conceptual models. Project-based learning (PBL) engages students in active learning via projects they carry out. We developed a new course format, in which groups jointly reverse-engineer and model Web-based information systems in two different modeling languages, UML and OPM, and then individually assess their peers' projects. The goal of this study was to investigate the development and evaluation of an online peer assessment tool students used for the peer assessment. About 130 undergraduate students in groups of six divided into teams of three modeled 23 systems in both UML and OPM. They then evaluated, compared, and ranked the clarity and understandability of the four models of two systems that their peers had constructed. Findings demonstrate that neither the order of the models assessment nor the assessor gender affected the grading, indicating assessment reliability. There were significant differences in model clarity and understandability between OPM and UML models in favor of OPM. These findings contribute to theory and practice of teaching and peer assessment in large-scale project-based undergraduate engineering courses.

#### Strand 10: Curriculum, Evaluation, and Assessment

## *Related Paper Set – Educative Curriculum Materials for Elementary Science: Exploring Teachers' Use and Teachers' and Students' Learning*

1:15pm-2:45pm, Smithfield

#### Presider: Elizabeth A. Davis, University of Michigan

**ABSTRACT:** Ambitious science teaching grounded in authentic scientific investigation provides an ideal context for students to acquire the conceptual understandings and scientific practices integral to becoming scientifically literate members of society. However, such opportunities continue to elude elementary students in the U.S. and elsewhere, in part because teachers are not always prepared to enact this ambitious instruction. Educative curriculum materials can provide one form of support for elementary teachers. We explore how elementary teachers use educative curriculum materials-curriculum materials designed to promote student learning as well as teacher learning. Building on commercially-available, reform-oriented, kit-based curriculum materials, we overlaid a set of educative features. These features were intended to support teachers in developing stronger subject matter knowledge, recognizing and establishing curricular coherence, fostering scientific practices in the service of developing conceptual understandings, and engaging students with other reform-oriented instructional practices. This related paper set presents the results of a program of research conducted to explore how teachers used these educative features and to characterize teacher learning, teacher practice, and student learning for classrooms in which teachers received the enhanced version of the curriculum materials, as compared to those in which teachers used the original curriculum materials.

Investigating the Impacts of Educative Curriculum Materials: A Quantitative Perspective Patrick S. Smith, Horizon Research, Inc., ssmith62@horizon-research.com Adrienne A. Smith, Horizon Research, Inc. 'Barely Four Hours a Week': Goals, Priorities, and Trade-offs in One Elementary Teacher's Investigation-Based Science Instruction Stefanie K. Iwashyna, University of Michigan, siwashyn@umich.edu Anna Maria Arias, University of Michigan Elizabeth A. Davis, University of Michigan Annemarie S. Palincsar, University of Michigan

Investigating the Effects of Teaching Challenging Science Text with and without Educative Literacy Features Annemarie S. Palincsar, University of Michigan, annemari@umich.edu Anna Maria Arias, University Of Michigan

Supporting Use of Scientific Academic Language: Teachers' Use of Content-Corused Educative Features Sylvie M. Kademian, University of Michigan Anna Maria Arias, University of Michigan Elizabeth A. Davis, University of Michigan Annemarie S. Palincsar, University of Michigan

Teachers' Use of Curriculum Material to Engage Elementary Students in Science Practices Integrated with Science Content

Anna Maria Arias, University of Michigan John-Carlos Marino, University of Michigan Sylvie M. Kademian, University of Michigan Elizabeth A. Davis, University of Michigan Annemarie S. Palincsar, University of Michigan Brian J. Reiser, Northwestern University

#### Strand 11: Cultural, Social, and Gender Issues

#### Symposium – Science Education for Learners with Special Needs

1:15pm-2:45pm, Birmingham

#### **Presenters:**

Anna R. Lewis, University of South Florida St. Petersburg, ARLewis@usf.edu J. Randy McGinnis, University of Maryland Sara Aronin, West Virgina University

**ABSTRACT:** This session has two purposes: 1. To report on the status of learners with special needs in US public schools, and 2. To identify gaps in the science education research worldwide, specifically in areas pertaining to the school-aged population of learners with special needs. In the US, Approximately 95% of the 6.5 million school age students with disabilities are educated in regular schools, with majority of them spending at least 80% of their day in general classrooms. Among the many findings of a study conducted by Kahn & Lewis (2013), the most encouraging was that the overwhelming majority of science teachers surveyed believe they need and want professional development in this area; in fact, most feel it should be required. The implications of the findings from the survey for teacher education programs, districts, and national organizations will be discussed. In addition, gaps in the literature base will be identified as found in a recent comprehensive review of the literature (McGinnis and Kahn, 2013). In this session specific research questions that need to be answered for improving science teaching and learning for learners with special needs in science will be presented; sharing of ideas and experiences will be solicited and encouraged.

#### Strand 13: History, Philosophy, and Sociology of Science NOS & PCK 1:15pm-2:45pm, Heinz Presider: David E. Long, George Mason University

## Assessment of Understandings of Nature of Science in Science Education: Past, Present, and Future Fouad Abd-El-Khalick, University of Illinois at Urbana-Champaign, fouad@illinois.edu

**ABSTRACT:** This review of the literature explores the history of assessing learners' conceptions of nature of science (NOS) from the 1950s to the present. This exploration pays close attention not only to the shift from mostly convergent-type, quantitative to the largely open-ended, qualitative variety of the most widely used NOS assessments, but also scrutinizes the extent of use, and the psychometric properties and trustworthiness of these assessments, respectively. While tracking changes in the nature and focus of NOS assessments, the review pays particular attention to the 'strained' nature of the domain given the seemingly contested nature of the target-of-assessment (i.e., the construct of NOS itself), and the varied perspectives regarding the ideal context(s) within which these assessments are most meaningful, as well as the goal of such assessment. The review concludes with sketching a pathway forward to help navigate the tricky landscape associated with the 'nature of NOS' and the pragmatic needs of assessing student learning of what has consistently been deemed a central and organizing theme for scientific literacy and precollege science education.

### A Comparison of Teachers' Knowledge Structures for NOS and SI and their Classroom Practice

Stephen A. Bartos, Middle Tennessee State University, Stephen.Bartos@mtsu.edu

#### Norman G. Lederman, Illinois Institute of Technology

**ABSTRACT:** This investigation examined teachers' subject matter knowledge structures for NOS and SI in comparison to those conceptions espoused in their classroom practice. It was conjectured that such a framework would provide insight beyond what can typically be gleaned from commonly utilized NOS- and SI-assessments. In general, from multiple data sources teachers' classroom practice knowledge structures were inductively-generated and then compared to teachers' conceptions of NOS and SI communicated through a questionnaire and related interview. For all participants, results indicate limited congruence between the two knowledge structures. While there was moderate similarity typically evidenced at the level of included concepts, a notable dearth of explicit connections between included concepts characterized teachers' classroom practice knowledge structures. Results underscore the difficulty in both developing integrated and coherent conceptions of NOS and SI, and in seeing these manifest themselves during instruction. Implications for the vision of science content, science practices, and NOS forwarded in the NGSS are further examined, among others, in light of these data.

## Impact of Self-Regulation on Pre-Service Science Teachers' Conceptual Understandings about Nature of Science in Hypermedia

Mehmet F. Tasar, Gazi Universitesi

Nagihan Imer Çetin, Gazi Universitesi

#### Betül Timur, Çanakkale On Sekiz Mart University

**ABSTRACT:** We examined "how self-regulation affected pre-service science teachers' learning about nature of science (NOS) while using hypermedia". The research was conducted in two different 3rd year groups of pre-service science teachers. One group was randomly assigned as experimental group to examine the effectiveness of self-regulation on learning about NOS within hypermedia, the other group was assigned to control group to examine the role of hypermedia in learning of nature of science. Participants in the experimental group, who were encouraged to use self-regulatory techniques, learned the NOS in hypermedia while participants in the control group learned NOS by using only hypermedia. Data were gathered by VOSTS questionnaire, concept map and think aloud protocol. The findings emerged from VOSTS and concept maps showed that experimental group's NOS understandings developed more than the control group's. The think aloud protocol data indicated that the experimental group used these self-regulation behaviors as follows: "Setting goals and planning", "Recycle goal in working memory", "Judgment of learning", "Content evaluation", "Expectation of adequacy of content", "Monitoring progress toward goals", "Monitoring learning strategy use", "Monitoring time", "Repetition", "Reviewing notes", "Taking notes", "Goal-directed search". By contrast, control group used mostly ineffective strategies.

The Clinical Internship's Influence on Mentor Teachers' Classroom Practice for and Conceptions of NOS

Judith S. Lederman, Illinois Institute of Technology, ledermanj@iit.edu

Stephen A. Bartos, Middle Tennessee State University

Selina Bartels, Illinois Institute of Technology

Norman G. Lederman, Illinois Institute of Technology

**ABSTRACT:** This study assessed the influence of the student teaching apprenticeships on both mentor teachers' and student teachers understanding and teaching of nature of science (NOS). Over the course of the 15-week program, the mentor teachers and student teachers engaged in cycles of planning for, teaching, assessing, and reflecting on NOS. Lesson plans, classroom observation and interview data were analyzed to gain insight into the effect of this relationship on the student teachers' and mentor teachers' understanding and teaching of NOS. The VNOS-D+ (Lederman & Lederman, 2009) was used to access the changes in both groups' understandings of NOS prior to and at the conclusion of the apprenticeship. Through this experience student teachers' evidenced more informed conceptions of NOS at the conclusion of the student teaching apprenticeship. Additionally, mentor teachers expressed an intention to continue teaching NOS lessons that were developed by the student teachers, in addition to incorporating NOS into other lessons. Implications for the professional development of both inservice and preservice teachers are made.

#### **Strand 14: Environmental Education**

#### EE perceptions and Understandings amongst Middle, Secondary, and College Students

1:15pm-2:45pm, King's Garden 4 **Presider:** Patricia Patrick, Texas Tech University

*Exploring Students' Understanding of the Energy Concept in Environmental Science Context* Mihwa Park, University at Buffalo, mihwapar@buffalo.edu Joseph A. Johnson, Edinboro University of Pennsylvania

**ABSTRACT:** Energy is a core and unifying concept across science disciplines and grade levels. However, little is known about how students demonstrate their understanding of energy in environmental science contexts. This study aimed to develop an assessment instrument and answer the following research questions: Is the instrument developed capable of producing reliable measures for assessing students' understanding of the energy concept? What ideas are held by college students, taking a beginning environmental science course, regarding energy in an environmental science context? An assessment instrument for understanding of the energy concept in an environmental science context was developed and tested for validity using a partial credit Rasch model analysis. Statistical analysis was followed by qualitative analysis of student responses to open-ended questions to explore common student conceptions. Study findings indicate that the assessment instrument is both reliable and valid for assessing students understanding of the energy concept and that student difficulty in understanding of energy is affected by both energy aspects and science content addressed. Qualitative analysis revealed several student conceptions of energy inconsistent with current scientific thought and science curricula. These findings can be used to inform practice in environmental science classrooms to better address these alternative conceptions.

### Secondary Marine Science Students' NOS Views, Socioeconomic Culture and Willingness to Mitigate Global Warming

Benjamin C. Herman, University of South Florida, bcherman@usf.edu

**ABSTRACT:** This study investigated Florida secondary marine science students who have learning experiences with the NOS and climate change/global warming to determine how their: 1) beliefs about global warming (GW) scientific methods and 2) socioeconomic culture are related to the extent they would act to mitigate GW. 595 GW surveys were randomly distributed to 28 marine science sections across two socioeconomic strata in a large Florida school district. 55% (N = 326) of the surveys were retained for analysis. Students who were aware of the extent scientists employ non-experimental procedures and ideas from various scientific fields were significantly (p > 0.05) more likely to engage in passive to moderately involved actions (e.g. support GW education, paying more for fuel) to mitigate GW than students

who were naïve or unsure about these methodological aspects of science. Furthermore, Title 1 students were significantly more willing to take on actions, passive in nature to those that would impose significant lifestyle changes (e.g. limiting offspring rates and meat consumption), that mitigate GW. Implications include preparing science teachers to "read" their students' socioeconomic/cultural background, and optimally teach about NOS and socioscientific decision making in response to large scale controversial SSIs such as GW.

#### *Reimaging Environmental Education: Urban Youths' Perceptions and Investigations of their Communities* Marissa Bellino, The Graduate Center, CUNY, marissabellino@gmail.com Jennifer Adams, Booklyn College- CUNY

**ABSTRACT:** Entrenched in an era of education reform that continually espouses a dominant set of values, schools have become detached from the communities in which they are situated and the lived experiences of their students. Environmental education has the potential to connect youth to their local communities but is often taught within a traditional paradigm where the historical, social, political, and economic causes of local environmental injustice are obscured. A critical pedagogy of place encourages educators to advocate for teaching and learning practices that reveal how modern developed economies have created environmental problems that are experienced as social injustices, disproportionately felt depending on race, class, and other social factors. The focus of this study is to explore how enacting a critical pedagogy of place and using a participatory methodology (Photovoice) in an urban science classroom can reveal the ways young people define, identify, and relate with their communities. Throughout the semester a variety of field texts and data were co-constructed including a community reflection, photographs, narratives, focus groups, presentations, reflections, and blog posts. Issues of globalization, consumption, gentrification, safety, and privatization of public spaces emerged as most salient to the students' experiences.

Sustainability on Earth and Science Learning: Perceptions from 8th Grade Pupils Involved with a Role Playing Activity

Sofia Freire, Institute of Education of University of Lisbon, asraposo@ie.ul.pt Mónica Baptista, Institute of Education of University of Lisbon

Monica Baptista, institute of Education of University of Lisbor

Ana Freire, Institute of Education of University of Lisbon

**ABSTRACT:** Current society places great challenges to citizens and as such to curricula. Raising awareness about sustainability is an urgent need and as such education for sustainability has gained relevancy for the last decades. It is acknowledged that science education can work as an important context for educating for sustainability. The goal of the present study is to know pupils' perceptions about the construction of a nuclear power plant after being involved with an activity of role playing, namely to identify their degree of involvement with the topic under exploration as well as the type of competencies manifested while involved in the activity. This is qualitative study, adopting an interpretative orientation. Participants were 39 pupils from 8th grade. Data analysis was inductive and consisted of uncovering salient patterns, singularities, and themes associated with the research aims. This study shows the importance of bridging science and sustainable education. Using an authentic fictional situation made the discussion relevant at the eyes of the pupils, and they were engaged with searching relevant information, thinking about it, and ways to present and to support their position. By proceeding this way, pupils became implicated with the theme under discussion and learnt about the curricular topic energy.

### Strand 15: Policy

Supporting the STEM pipeline 1:15pm-2:45pm, King's Garden 1 Presider: Sharon J. Lynch, George Washington University

What Can Be Learned About the Outcomes of NSF STEP-funded Projects From Publicly Available Data? Maryanne Sydlik, Western Michigan University, maryanne.sydlik@wmich.edu Cody T. Williams, Western Michigan University

**ABSTRACT:** The National Science Foundation invests large sums of money annually to fund programs designed to transform STEM education programs (e.g., STEP; TUES; GK12; S-STEM). The STEP program's (Science, Technology,

Engineering, and Mathematics Talent Expansion Program) goal is to build a workforce prepared to support and advance the country's need for ongoing technological and scientific advancements by increasing the retention and graduation of undergraduates in STEM fields. STEP projects are expected to achieve increased retention and graduation rates by developing curricular changes, innovations in student support systems, and making significant impacts on institutional culture. Given this wide scope of programmatic goals, it appears hard to quantify what might represent success or failure of STEP-funded initiatives, short of counting the number of students retained and graduating with STEM majors. Over the past 5 years, STEP has funded at least 144 projects, but very little information is available to evaluate what has/has not worked. Our study uses information available to the public via NSF STEP website awards documents and reported project dissemination efforts to begin to analyze the number and kinds of projects funded, and will serve as a starting point for a more systemic evaluation of STEP projects.

Postsecondary Outcomes for Graduates of Inclusive STEM-Focused High Schools

Barbara Means, SRI International, barbara.means@sri.com

Ann House, SRI International Viki Young, SRI International Haiwen Wang, SRI International Naomi Tyler, SRI International

**ABSTRACT:** This paper describes selected findings from a longitudinal study of inclusive STEM high schools (ISHSs) that provide mathematics and science preparation for a STEM college major and accept students on the basis of interest rather than prior achievement. The study involved surveys of 12th-grade students from three ISHSs, surveys from 12th-graders at three nearby comparison high schools without a STEM focus, and surveys from the ISHS students one year after graduation. The latter postsecondary survey was completed by 65% of the ISHS graduates who had completed a survey at the end of grade 12. Results show that nearly all responding ISHS graduates were attending college, most in 4-year degree programs. The great majority reported that they felt well-prepared for college and were doing well in their classes. A large proportion (84%) had declared a major by the end of their freshman year, and of these, over half had selected a STEM field of study. These data provide insight into the kinds of students that ISHSs serve, the experiences provided in these schools, and the potential for the long-term "ISHS" effect that school leaders and policymakers implementing this model have hoped to gain.

An Investigation of Urbanicity and Gender: Implications for Supporting the STEM Pipeline

Eric N. Wiebe, North Carolina State University, eric\_wiebe@ncsu.edu

Alana Unfried, North Carolina State University

LaTricia Townsend, North Carolina State University

Malinda Faber, North Carolina State University

Jennifer O. Corn, North Carolina State University

**ABSTRACT:** There is heightened policy interest in supporting student interest and perseverance in STEM related career pathways, including in the sciences. In response to this need, educational organizations across the country are implementing innovative STEM education programs, designed in part to increase student attitudes toward STEM subjects and careers. It is also known that demographic factors such as gender and locale influence likelihood of persisting in STEM career pathways. This paper describes results of a statewide STEM attitudes survey and reports on differences based on urbanicity and gender over multiple grades attitudes towards STEM areas and interest in pursuing careers in STEM fields. Results of the work indicate notable differences based on both these demographic dimensions and conclude the importance of considering these factors in policy development regarding STEM pipeline initiatives.

#### The Impact of STEM Charter and Magnet Schools on Achievement

Eugene Judson, Arizona State University, Eugene.Judson@asu.edu

**ABSTRACT:** Promotion of schools that focus on science, technology, mathematics, and technology (STEM) has been prevalent in recent years. To date, most related research has focused on characterizing STEM schools and determining their value in maintaining and developing high school students' commitment to STEM. Related prior research has focused on high schools, with a more recent shift toward examining inclusive STEM high schools. This study examined the effect of STEM elementary charter and magnet schools on student achievement in mathematics, reading, and language arts.

Within this study, a distinction was made between STEM charter schools and STEM magnet schools; the latter being schools operated by traditional public school districts. Achievement of students, who transferred to STEM magnet and STEM charter schools and remained in those schools for three years, were compared to (a) achievement prior to the transfer, and (b) achievement of students who transferred to non-STEM schools. Overall, no discernible effect on student achievement was detected on the students who transferred to either type of STEM elementary schools.

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

### Poster Session A 3:15pm – 4:15pm, Ballroom 2, 3, and 4

#### Strand 1: Science Learning, Understanding and Conceptual Change *Poster Session A* 2:15mm A:15mm Dellroom 2: 2: and 4

3:15pm – 4:15pm, Ballroom 2, 3, and 4

#### A1. Profiles in Learning by Argumentation

Lauren Barth-Cohen, University of Maine, lauren.barthcohen@maine.edu Daniel Capps, University of Maine Jonathan Shemwell, University of Maine

**ABSTRACT:** Although it is reasonable to expect scientific argumentation in the classroom to deepen content knowledge, few studies have illuminated precise mechanisms for how the processes of argumentation can promote knowledge construction. The present study investigates how aspects of argumentation, such as rebuttal and revising a claim, can support learners in developing content knowledge in geology. We use the Knowledge in Pieces epistemological perspective to model developing knowledge at a fine grain level. Data consisted of observations of middle school earth science teachers engaged in a multi-day professional development workshop that focused on modeling three different time periods in Earth's geologic history. Much of the workshop took place in the field, where the teachers were constructing arguments from visual geologic evidence. The analysis focused on interactions between one of the teachers and the workshop instructor. We find that aspects of argumentation, such as rebuttal and revising a claim can function as mechanisms by which arguments supports knowledge construction. These accounts constitute the beginnings of a model for how argumentation can support learning and may be helpful for future work aimed at designing instruction where argumentation supports learning.

## A3. Bridging Emergent Attributes and Darwinian Principles in Teaching Natural Selection Dongchen Xu, Arizona State University, dongche1@asu.edu

#### Michelene T.H. Chi, Arizona State University

**ABSTRACT:** Many scientific processes such as diffusion, heat transfer and natural selection can be defined as emergent processes. However, students often have misconceptions about these processes as they misuse a direct causal schema to explain emergent processes. The problem is their lack of emergent schema for these processes. In order to help students construct a correct emergent schema: five inter-level attributes that explain the relationship between the micro-level interactions and macro-level patterns in emergent processes were used to develop learning materials for natural selection. This new set of learning materials focusing on emergent attributes was compared to another set of learning materials focusing on Darwinian principles. In addition, a third set of learning material that combined Darwinian principles and emergent inter-level attributes was created. This third set of learning material prompts participants to use emergent attributes to generate and explain Darwinian principles, and in the process reflect on their understanding of the emergent attributes. Results suggested that participants with higher prior knowledge of natural selection benefited more from this

third approach, as they answered deep transfer questions more successfully than participants who received learning materials that only focused on either emergent attributes or Darwinian principles.

#### A5. The Evolution of Science Literacy: Examining Intertextual Connections in the Course of Science Literacy Carol J. Manocchi-Verrino, Fordham University, manocchi@fordham.edu John Creven, Fordham University.

John Craven, Fordham University

**ABSTRACT:** A call for a new perspective of science literacy has been marked as the impetus of change in science education, suggesting that a meaning-making approach to literacy and inquiry are central to learning science. This study explored how science literacy evolved in a classroom where this reconceptualized view of science literacy guided curriculum design and instruction. The teacher/researcher incorporated Interactive Science Notebooks (ISNs) and Interactive Reading Organizers and Comprehension Strategies (IROCS) into instructional materials. In a class consisting of 20 mainstream and special education students combined, this 7-week study collected data using student work samples, Likert scales, stimulated recall interviews, a teacher/researcher journal, and students' position papers. A systematic design framework was used for the three-phase analysis. Hyperresearch® software facilitated the identification of open codes, an axial code. The data suggests that science literacy evolves on a continuum, and the degree to which learning evolves seems to be contingent upon students' uses of intertextual connections. Several notable insights emerged which informs curriculum design, instruction, and assessment. This study suggests a possible correlation between the use of intertextual connections and inquiry behaviors, and the use of a continuum to measure science literacy.

## A7. *Expanding Elementary Students' Participation in Experimentation and Argumentation* Eve Manz, University of Colorado Boulder, eve.manz@colorado.edu

**ABSTRACT:** This poster examines aspects of experimentation in which we might profitable engage elementary students, in particular, those that can spark argumentation and support the development of conceptual understandings. It presents an analysis of how one third grade class planned, carried out, and interpreted a plant growth experiment that modeled the effects of light in a backyard ecosystem. Three foci of students' work are examined: defining attributes, operationalizing the independent variable, and considering the way that the experiment represented the backyard system. The poster presents excerpts of student talk that illustrate the ways that they engaged in argumentation about these aspects of the experiment and shows how each kind of conversation contributed to a more nuanced and powerful understanding of plant maturation, reproduction, and needs. This work suggests the social opportunities and conceptual affordances available in parts of experimental activity that are usually simplified for use with young students.

#### A9. Reading and Learning of Science Concepts from Text – An Eye Tracking Analysis

Fang-Ying Yang, National Taiwan Normal University, fangyang@ntnu.edu.tw

Jinmian Yang, University of California, San Diego

#### Keith Rayner, University of California, San Diego

**ABSTRACT:** Using the eye-tracking method, this study explored the context effect on the science-text reading and comprehension. This was a within-subject experimental design. Twenty-four university students participated in the investigation. Participants were asked to read 13 statements describing ideas about the earth while their eye movements were recorded by EyeLink II. Each to-be-read statement was consisted of two sentences. The first sentence provides the contextual information that is related, unrelated or neutral to the second one that shows the target conceptual idea about the earth. T-test and correlation analyses were applied to probe the associations among eye movement patterns, contextual conditions and the comprehension rates. The result supported that the reading of related contextual information could facilitate the reading on the target passages. It was also found that the higher the re-reading time on the contextual information and the more the number of fixations before leaving the antecedents, the lower the comprehension result.

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

Poster Session A

3:15pm – 4:15pm, Ballroom 2, 3, and 4

## A11. *Children's Collaborative Reasoning: Coordinating Everyday Evidence into Problem Solving* Mijung Kim, University of Victoria, mjkim@uvic.ca

**ABSTRACT:** Expecting scientific reasoning as one of the desirable learning outcomes of scientific literacy, K-12 school science has implemented various instructional strategies. Even though the coordination of theories and evidence might not be developed linearly throughout the years, children become cognitively and socially capable of scientific reasoning by making connections between theories and evidence. Researches claimed young children (K-3) are able to reason like scientists such as understanding correlations in causal structures and recognizing alternatives for reality. And yet, research findings also explain complex notions of children's abilities of reasoning on coordination between theories and evidence. The difficulties may come from inconsistency between background beliefs and evidence. This study examines children (Grade 2-3)'s reasoning based on their everyday evidences and hypothesis in order to investigate how children use evidences (background beliefs, everyday experiences, etc.) in hypothesis testing and how those evidences are evaluated and developed through collaborative reasoning. Qualitative data (video audio data and children's written work) was collected and analyzed through thematic coding process. Research findings suggest children's everyday and bodily experiences were fundamental bases but also became barriers to learn scientific concepts. Collaborative reasoning process was effective to evaluate misleading evidences through classroom discussion.

A13. Disentangling Aspects of Expansive or Bounded Framing that Impact Transfer

Diane Lam, UC Berkeley, dianelam@berkeley.edu Xenia Meyer, University of California, Berkeley Clay Carrigan, UC Berkeley Naqia Yasini, UC Berkeley Iana Meitlis, UC Berkeley Michael DeChenne, UC Berkeley Claire Abu-Assal, UC Berkeley Maya Srinath, UC Berkeley Norielle Adricula, UC Berkeley Jenine Hassoun, UC Berkeley

**ABSTRACT:** Experimental and classroom-based research has provided evidence to support the idea that expansively framing learning environments to extend across settings (or times, places, and participants) and to position students in the role of having authorship of their own ideas, promotes transfer. Engle et al. (2011) describe a tutoring experiment that this paper builds from directly, where secondary students participated in tutoring sessions framed in either expansive or bounded manners. They found that students in the expansive condition transferred twice as many facts and knowledge elements from an assessment about the cardiovascular system to another about the respiratory system than students in the bounded condition. This paper extends this work by disentangling the effects that the framing of settings and roles in bounded or expansive manners. Initial findings suggest that the expansive framing of settings may be more important to promoting transfer of knowledge elements than the expansive framing of role. Findings also reveal that the expansive framing of setting and role combined lead to a greater transfer of facts related to the cardiovascular and respiratory systems.

A15. Epistemological Beliefs and Motivational Factors on High School Students' Achievement in Physics
Muhammet Mustafa Alpaslan, Texas A&M University, alpaslan27@tamu.edu
Bugrahan Yalvac, Texas A&M
Fatma Alpaslan
ABSTRACT: The purpose of the study was to investigate the relations between epistemological beliefs, motivational

learning strategies, and achievement in physics. The study was conducted with two hundred nine high school students in Turkey. Results from structural equation modeling revealed that epistemological beliefs influences students' motivational strategies to learn physics. The belief about simplicity of knowledge led the students to have low motivation to learn physics and low achievement in physics. Implications and future direction were discussed.

#### A17. *Teachers Guiding Students' Models of Magnetism* Jouni Viiri, University of Jyväskylä, jouni.viiri@jyu.fi Sari Harmoinen, Pohjankartano School, Oulu

**ABSTRACT:** We investigated how teachers guided students' learning and how teachers' guidance affects their students' learning. Three teachers in an ordinary lower secondary school implemented the magnetism teaching sequence, which was developed by one of the teachers. The goal of the learning sequence was to help students construct and build upon scientifically valid mental models of magnetism. The participants in the study were the three teachers and their 47 (15, 15, 17) students from three ninth-grade classes (an average age of 15). Data was gathered using video recordings of the lessons (analyzed with Atlas.ti software), the students' investigation sheets, pre- and posttests about magnetism. There were substantial differences between the teachers' guidance and they implemented the critical actions in different lessons and different order. We found that if a teacher uses many types of guidance in an appropriate way, then the students' modeling process will be more successful. Students need to be provided with steps (critical actions) to produce more sophisticated models of the concept of magnetism. It is important that teachers pay attention to the most important elements of their students' models so that the students can obtain the appropriate guidance for the creation of their mental models.

## A19. Negotiating Identities: Exploring Graduate Students' Views of Scientists and Mathematicians in an Interdisciplinary GK-12 Program

Hillary Mason, University Of Colorado, Denver, Hillary.Mason@ucdenver.edu

Bryan Shao-Chang Wee, University of Colorado Denver

Julie Rodriguez, University of Colorado Denver

Mike Jacobson, National Science Foundation

Jim Loats, Metropolitan State College of Denver

**ABSTRACT:** As students experience science and math in different contexts, they develop cultural stereotypes that are attached to, and help to form, their science and math identities. This study explores how graduate students in one GK-12 program perceive scientists and mathematicians. Using identity theory as a theoretical framework, this research aims to further understanding of how STEM graduate students internalize perceptions and meanings held for the roles of scientist and mathematician, and the implications of these meanings as participants in an interdisciplinary GK-12 program. A case study follows six science, engineering, and math graduate students over the course of a 12-month residency in the GK-12 program. Visual methods of drawings and semi-structured interviews were employed before and after the program to elicit the mental schemas of how graduate students perceive scientists and mathematicians, while interviews reveal narrow views of science and math and what it means to be a scientist or mathematician. This dichotomy was less prevalent in the engineering students, and raises questions about the inclusion of math and engineering in science and more broadly, STEM.

### A21. Towards a Typology of Argument Schemes that Could Describe a SSI Discussion in the Science Classroomroom

Chrystalla Lymbouridou, Ministry of Education & Culture, Cyprus, clymbouridou@gmail.com Maria Evagorou, University of Nicosia

**ABSTRACT:** Pedagogy on SSI includes elements such as moral education, moral development, cognitive development and the support of the emotional belief system of the child (Zeidler and Keefer, 2003). A methodological problem is that moral and emotional-reflective issues cannot be separated from cognition; therefore SSI pedagogy elements are overlapping. Another methodological issue is that science education tools for argumentation might be used for assessing the epistemic quality of arguments, but do not provide any means to describe the epistemic practice performed through several types of arguments. This paper uses insights about moral and practical reasoning that assume that moral reasoning cannot be separable from cognition but not equal to mere theoretical reasoning and proposes and modifies Schellen's (1985) argument schemes typology so as to grasp epistemic practices that could describe the moral, emotional and

scientific part of the lesson. Schellen's typology is selected among others as it provides distinction of theoretical and practical argument schemes in a higher level hierarchy, and furthermore, uses the type of warrant – the reasoning scheme – as a second criterion for the typology. Missing categories provided by literature are added to the typology and grounded through theoretical means.

### A23. Implications for Grouping Problem-Solving Teams Based on Students' Metacognitive Competence Pavlo D. Antonenko, University of Florida, p.antonenko@coe.ufl.edu

**ABSTRACT:** This study reveals the patterns of co-regulated learning in problem-solving dyads consisting of high metacognitive thinkers (HMT), low metacognitive thinkers (LMT), and both LMT and HMT students. The study was conducted in the context of solving an ill-structured problem that served as an enrichment activity in a high-school biology classroom. Students' conversations were analyzed in a set of turns defined as an episode. Each turn within an episode was coded using Azevedo and colleagues' (2008) framework of regulatory variables. Our findings show that, interestingly, mixed dyads comprising both HMT and LMT students engaged in more co-regulatory behaviors than HMT-only dyads. This pattern of collaborative problem-solving behavior resulted in a 27 percent improvement in overall problem-solving performance compared to LMT-only dyads. These results provide important implications for designing collaborative problem solving experiences and understanding the role of metacognitive competence in mediating problem solving in science.

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

3:15pm - 4:15pm, Ballroom 2, 3, and 4

#### A27. Using Trade Books to Engage Students in STEM Learning

Kristina Maruyama Tank, University of Minnesota, kmtank@umn.edu

Bhaskar Dahal, University of Minnesota

Tamara J. Moore, Purdue University

**ABSTRACT:** In recent years there has been an increasing emphasis on the integration of multiple disciplines in order to help prepare more students to better address the complex challenges they will face in the future. However, there is limited research on STEM integration in the elementary classroom, especially with STEM and other content areas. As this type of approach is being more widely implemented, additional research is needed to better define and explore the effects of this integration in elementary classrooms. Building on the integration research around science and literacy integration, this research examines how high quality trade books can be used to facilitate STEM learning in elementary classrooms where time and resources are limited. The focus of this study is on four teachers and 110 fifth graders from the same elementary school in an urban school district. The subjects were observed while teaching a traditional and an integrated science, engineering and literacy unit. Student learning during the traditional and integrated units were measured through pre/post assessments. Additionally, observation, interview and science notebook data were used to determine the effects of using high quality literature and to support the facilitation of integrated STEM and literacy instruction.

A29. Probing the Dynamics of Primary Science Classrooms in Nigeria in Relation to Pupils' Interest in Science Olatunde Lawal Owolabi, Lagos State University, owot2002@yahoo.co.uk

Peter A. Okebukola, Lagos State University Wasiu Otun, Lagos State University Ayodele Ogunleye, University or Lagos Sunday Banjoko, Lagos State University

Jimmy Avoseh, Lagos State University

Salihu Ojo Sadiku, Lagos State University

**ABSTRACT:** This is an in-indepth study of science classroom dynamics in primary school.Vygotsky's (1962) social development theory guided the study. This is a case study which used a combination of quantitative and qualitative approaches. Observation Schedule, interview and interest inventory were the instruments used to gather data. Maping of the science teachers interactions was developed to describe events and geo-spatial arrangements. Student-teacher

interactions were captured further using open-ended narrative method. Handicap of facilities reflected in class dynamics. The school science laboratory was poorly stocked and hence hindered experimental work., Class sessions were mainly lecture and discussion. Dynamic of interactions did not indicate any gender bias.

#### A31. Responding to the NGSS: Local Elementary Teachers' Perceptions of Teaching Science

Erica M. Riggs, Wright State University, riggs.21@wright.edu

Michelle A. Fleming, Wright State University

**ABSTRACT:** This study examines elementary teachers' perceptions of science, teaching science and scientific practices, as well as their responses to the Next Generation Science Standards. Using a multi-method case study research approach, twenty-four elementary teachers participated in the survey during the summer of 2013. Follow up interviews and classroom observations during the fall of 2013 allowed for triangulation of data. Emerging themes and professional development of inservice elementary teachers around NGSS will be addressed during the presentation.

## Strand 4: Science Teaching--Middle and High School (Grades 5-12): Characteristics and Strategies *Poster Session A*

3:15pm-4:15pm, Ballroom 2, 3, and 4

#### A33. Learning with Optical Black-Box-Experiments in the 6th Grade

Henning Rode, Leibniz Universität Hannover, rode@idmp.uni-hannover.de Gunnar Friege, Leibniz Universität Hannover

**ABSTRACT:** After the large-scale assessment studies TIMSS and PISA several measures have been taken to enhance the quality of science teaching in Germany. Educational standards with several competencies have been implemented, furthermore in SINUS e.g "development of task culture" is mentioned to improve teaching and learning physics content. In this empirical study (N>100) at lower secondary school (6th grade) a sequence of optical black-box experiments has been used in standard physics class. Usability and difficulty of the black-boxes, quality of instruction and students' motivation have been in focus of empirical research.

#### A35. A Review of Research on Students' Understanding of Matter

Jan Christoph Hadenfeldt, (IPN) Kiel, hadenfeldt@ipn.uni-kiel.de

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

**ABSTRACT:** Understanding the structure and properties of matter is an essential part of science literacy. Over the last decades the number of studies on students' conceptions of matter published in peer reviewed journals has increased significantly. In order to understand how students progress in their understanding of matter, there is a need to identify common patterns across the studies at hand. Andersson (1990) developed a first framework to organize students' understanding of matter into four categories: students' conceptions about 1) chemical reactions, 2) physical states and their changes 3) atoms, molecules and particle systems and 4) conservation. The aim of this piece of scholarship was to identify how subsequent research on students' conceptions of matter adds to this framework. We analyzed studies on students' conceptions of matter along a series of five developmental levels corresponding to an increasingly complex knowledge base related to the four categories identified by Andersson (1990). As a conclusion we present a model describing students' progression in understanding matter which may contribute to the development of a K-12 learning progression for matter.

### A37. First Semester Changes in Teacher Questioning from Argument Based Inquiry Professional Development Brian R. Pinney, University of Iowa, brian-pinney@uiowa.edu

Brian M. Hand, University of Iowa

**ABSTRACT:** Recent Practices for K-12 Science Classrooms have placed additional importance on the inclusion of student generated questions in addition to student centered practices that stress teacher questioning to elicit student understanding (National Research Council, 2012). This case study examines the changes that occur in teaching practice in a rural Midwestern sixth grade classroom undergoing the teacher's first semester of argument based inquiry professional

development. The study examines whether the teacher questions elicit and challenge student ideas, how teacher responds to student claims, and how the teacher develops student generated questions that serve the basis for their investigations. Teacher questions across the semester developed from mostly IRE into challenging student replies and seeking consensus across students. Teacher response to student claims went from purposefully selecting correct answers for discussion to integration of student idea and challenging using logic and evidence. Student generated questions for study did not show progress through the semester, implying that questioning practices in the classroom are complex. Implications for professional development for the inclusion of argument based inquiry practices called for in the Next Generation Science Standards are proposed.

#### Strand 5: College Science Teaching and Learning (Grades 13-20) *Poster Session A*

3:15pm – 4:15pm, Ballroom 2, 3, and 4

A39. Faculty Use of "Clickers" in University Learning Environments Grant E. Gardner, Middle Tennessee State University, Grant.Gardner@mtsu.edu Subodh Dutta, East Carolina University Karen Mulcahy, East Carolina University Vera Tabakova, East Carolina University Diane Majewski, East Carolina University

**ABSTRACT:** Call for education reform in undergraduate STEM courses typically revolve around the idea that teaching should be built on the same principles of scientific practice. What this implies is that scientific teaching should, "involve(s) active learning strategies to engage students in the process of science and teaching methods that have been systematically tested and shown to reach diverse students" (Handelsman et al., 2004, pg. 521). One mode in which education reform has taken place is through the use of educational technologies. In the large introductory STEM classroom one of the most prolific of these technologies in recent years are the student responses systems (frequently called "clickers"). This study examines faculty use of clickers in a large southeastern university (n = 201). Specifically the study examines a survey instrument describing how faculty used clickers to engage students, their satisfaction levels with the technology, supports and frustrations associated with the technology, typical course sections taught, as well as their awareness with clicker alignment to Universal Design of Learning Principles. Significant differences in use were found between science and non-science departments. No correlations were found associating clicker use to collected demographic variables. Implications for science teaching in higher education are discussed.

#### A41. TPACK Development of University Physics Instructors in Two Contexts

Syh-Jong Jang, Chung-Yuan Christian University, jang@cycu.edu.tw

Yahui Chang, School of Education, Shaanxi Normal University, China

**ABSTRACT:** Although Technological Pedagogical and Content Knowledge (TPACK) has been gaining recognition from educational researchers in recent years, few studies have addressed students' perceptions of their teachers' knowledge in university settings. The purpose of this study was to investigate the TPACK development of two physics instructors over the course of the semester in two contexts (Taiwan and China). Multiple data were collected and analyzed, including the pre-test and post-test TPACK survey data, two instructors' interviews and in-class observations, and students' feedback and opinions. The results revealed that John's IRS and TIA scores increased significantly, and Mike's KSU score increased significantly from the middle to the end of the semester. John (Taiwan) emphasized life examples and use of multimedia, however, Mike (China) emphasized students' knowledge and evaluation. They showed the different teaching characteristics in the two contexts. The research implications of this study are provided along with suggestions.

A43. Virtual Participation in the PCK Summit: Web-Based Resources for Researchers Julie Gess-Newsome, Oregon State University-Cascades, julie.gess-newsome@osucascades.edu Janet Carlson, BSCS April L. Gardner, Biological Science Curriculum Study **ABSTRACT:** In October 2013, The PCK Summit brought together 25 international researchers from seven countries and 13 research groups to systematically explore the models and definitions used in their pedagogical content knowledge (PCK) research and the relationship of PCK to other teacher professional knowledge bases. The goal of the Summit was to examine the possibility of reducing divergences in the field and perhaps finding points of convergence in order to catapult future research efforts. One result of the PCK Summit is a set of six web-based modules that are organized around key question sets from the Summit. The design of each module includes an exploration of the question set followed by a deeper explanation phase supported by use of video clips from the Summit, Power Point slides, and readings. Each module concludes with an application phase in which participants consider the implications for their work. This session is designed as an introduction to the components of the web-based modules with suggestions about how they might be used by researchers or within graduate courses and seminars to engage others in richer conversations about PCK and PCK research.

### A45. Using Point-of-View Video Data to Analyze the Development of Scientific Expertise in Undergraduate Research

Joseph A. Harsh, Indiana University Science Education, jharsh@indiana.edu Adam V. Maltese, Indiana University Science Education Russell Balliet, Indiana University Science Education

Michael Lathery, Noblesville, IN Community Schools

**ABSTRACT:** Undergraduate research experiences (UREs) are a vetted educational tool commonly perceived to advance student interest in STEM and prepare them for careers in these fields. However, while prior research based on self-report data has demonstrated the effectiveness of these educational experiences, little work exists on the actual practices by which UREs affect student outcomes. This study uses point-of-view cameras to capture observational data on students' behavior in research activities. Early findings begin to provide detailed insight to the engagement of URE participants in the research process and community, direct evidence on specific outcomes, and information on practices that contribute to skill development. It is believed this work has implications for the refinement of UREs in support of student learning.

#### A47. *Taking College Science Teaching to the Next Level* Selcen Guzey, University of Minnesota, kendi003@umn.edu David Langley, University of Minnesota

**ABSTRACT:** Designing and teaching large college courses in introductory biology is a challenging task. Creating motivational learning environments where students engage in activities that encourage and support meaningful learning in science is critical. However, few college faculty use effective teaching strategies that provide meaning experiences and unique learning opportunities. In this study, we examined beliefs and pedagogical practices of an experienced college faculty who teaches introductory biology courses using active learning strategies. We found that teaching in active learning classrooms that are designed to foster interactive, student centered learning experiences can help faculty shift teacher-centered beliefs about student learning to more constructivist beliefs. However, it is important to note that active learning teaching skills are learnable and can be used productively by college faculty for all learning spaces.

## A49. Using WordCloud to Inform Students' Energy Understanding—Applying Text Mining and Social Network Analysis (SNA) Approach

Shannon Sung, Spelman College and University of Georgia, ilaria.huang@gmail.com

**ABSTRACT:** The study is part of the major project on creating and validating an interdisciplinary assessment instrument to elicit college students' interdisciplinary understanding in science using energy examples (IUS-E). One criteria for establishing desirable construct validity of the measure is through the think-aloud technique, which enabled students to elaborate more on their rationale of multiple-choice and open-ended responses. Analyzing the interview transcripts are usually time consuming and require prudent, close analysis; however, as a preliminary exploration of the interview transcripts, text mining method with wordcloud and social network analysis (SNA) visualize the common terms and the similarity of terminology used among respondents. The visual aids provided a convenient means to communicate the initial findings with instructors and/or researchers. By using R packages, besides the wordcloud images, each individual's degree and betweenness of centrality was represented by varying sizes of nodes and edges assigned in R.

Such goal was accomplished by transforming two-mode (actor-term) network into one-mode (actor-actor) network using most frequently-used terms in the transcripts after the cleaning process. The current innovative approach offers insight for mining preliminary reasoning processes for validating and exploring a prototype interdisciplinary science instrument. Discussions and implications for interdisciplinary science education were included.

#### **Strand 6: Science Learning in Informal Contexts**

#### **Poster Session** A

3:15pm - 4:15pm, Ballroom 2, 3, and 4

A51. *The Perspective of Fossil Clubs and Paleontologists for Participating in a Community of Practice* Kent J. Crippen, University of Florida, kcrippen@coe.ufl.edu

Bruce MacFadden, University of Florida

Shari Ellis, Florida Museum of Natural History

Austin Hendy, University of Florida - Florida Museum of Natural History

#### Betty Dunckel, Florida Museum of Natural History

**ABSTRACT:** Throughout the U.S., fossil clubs host speakers, meetings, festivals, and field trips; conduct outreach; work with scientists; build their own collections; and use the Web to learn about paleontology. Currently, there are no published reports of research regarding the nature of the informal learning or participation in the context of fossil clubs. As a first step toward uniting fossil clubs and professional paleontologists, we conducted a needs assessment for the development of an innovative, networked Community of Practice (FOSSIL CoP). This study uses the perspective of members of fossil clubs and professional paleontologists in the U.S., through data collected via a Web-based survey to assess the attitudes, knowledge, prior experience and needs related to participating in the FOSSIL CoP. This study speaks to this year's conference theme-Awakening Dialogues: Advancing Science Education Research, Practices and Policies-because it focuses on understanding the participants and participation involved with two well-established human enterprise elements focused on paleontology, one operating in the space of formal and the other informal science learning. It will be of particular relevance to those members interested in using design-based research to address traditionally difficult problems in science education through the research and development of transformative learning environments.

A53. Addressing Inquiry during Professional Development at an Informal Science Institution

Gary M. Holliday, The University of Akron, gholliday@uakron.edu

Norman G. Lederman, Illinois Institute of Technology

Judith S. Lederman, Illinois Institute of Technology

**ABSTRACT:** This study looked at a life science course that was offered at and taught by education staff of a large Informal Science Institution (ISI) located in the Midwest USA. The curriculum, materials, and agendas for the course were developed by education staff and complemented the permanent life science exhibition. Aside from this course being broad based and interdisciplinary, it explored how to further the incorporation of inquiry-based teaching methods into the classroom. Portfolios and reflection essays provided the data for the study. In addition, all participating elementary and middle school teachers (n = 187) were asked to complete an evaluation at the end of each day's session. This included several questions that required participants to reflect upon the content presented throughout the course of the day, focusing on their satisfaction and effectiveness of instruction. Overall, teacher responses indicated a perceived efficacy in learning about and ability to teach inquiry to their students. However, there were unclear understandings about inquiry among both ISI staff and participants. The findings described here can assist developers of informal science professional development that desire to incorporate inquiry into their teacher learning experiences.

#### A55. Effects of Live Facilitation in the Mythbusters Exhibit

Aaron Price, Museum of Science and Industry, Chicago, aaron.price@msichicago.org

Katherine Gean, Museum of Science and Industry, Chicago

Heather Barnes, Museum of Science and Industry, Chicago

**ABSTRACT:** Mythbusters: The Explosive Exhibition is a traveling exhibit based on the popular television show. It includes a traditional, interactive free flow exhibition space followed by a live facilitated show ("Live Show") about

reaction time where audience members dodge paint balls using various types of warning cues. This study gave a pre-test to 333 children entering the exhibit. The test was based on the learning and engagement goals of the exhibit. A post-test was given to 80 children after they walked through the floor exhibit and before they watched the Live Show and to 191 children after they watched the Live Show. 32 children were interviewed in lieu of taking the post-test. Findings show knowledge and attitude gains by the children who saw the Live Show versus the ones who did not. However, no gains were found on items related to recognizing terminology related to the scientific process. Interviews suggest this may be due to ambiguously worded items.

#### A57. Getting Students OUTSIDE: Using Technology as a Way to Stimulate Engagement

Carrie J. Boyce, The University of Southern Mississippi, carrie.boyce@eagles.usm.edu

Chandrani Mishra, The University of Southern Mississippi

Kristy L. Halverson, University of Southern Mississippi

Aimee K. Thomas, Loyola University New Orleans

**ABSTRACT:** Informal learning environments provide learners with unique experiences that allow them to actively participate in learning while promoting a positive attitude towards and an increased interest in science. One way to enhance informal science learning is through the integration of technology. This integration is particularly useful in engaging underrepresented students in learning science. The OUTSIDE program engages underrepresented, middle school students in an informal learning environment supplemented with tablet technology. The purpose of this study was to explore how fifth grade students interacted with nature using tablet technology. Participants included 55 fifth grade students from two low-income schools. Students attended one naturalist led nature hike. We found that students used the tablet technology to explore nature and stay engaged throughout the hike. The iPads were used as references, data collectors, and engagement tools. Students had an intense desire in returning to the site for future learning experiences and they responded positively towards interacting with nature. Prior research has indicated that students in this age group are likely to lose interest in science and the incorporation of field-friendly technology that engages students with nature, not technology alone, is a useful tool for keeping students interested in science.

### A59. An Exploratory Study: How Do Extracurricular Robotics Activities Change Students' Attitudes Toward Science?

Niyazi Erdogan, Texas A&M University, niyazierdogan@tamu.edu Ayse T. Oner, Texas A&M University Alpaslan Sahin, Texas A&M University Mary Margaret Capraro, Texas A&M University Robert M. Capraro, Texas A&M

**ABSTRACT:** Informal education is described by National Research Council (NRC) as "an essential conduit to increase public interest in and understanding and appreciation of science, technology, engineering, and mathematics". In this study, researchers are interested in examining students' attitudes toward science in informal learning environments. Thus, we will seek answers whether there is a statistically significant difference between students' pre and post attitude scores, and statistically significant difference between treatment-who participated in extracurricular robotics program- and control group post attitude scores. Participants (N=66; 28 male and 38 female) were 9th through 12th grade students from four inner city charter schools in Texas. Students' attitudes towards science was evaluated using the Test of Science related Attitudes (TOSRA) survey. A number of paired sample t-test was used to analyze students' pre and post survey results. Results indicated that the extracurricular robotics activities did not make any significant change in students' attitudes for both groups. One of the reasons for this conclusion may be the unstructuredness of the extracurricular program.

A61. How Popular Media Influences Students' Images of Scientists and Their Interest in Science

Jennifer Jocz, National Institute of Education, jennifer.tan@nie.edu.sg

Junqing Zhai, National Institute of Education, Singapore

Aik-Ling Tan, National Institute of Education

**ABSTRACT:** Research has shown that children's interest in science and scientific careers can be influenced by popular media. Additionally, children's' knowledge of a particular science career may affect their interest in pursuing that area of study. This lack of interest could result in fewer individuals qualified for scientific careers and a population unprepared to

engage with scientific issues. Thus this study aimed to investigate what influenced students' ideas about scientists and how these influences related to their perceptions of scientists and students' interest in a science-related career. Data was collected from 15 grade 4 classrooms in Singapore using a questionnaire and drawing activity. Results indicate that students' influenced by non-scientifically accurate depictions of scientists tended to have a weaker understanding of scientific work. Additionally, knowledge of scientific work was related to how positively and realistically students viewed scientists. Students with positive views of scientists were also more likely to want to pursue a science-related job. These findings suggest that it is important to help children understand that some scientists they see in the media do not represent real scientists. By doing so, children will gain a realistic understanding of scientists which may motivate them to pursue science in the future.

A63. Using Thematic Comics to Promote Public Understanding of Nanotechnology Huann-Shyang Lin, National Sun Yat-Sen University, huannlin@faculty.nsysu.edu.tw Shu-Fen Lin, National Changhua University of Education John K. Gilbert, King's College London Zuway-R Hong, National Sun Yat-sen University Ling Lee, National Sun Yat-sen University

**ABSTRACT:** The purpose of this study was to explore the effectiveness of using thematic comics to promote public understanding of nanotechnology. The proportionate stratified sampling procedure was used to invite representative 207 laypeople in a city. They were randomly assigned to either text booklet reading group or computer animated comics group. Comparisons of pre- and post-tests reveal that both interventions of reading text booklet and watching computer animated comics significantly promoted laypeople's knowledge of nanotechnology (p < 0.001) while their trust in government agencies, industrial sectors, and scientists in managing nanotechnology, as well as their perceptions of benefit and risk of nanotechnology changed slightly toward positive direction. The initial encouraging results shed lights on the identification of feasible ways of science communication and merit further investigations of presenting nanotechnology learning materials for laypeople.

### Strand 7: Pre-service Science Teacher Education *Poster Session A*

3:15pm – 4:15pm, Ballroom 2, 3, and 4

A65. Analyzing Identity Discourse in Statements of Preservice Teachers' Science Learning Experience and Teaching Philosophy

Pei-Ling Hsu, University of Texas at El Paso, phsu3@utep.edu Giuliano Reis, University of Ottawa

Angelica Monarrez, University of Texas at El Paso

**ABSTRACT:** Although identity has become a central issue in science education, it remains unclear how preservice science teachers articulate both their learner and professional identities. Grounded on the perspective that language is a resource for identity (re)construction, this study draws on identity theory (Gee, 2000) to investigate the types of identity present in preservice science teachers' learning autobiography and teaching philosophy narratives. Our findings show that affinity identity is the most frequent type of identity found in participants' discourse—with nature identity being the least frequent. We conclude by providing suggestions on how our findings can be used to improve the quality of teacher education programs through the development of future teachers' identities.

A67. *Mentor Teacher Contributions to Preservice Teacher Learning to Use Student Ideas in Science Instruction* Elsa N. Schaub, University of Arizona, eschaub@email.arizona.edu

**ABSTRACT:** The sense that preservice teachers make of their learning to teach experiences influences how they reason about and enact instruction. This study examined the influence of mentor teachers (MTs) in supporting preservice teachers (PSTs) sense making of the high-leverage practice of eliciting and using student ideas in science instruction. I followed two MT – PST pairs during the semester prior to student teaching, when PSTs were enrolled in the science methods course and carried out assignments in their mentors teachers' K-5 classrooms. By adopting a situative perspective on PST

learning and using four core problems of practice as a framework to characterize participants' ideas, two important differences were found in the ways MTs talked to their PSTs about student ideas in instruction. These differences were associated with the goals MTs set for PST learning while in their classrooms, and their focus for thinking about student learning in the context of instruction. The analysis also revealed that when these goals and focus aligned with methods course frameworks, these MTs would draw on classroom experiences to help PSTs notice and make sense of student thinking, enhancing the potential for making principled connections between science methods course and field experiences contexts.

### A69. Supporting Pre-Service Science Teachers in Developing Culturally Relevant Pedagogy Without Access to Diverse Settings

Stephen Krajeski, Penn State University, sek194@psu.edu

Scott McDonald, Pennsylvania State University

**ABSTRACT:** Preparing pre-service science teachers to teach in diverse classrooms is difficult to accomplish without immersing them within these settings. This study investigates how participating in a near-authentic intervention impacts pre-service science teachers' views on the role of culture within science instruction and what factors help or hinder their development of culturally relevant pedagogy. Results show that pre-service science teachers benefitted by designing pedagogy based on multiple intelligences and incorporating the cultural backgrounds of their students. However, barriers that pose difficulties for pre-service science teachers becoming proficient at culturally relevant pedagogy are: (1) a tendency to make pedagogical choices based primarily on personal experiences learning science and observing professionals within authentic school settings; and (2) a disconnect between the self-proposed values pre-service science teachers state they possess and evidence of these values being integrated into their practices.

#### A71. Impact of Scientific modeling on Pre-Service Teachers' Knowledge Generation

Frackson Mumba, University of Virginia, fracksonm@excite.com

#### Vivien M. Chabalengula, University of Virginia

**ABSTRACT:** This study examined the impact of a Model-Based Inquiry Instruction (MBII) using a human respiratory system model, among 20 pre-service high school biology teachers' knowledge generation and understanding of how a respiratory system functions when one is breathing. Data was collected using three instruments: the pre-and post-model drawings of a respiratory system which required students to show and label the five parts (chest cavity/rib cage, trachea, bronchi, lungs and diaphragm. (Note: these parts were the foci because the model represented these parts); knowledge tests based on these parts, and perception questionnaire which required students to indicate how the model helped them to generate knowledge. Two major findings were revealed: First, with respect to biological understanding, students gained better conceptual understanding of how a respiratory system functions and achieved higher test scores. Second, with respect to students' perceptions about the human respiratory system model, nearly all students thought that the human respiratory system model helped them understand the location of all five parts, and enabled them to see how these parts function when the model is manipulated. Implications for MBII in pre-service teacher education are discussed. Key Words: knowledge generation, modeling, pre-service teacher

## A73. The Impact of an Optional Mastery Experience on Science Self-Efficacy in Elementary Pre-Service Teachers

Christine Knaggs, Lourdes University, cknaggs@lourdes.edu

Toni A. Sondergeld, Bowling Green State University

**ABSTRACT:** The science achievement of U.S. students has raised concerns regarding our ability to compete in a global economy. Research has shown that pre-service elementary teachers who experience science as both a "learner" and "teacher" are more likely to effectively teach science. Bandura's construct of self-efficacy (SE) is used in this study. Twenty students in a science pedagogy course participated in the initial round of research, with twelve students participating in an optional course mastery experience. Our study consisted of a repeated measures with intervention concurrent mixed methods design, using the quantitative survey STEBI-B with additional qualitative questions added. Quantitative results showed significant increases in both sub-scales of SE: personal efficacy and outcome expectancy, in both the mastery experience and the non-mastery experience groups. In addition, the non-mastery group possessed significantly higher personal efficacy scores than the mastery group at the beginning of the course, but not at the end. Data integration of quantitative and qualitative data allowed us to develop two meta-inferences: "Fostering a Positive Attitude",

which was greatly enhanced through the mastery experience, and "Developing A 'Science Teacher' Perspective", as both groups exhibited a heightened ability to envision themselves as teachers of science at the end of the course.

#### A75. Pre-service Elementary Teachers' Understanding of Inquiry

Kristin N. VanWyngaarden, University of Nebraska at Omaha, kvanwyngaarden@unomaha.edu Sheryl L. Mcglamery, University of Nebraska

Saundra L. Shillingstad, University of Nebraska at Omaha

**ABSTRACT:** This qualitative study of 28 pre-service elementary teachers chronicles their growth as they struggle to understand inquiry. The purpose of the study was to determine what understandings pre-service elementary teachers had about inquiry as a method of teaching and learning. Further, when given modeling, instruction about inquiry and practice with inquiry labs were there changes in the teachers' understandings about inquiry? And finally, after instruction were they able to work confidently at the structured and guided levels of inquiry? Data sources included written reports, journals, labs, lesson plans and a science biography about the nature and scope of science courses taken in middle school through college. The findings indicated that a limited exposure to inquiry beyond the structured level of inquiry and limited experience in some content areas impaired the pre-service teachers' construction of an understanding of inquiry. The pre-service teachers were challenged most by assessing the learning of children after teaching science labs using inquiry as the primary method.

A77. Evolutionary Reasoning Patterns and Acceptance Levels in Chinese Pre-service Biology Teachers: A Global Comparison

Xin Wei, Beijing Normal University, lakewe@gmail.com Ross H. Nehm, Stony Brook University (SUNY) Minsu Ha, Stony Brook University (SUNY) Jian Wang, Beijing Normal University Dan Hou, Tianjin Normal University

**ABSTRACT:** The goal of our study was to examine a large, cross-sectional sample of Chinese pre-service biology teachers in order to document and compare their evolutionary acceptance levels and evolutionary reasoning patterns to equivalent samples from other nations. This approach was taken to better understand the degree to which particular evolutionary reasoning difficulties exist independent of religious worldviews. Specifically, we asked: (1) Do Chinese preservice biology teachers display higher levels of evolution acceptance and knowledge relative to other nations? (2) Do differential evolutionary reasoning patterns documented in American samples (e.g., increased difficulty with plant evolutionary reasoning models characterize Chinese pre-service biology teachers? And (3) What types of overall evolutionary reasoning models characterize Chinese pre-service biology teachers? A total of 160 teachers completed ACORNS items and the CINS and MATE instruments. Findings revealed that Chinese teachers' knowledge (CINS), and acceptance (MATE) were equivalent with teachers' scores from other countries, whereas performance on explanation tasks was lower. Evolutionary reasoning biases associated with particular contexts (e.g., plant evolution, trait loss) were pronounced in Chinese teachers. These findings suggest that evolutionary reasoning difficulties and acceptance levels extend beyond religious factors, and pose challenges in cultures with minimal religiosity.

### Strand 8: In-service Science Teacher Education

Poster Session A

3:15pm – 4:15pm, Ballroom 2, 3, and 4

A79. The Role Scientist Mentors Play with Science Teachers During A Summer RET Program

Rommel J. Miranda, Towson University, Rmiranda@towson.edu

Julie B. Damico, Towson University

Rommel J. Miranda, Towson University

**ABSTRACT:** This study sought to determine scientist mentors' beliefs about their primary motivation for working with teachers in a summer Research Experiences for Teachers (RET) program. Additionally, this study investigates scientist mentors' beliefs regarding the role they play with teachers during a summer RET program and examines the extent to

which scientist mentors support teachers in translating aspects of their summer research experiences into educational opportunities for their students. Qualitative methods were used to explore this study's research questions. Supported with NASA funding, twenty-seven scientist mentors participated in this study and collaborated with high school teachers (1:1 Match) during a large mid-Atlantic university RET program. Findings reveal that scientist mentors' motivations for working with teacher are to engage in public outreach, to impact the next generation of scientists and researchers, and to benefit from collaborations with an educator. The findings also indicate that scientist mentors believed that their roles include, developing teacher research projects, providing guidance and support to teachers regarding their research project, helping teachers to disseminate research findings, and assisting teachers in translating research activities into their classrooms. The results of this study inform our ideas about how to best bring educators into the world of authentic science research.

#### A81. Science Teachers' Perceptions Towards STEM Education: Possibilities and Challenges Heba El-deghaidy, American University in Cairo and Suez Canal University, h.eldeghaidy@aucegypt.edu Nasser Mansour, Exeter of University-UK and Tanta University- Egypt Mohammed Alzaghibi, Ministry of Education

**ABSTRACT:** In order to promote STEM education in Saudi Arabia through developing a professional development model, this study seeks to identify teachers' perceptions regarding STEM education and its interdisciplinary nature, identifying the factors that facilitate or hinder such form of instruction in their schools and what variables could influence their perceptions. Being one of the first studies in STEM education in Saudi Arabia, this on-going study that elicits teachers' perceptions about STEM education through the use of qualitative methodologies. The instruments included online open-ended questionnaires and semi- structured interviews as utilising them together strengthens the research design and adds depth-and-breadth to the research findings in addition to triangulating the findings. The study ends by providing recommendations and suggestions that could lead to develop a professional development model of what teachers need in terms of content knowledge and pedagogical content knowledge to enact STEM education in class. Such model would be based on data from an Arab country that takes into account cultural factors and the nations priorities into account.

#### A83. Engaging Professional Development and Developing a Community of Practice

Morten Lundsgaard, Office of Mathematics, Science, and Technology Education, mlundsga@illinois.edu Chris P. Cunnings, University of Illinois at Urbana-Champaign

**ABSTRACT:** In this paper we present research on a professional development (PD) project for in-service high school physics teachers. The two-year long project applies a lesson study approach to PD in which teachers are developing laboratory-centered units. Our research focuses on 1) what instructional activities teachers are discussing when developing laboratory-centered units; 2) how teachers connect the experimental activities with other instructional activities when developing laboratory-centered units; 3) teachers' sharing of classroom experiences and its impact on their instruction; 4) the impact of teachers' autonomy within a PD program on their attitude toward the PD program; 5) the role of a continued PD in the development of a community of practice.

## A85. Examining the Effects of Professional Development on Students' Attitudes, Experiences with Inquiry, and Content Knowledge

#### Michelle Cook, Clemson University, mcook@clemson.edu

**ABSTRACT:** Professional development for in-service teachers is an issue of statewide and national concern. This study is part of a larger research project that investigates the effects of a professional development experience on high school biology teachers' content knowledge, teaching efficacy, ability to develop and implement inquiry-based instruction, as well as student performance and interest in science. This study specifically focuses on data collected from high school students taking biology from teachers involved in the professional development. Pre-and post measures on the Attitudes Towards Science Inventory and on a survey used to characterize experiences with practices associated with inquiry were collected from the students. In addition, scores on state-level end-of-course test scores of students taught by teachers in the program were compared with those of other students. The findings indicate no significant differences between students in these groups in terms of end-of-course test scores. However, positive changes were noted in terms of students attitudes and interest in science as well as experience with practices associated with inquiry. In light of findings from other data

collected, evaluating professional development programs with student performance on end-of-course tests is shown to be limiting.

## A87. Foregrounding Youth Narratives of Informal Science Learning: A Professional Development Model Daniel Birmingham, Loyola University Chicago, dbirmingham@luc.edu

#### Angela Calabrese-Barton, Michigan State University

**ABSTRACT:** School science continues to fail to engage youth from non-dominant communities. Even when reforms result in improvements in achievement, they do not reach all students equally (Carlone et al, 2011). Research also demonstrates that informal science learning settings support both knowledge gains and increasing interest to participate in science among youth from non-dominant communities (Dierking, 2007; Falk et al, 2007; HFRP, 2010). Despite the successes, little is known about how teachers can learn from informal science practices to support student engagement in science. In this paper, we examine how inservice middle school science teachers interpret and learn from youth narratives of learning and doing science in informal settings. Our study describes, examines and interrogates a professional development model that places youth experience at the center of teacher learning. This project reveals the ways in which informal science learning opportunities hold power to influence formal science instruction. Additionally, this study contributes a professional development model that places youth voice/stories into professional development experiences has major implications for the ways in which teachers learn by shifting what and how they learn.

## A89. Impact of Explicit Nature of Science Instruction on Middle School Science and Mathematics Teachers' Understanding of the Nature of Science

Sissy S. Wong, University of Houston, sissywong@uh.edu

Lionnel G. Ronduen, University of Houston

Eunjin Bang, Iowa State University

**ABSTRACT:** This research study examined the nature of science (NOS) knowledge of middle school science and mathematics teachers (N=21) as they engaged in an online master's program that focused on integration of both content areas. This study utilized two NOS instruments to collect data on the initial NOS conceptions the teachers held prior to starting the program, and one year after starting the graduate program. This study examined changes in NOS understanding of the group as a whole, between the science and math teachers, and whether years of classroom service is related to level of NOS understanding, Two case studies were also completed to compare each participant's responses on the two instruments implemented in this study. Findings show that the teachers' views of NOS became more developed in the areas of scientific methods, scientific advancement, and the definitions of theories and laws. By understanding the NOS understanding of practicing middle school science and math teachers, researchers and teacher educators may gain insight into how to foster and develop NOS understanding in preservice and practicing teachers.

## A91. Case Study: Impact of Instructional Coaching on Science Teacher's Inquiry-Based Instruction in Rural Schools

SoonChun Lee, University of Nebraska, Lincoln, slee37@unl.edu

Gwen Nugent, University of Nebraska, Lincoln

Gina Kunz, University of Nebraska, Lincoln

James A. Houston, University of Nebraska-Lincoln

Sue Ellen DeChenne, University of Northern Colorado

**ABSTRACT:** Although the Next Generation Science Standards will allow students and teachers to focus more on science and engineering practice, it now demands science teachers to amend their beliefs and teaching practice. Embedded professional development supported by an instructional "coach" is a promising strategy for addressing the need for change in science education. This paper draws on empirical data from a specific case as part of a larger study being conducted through a research center at a university in the Midwest U.S. The purpose of this study is to determine the value-added from coaching over what could be learned from a PD alone. With in-depth analysis of a single case, that of teacher Kate who participated in the study, this paper will first describe how Kate implemented what she learned from PD without instructional coaching. Next, the differences in the teacher's beliefs and practice during and after distance-based instructional coaching, and how the coaching made a difference will be presented. We applied the Vygotsky Space to

analyze this case that is described in detail with interviews as well as observational and archival data. The results present that transformation as learning seemed to effectively occur during the coaching that provided her with many reflective opportunities.

**Strand 9: Reflective Practice** *Poster Session A* 3:15pm – 4:15pm, Ballroom 2, 3, and 4

A93. "Is That a Model?": Preservice and Inservice Teachers' Interpretations of Scientific Practices During Video Club

Heather J. Johnson, Vanderbilt University, heather.j.johnson@vanderbilt.edu Michelle Cotterman, Vanderbilt University

**ABSTRACT:** Preservice science educators, professional development facilitators, curriculum designers, and science teachers are concerned with how the eight scientific practices (Achieve, Inc., 2013) will integrate into K-12 science classrooms. Prior work shows that teachers' knowledge of the scientific practices is fairly limited (van Driel and Verloop, 2002) and their prior teaching experiences lead them to certain interpretations. The question is how prior knowledge and teaching experience influences teachers' interpretations and implementation of the scientific practices. To address this concern, we designed a videoclub to explore how teachers at different stages of their professional trajectory interpret the practices. We answered the questions: What do videoclub participants notice about scientific practices? How do preservice and inservice teachers compare in their identification and discussion of scientific practices? Four main findings emerged: Teachers noticed some practices; Preservice and inservice teachers at times misinterpreted practice; Preservice and inservice teachers of seeing practice. These findings suggest entry points to supporting teachers in engaging students with the scientific practices that can inform the design of curriculum materials, professional development, or preservice coursework to align teachers' understanding and use of the scientific practices with NGSS.

### Strand 10: Curriculum, Evaluation, and Assessment *Poster Session A*

Poster Session A

 $3{:}15pm-4{:}15pm,$  Ballroom 2, 3, and 4

A95. Validating Proposed Learning Progressions on Force and Motion Using the Force Concept Inventory Gavin W. Fulmer, National Institute of Education (Singapore), gavin.fulmer@nie.edu.sg Lyna Kwan, National Institute of Education (Singapore)

**ABSTRACT:** This study examines the validity of two proposed learning progressions on the force and motion concept when tested using items from the Force Concept Inventory (FCI). This is the first study to compare, in parallel, students' performance with respect to learning progressions for both "One-Dimensional Force and Motion" and "Newton's Third Law". It is also among the first studies on learning progressions within a Southeast Asian context. FCI items are coded according to an ordered multiple-choice based on the learning progression. Responses from 174 Singapore secondary students who completed the FCI during regular school time are analyzed using a partial-credit Rasch measurement model. Results show that the FCI items have good data-model fit and demonstrate the expected pattern of difficulty, with good coverage for both "One-Dimensional Force and Motion" and "Newton's Third Law" progressions. However, scale reliability and fit for the thresholds between levels are inadequate. Implications for future research for the instrument and for possible revisions to the learning progressions are discussed.

A97. Development of Assessment Items for a Learning Progression on Plate Tectonics and Geocognitions Seungho Maeng, Kangwon National University, South Korea, seunghom@gmail.com

Ki-Young Lee, Kangwon National University, South Korea

**ABSTRACT:** This study sought to re-define the geocognition from the view of reasoning practices, which can explicate how geoscientists think and learn. Also we developed assessment items to examine children's understanding of plate
tectonics and their reasoning practices of geocognitions. The re-identified geocognition consists of four kinds of reasoning practices. Spatial reasoning is to recognize the shape or pattern of objects, and to comprehend spatial properties. Temporal reasoning is to understand macro-scale of geoscientific deep time, and to apply micro-scale of relative time to diachronic schemes. Retrospective reasoning is to ascribe meanings to observed objects by backward reasoning from current observation to inference of past geological processes. System thinking is to synthesize information from each sub-system and interpret the relations between sub-systems. Four kinds of reasoning practices of geocognitions were embedded into the assessment items to examine the levels of understanding plate tectonics. We developed five ordered multiple-choice items and four open-ended items. A novel definition on geocognition proposed in this study would provide more significant insight into understanding and actualizing geoscientific practices. Moreover the assessment items integrating geocognition practices with the content of plate tectonics can investigate a learning progression for plate tectonics integrated with that for reasoning practices.

A99. Eighth Grade Students' Conceptions of Science Assessment and Feedback in Taiwan Min-Hsien Lee, National Sun Yat-sen University, Taiwan, leemh@mail.nsysu.edu.tw Tzung-Jin Lin, National Taiwan University of Science and Technology, Taiwan Chin-Chung Tsai, National Taiwan University of Science and Technology, Taiwan ABSTRACT: Since students' conceptions of assessment and feedback may play a central role in the learning cycle, this study explored the relationships between the two. We also examined the effects of conceptions of science assessment and feedback on the students' self-reported science learning performance. A total of 324 grade 8 students from two junior high schools in Taiwan participated in this study. Two instruments for assessing students' conceptions of science assessment and conceptions of assessment feedback, and one item regarding self-reported science learning performance were administered in this study. The stepwise regression results indicated that, in general, students with a Surface purpose of science assessment tended to emphasize Outcome and Corrective feedback, students with a Summative purpose of science assessment tended to stress Corrective and Process feedback, while students with a Formative purpose tended to center on all three types of feedback (i.e., Outcome, Corrective, and Process). Moreover, this study revealed that students perceived the Summative purpose of science assessment and Process feedback as being more likely to positively explain their science learning performance. On the other hand, the Surface purpose of science assessment was more likely to negatively explain their science learning performance.

A101. Beginning Chemistry Teachers' Representation of the Chemistry Curriculum Krista L. Adams, University of Nebraska-Lincoln, kadams12@unl.edu Julie A. Luft, University of Georgia

**ABSTRACT:** The purpose of this study was to document how beginning chemistry teachers represent the curriculum over the first three years in the classroom. In particular, we wanted to analyze the types of representations and the chemistry components teachers used for key chemistry topics. By knowing how the content is presented provides a better understanding of how science educators can support the development of teacher knowledge through professional development.

## A103. Cross-year and Cross-major Variations in University Students' Scientific Reasoning Lin Ding, The Ohio State University, ding.65@osu.edu

**ABSTRACT:** While it is broadly accepted that increased scientific reasoning can augment learning domain knowledge, it is still a debate as to how scientific reasoning may be increased through content learning. Building on the Neo-Piagetian framework of skill development in relation to knowledge acquisition, this study looks into the extent to which university students' scientific reasoning may differ across different year levels and content domains. In this study, a total of 614 student participants from four years of higher education and two majors (physical sciences and engineering) were recruited, representing learners exposed to different amounts and domains of content learning. We used the Lawson Classroom Test of Scientific Reasoning (LCTSR) to quantitatively measure student reasoning skills. Results showed that there was little divergence in student performance on the LCTSR across year and major. This indicated that regardless of how long students received higher education or what they studied, their scientific reasoning skills measured by the LCTSR largely remained stagnant. Findings of the study drive us to rethink the current status of tertiary-level science and engineering education.

A105. The Impact of Reform-Based Science Learning on U.S. Students' Science Learning Outcomes: PISA 2006 Nai-en Tang, University Of Missouri-Columbia, ntb5c@mail.missouri.edu

Chia-lin Tsai, University Of Missouri-Columbia

Lloyd H. Barrow, University Of Missouri

**ABSTRACT:** The purpose of the study is to understand to what extent students learn science through reform-based learning and the effectiveness of reform-based learning in the U.S. using data from the PISA 2006. Latent class analysis (LCA) results showed that three latent classes (i.e., high, medium, low usage of reform-based learning activities) were found to represent the data and around 20% of students in the U.S. learned science through reform-based learning activities on the regular basis. ANOVA results showed that the students who had more opportunity to learn science through reform-based activities had significantly lower achievement score, but significantly higher scores on affective leaning outcomes. Results and implications were discussed.

A107. Designing and Exploring Quality Classroom Assessments for Students' Learning in High School Chemistry

Kemal Izci, Van Yuzuncu Yil University, kikrc@mail.missouri.edu

Nilay Muslu, University of Missouri, Columbia

Shannon Burcks, University of Missouri

Marcelle Siegel, University of Missouri-Coluimbia

**ABSTRACT:** Core concepts and skills for the preparing students in the 21 century are outlined in science education reform documents (NRC, 1996; 2011), unfortunately teachers do not assess these standards with the rigor they deserve (Liu, Lee, Hofstetter, Linn, 2008). To address this emerging need, this study aimed to illustrate a design process constructing quality classroom assessments for high school chemistry and to investigate the effectiveness of these assessments for promoting students' understanding. Using multiple sources of data, including teacher generated assessments, teachers' and researchers' comments on developed assessments and students' responses to assessments, we were able to demonstrate how our assessment design align with research-based principles. Results showed that the developed assessments: a) cognitively challenged students to think critically, b) supported students' learning, c) have reduced potential biases, and d) motivated students to learn and engage in the learning process. Our study recommends that by participating in a research project, collaborating with other teachers and researchers, getting and giving feedback, and reflecting on their assessments, teacher can develop and utilize various types of quality classroom assessments. Finally, the assessment design principles and development model can be used in other science disciplines.

A109. Nursing Students' Attitudes Toward Science: A Modification of the Scientific Attitude Inventory II (SAI II)

Jill D Maroo, University of Northern Iowa, jill.maroo@uni.edu

Kristy L. Halverson, University of Southern Mississippi

**ABSTRACT:** The nursing profession combines the art of caregiving with scientific concepts. Nursing students need to learn science in order to start in a nursing program. However, previous research showed that students left the nursing program, stating it included too much science (Andrew et al., 2008). Research has shown a correlation between students' attitudes and their performance in a subject (Osborne, Simon, & Collins, 2003). However, little research exists on nursing students' overall attitude toward science, and currently there is no large scale quantitative study. In addition, we found no quantitative instrument published specific to measuring nursing students' attitudes toward science. For this reason we explored using the Scientific Attitude Inventory II (SAI II) (Moore & Foy, 1997) as an attitude questionnaire for nursing students. We ran a nationwide survey with 1,402 participants completing the 40 item questionnaire. We validated the questionnaire using both an exploratory factor analysis and a confirmatory factor analysis in order to explore nursing students' attitudes toward science, and discovered five different attitude scales in that questionnaire. Our study gives a baseline of the current attitude of nursing students toward science in the United States.

### Strand 11: Cultural, Social, and Gender Issues *Poster Session A*

3:15pm – 4:15pm, Ballroom 2, 3, and 4

A113. Language, Identity, and the Stress of Learning Science Language Salina T. Gray, Stanford University, sgray@stanford.edu Bryan A. Brown, Stanford University Andrew Wild, Stanford University Brian M. Donovan, Stanford University

**ABSTRACT:** Science language has been conceptualized as a hindrance to students' learning. Research on the challenges of learning science language varied from examinations of the complexity of language to explorations of the identity implications of using science discourse. This study adds to the existing body of research by examining how science language may have a socio-affective impact on students. Through a quasi-experimental study of N=56 students we used two psychological measures, Stroop Tests and Flanker tests, to measure if using complex language has a socio-affective impact. Students were randomly assigned to two conditions. Control group students watched an instructional video on the water cycle taught using complex science language. The Experimental group students watched the same video with simple language explanations. The results showed that there was no significant difference in students' ability to answer the questions correctly. Conversely, statistically significant findings were found in the rate of students in the experimental group (everyday language condition) answered significantly faster. These results implicated the manner in which complex science language limits students' cognitive capacity on complex cognitive tasks.

A115. Science Teacher Beliefs about Students and Reform in Rural, High Poverty, All African American Schools

Carolyn S. Wallace, Indiana State University, carolyn.wallace@indstate.edu

M. Jenice Goldston, University of Alabama, Tuscaloosa

Elizabeth R. Allison, University of Alabama, Tuscaloosa

**ABSTRACT:** Contemporary researchers posit that teacher expectations of African American students continue to be lower than those of Caucasian and Asian students (Atwater, 2000; Carlton Parsons, 2008; Mutegi, 2013) and that science education researchers should recognize the positionality of African Americans in the school experience explicitly. The purpose of this study was to investigate teacher beliefs about and expectations of students in rural, high poverty, all African American schools in the Southeastern United States in the context of introducing innovative science curriculum about nanoscience. Both teacher participants are experienced middle school teachers, one is African American and one is Caucasian. Both teachers have strong positive beliefs about student learning characteristics, including their "brightness," curiosity, and creativity. However, the two teachers differ in their beliefs about pedagogy with one being more traditional and the other being more inquiry-based. The results indicate that even for teachers with similar beliefs and learning expectations the implementation of the reform-based curriculum and student achievement may also be influenced by: (a) beliefs about the pedagogical approach of the reform; (b) beliefs about learning epistemologies ; and (c) the sociocultural characteristics of the classroom.

A117. Experiences of Women of Color Being Mentored in Computing

Maria Ong, TERC, ong.mia@gmail.com

Lily Ko, TERC

Rachel R. Kachchaf, TERC

Apriel K. Hodari, Council for Opportunity in Education

**ABSTRACT:** To remain globally competitive, the U.S. needs to increase the size and diversity of its computing workforce. The large declines over the past decade in computer science education and careers for women, especially women of color, may appear to be insoluble, but they are, in fact, a great opportunity. Through a study of life stories of 29 women of color in computing, we uncover and make explicit the assumptions, attitudes, beliefs, and practices that enable these women, or impose limitations, specifically focusing on aspects of mentoring. Narrative analysis of our participants' experiences regarding being mentored in computing revealed three main themes: Learning Content and Skills, Navigating

the Science Environment, and Demonstrating a Caring Attitude. Our participants felt that good mentors went beyond teaching technical skills to helping the women build professional networks and demonstrating professional and personal care about the women. We discuss the implications of these findings and develop a guideline for the undergraduate-and-professional mentoring network we are designing as an intervention feature in our current project. Utilizing these principles will allow us to use an evidence-based approach in creating an effective mentoring program tailored to meet women of color's needs in computing.

# Strand 12: Educational Technology *Poster Session A*

3:15pm-4:15pm, Ballroom 2, 3, and 4

### A119. Computer Assisted Approach vs. Constructivist Approach for the Instruction of Cell Division and Reproduction

Yilmaz Kara, Karadeniz Technical University, yilmazkaankara@yahoo.com

**ABSTRACT:** The purpose of this study was to compare if any difference between the actives of constructivist and computer-assisted approach of cell division and reproduction in terms of biology curriculum. A pretest–posttest control group design was adopted. The sample consisted of 57, 10th grade level, 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 cognitive objectives related to cell division and reproduction unit, SRPS, STSE, and CSAV objectives, the t-test was applied to the data obtained through the instruments of the study. As a result, the constructivist activities were more effective than the computer-assisted activities in order to fulfill the cognitive objective requirements for the cell division and reproduction topic, but both constructivist and computer assisted activities could not able to make statistically meaningful change for the behavioral objectives within the limited time period.

A123. Learning with Digital Evolution Software: Improving Student Understanding and Acceptance of Evolution

Amy M. Lark, Michigan State University, majchrz1@msu.edu

Gail Richmond, Michigan State University

Robert T. Pennock, Michigan State University

**ABSTRACT:** [Digital evolution software] is award winning digital evolution software that provides students with the opportunity to learn fundamental evolutionary concepts while simultaneously engaging in authentic science practices. In this way, [digital evolution software] is exceptionally well aligned with reform-based teaching practices, such as those advocated by the Next Generation Science Standards and Vision & Change. We present preliminary results of a multiple-case study on the classroom implementation of [digital evolution software] and its effects on student learning of evolution. Students were assessed prior and subsequent to engagement in exercises involving [digital evolution software]. Both content understanding and acceptance of evolution as a real, explanatory, and evidence-based phenomenon were assessed. We found that students in lower-division biology courses saw significant increases in both understanding and acceptance of evolution software].

A125. The Impact of a Science Methods Course on Pre-Service Science Teachers' Technological Pedagogical Content Knowledge

Sedef Canbazoglu Bilici, Aksaray University, sedefcanbazoglu@gmail.com

Havva Yamak, Gazi University

Nusret Kavak, Gazi University

Selcen Guzey, University of Minnesota

**ABSTRACT:** The purpose of this study was to assess pre-service science teachers' TPACK over a semester-long course and their views about the course design. In this research, a science methods course was developed by modifying

Magnusson, Krajcik and Borko's (1999) transformative PCK model and its components. 27 pre-service science teachers took the course toward the end of their four-year teacher education program. Lesson plans, observations, and science methods course practices evaluation form were used as data collection tools. Technological Pedagogical Content Knowledge based lesson plan assessment instrument (TPACK-LpAI) and Technological Pedagogical Content Knowledge Observation Protocol (TPACK-OP) were used to analyze data obtained from observations and lesson plans. Also, science methods course practices evaluation form data was analyzed using the NVivo 9.0 program employing descriptive analysis, content analysis, and constant comparison method. The results showed that preservice teachers gained knowledge of "effective usage of educational technology during science instruction" by observing their classmates' microteaching and the transformative TPACK based training given in the science methods course.

## A127. STEM Teacher Development Using Web 2.0 Tools for Collaborative Instructional Design Pavlo D. Antonenko, University of Florida, p.antonenko@coe.ufl.edu

**ABSTRACT:** This study investigated changes in 50 inservice science, technology, pre-engineering and mathematics teachers' technological pedagogical content knowledge and technology integration self-efficacy as a result of engaging in Web 2.0 enhanced collaborative instructional design of a problem solving activity. Previously validated surveys of technological pedagogical content knowledge and technology integration self-efficacy were used to collect data in the prepost format. Improvements were observed in both perceived technological pedagogical content knowledge and technology integration self-efficacy were used to collect data in the prepost format. Improvements were observed in both perceived technological pedagogical content knowledge and technology integration self-efficacy relative to performance outcome expectations, self-evaluative outcome expectations, social outcome expectations, and interest. Results of this study suggest that instructional design 2.0 can be used to supplement traditional professional development experiences and that collaborative instructional design may be a contributing factor in teacher's self-efficacy to integrate technology in the classroom and their technological pedagogical content knowledge.

**Strand 13: History, Philosophy, and Sociology of Science** *Poster Session A* 3:15pm – 4:15pm, Ballroom 2, 3, and 4

#### A129. *The Epistemic Beliefs and Socio-cultural Views of Science in College Majors and Mon-majors* Brendan E. Callahan, Kennesaw State University, bcallah7@kennesaw.edu Samantha R. Fowler, Florida Institute of Technology

**ABSTRACT:** There is an uneasy relationship between many college students and science. In some cases, this uneasiness is a result of perceived conflict between science and their personal views. The field of epistemology studies the nature of human knowledge, which has the potential to impact students' views on science. We conducted a study in order to quantify the relationship between college students' epistemological views and their socio-cultural views of science. A total of 206 undergraduate students (both science majors and non-majors) completed the Epistemic Beliefs Inventory (EBI) and the Thinking about Science Survey Instrument (TSSI). The EBI was designed to measure students' views on five factors of knowledge, while the TSSI measured nine dimensions of scientific beliefs. We found a positive correlation between belief in an omniscient authority and certain knowledge. We also found these same students had a generally negative attitude towards science in general with no significant difference between science majors and non-majors. This paper provides evidence that there is a relationship between students' epistemological views and how they perceive the scientific enterprise.

#### A131. Developing and Implementing a NOS Focused Course for Science Education Undergraduate Freshman John M. Hilton, Delaware Technical College & Community Center, jhilton14@comcast.net Michael H. Buoni, Delaware Technical Community College

**ABSTRACT:** How an undergraduate, freshman year, NOS-specific course affects students' beliefs about science Abstract Research shows that K-12 teachers typically possess naive views of NOS. Our college does not offer a methods course, and since the nature of science instruction in content courses is widely varied, we created a required NOS-specific course that our secondary science education majors take during their freshman year. The main goal of our course is to enable students to appropriately frame science prior to taking their content courses. This defining characteristic is achieved, in part because students take the NOS course as freshmen. Our second defining characteristic is the multicontextualized approach to presenting the tenets of NOS. Students are exposed to explicit NOS tenets within the context of common science content and cultural-historical exemplars. The goal of our study was to assess whether the course influenced students' perceptions of, and ideas about, science. We used the Thinking about Science Survey Instrument (TSSI) developed by William W. Cobern (2000) at the beginning and end of the course to look for change. Major themes emerged from the survey data which showed that students' thinking about science changed over the course of the class. We plan to use the results to influence more focused research and course refinement.

### A133. Developing Pre-Service Science Teachers' NOS Views: Using Blogs as a Platform for Reflection Sinan Ozgelen, Mersin University, sozgelen@gmail.com

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, 30 PSTs (18 female, 12 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.

### **Strand 14: Environmental Education**

*Poster Session A* 3:15pm – 4:15pm, Ballroom 2, 3, and 4

### A135. Exploring Fourth and Eighth Grade Students' Views of Energy Flow through Ecosystems Ashlie B. Arkwright, University of Kentucky, ambeal@uky.edu

Rebecca McNall Krall, University of Kentucky

**ABSTRACT:** Although students in grades four through eight are expected to be familiar with basic concepts related to energy flow through ecosystems, research studies conducted outside the U.S. indicate that K-12 students of all ages often hold alternative conceptions about this topic (see Adeniyi, 1985; Munson, 1994; Ozkan, Tekkaya, & Geban, 2004). This descriptive study examines 72 fourth and eighth grade students' understandings of the sun as the original energy source for most ecosystems. Students completed a multiple-choice instrument with common alternative conceptions embedded in the distractor options, as well as open written explanations. Descriptive analysis of multiple-choice responses included calculation of frequencies and percentages for the overall student scores, as well as scores for each answer option by low, middle, and high performing subgroups. Students' written responses were scored by a team of researchers based on the degree to which the responses reflected accurate scientific explanations of assessed phenomena. Data analyses revealed several troublesome areas, including the ability of plants to store and later use excess food made during photosynthesis. Implications for teaching about this topic will be discussed.

#### A137. Examining Cultural Bias in Standardized Science Test Items

 $Juliann\ Dupuis,\ Notre\ Dame\ of\ Maryland\ University,\ jdupuis@ndm.edu$ 

Eleanor D. Abrams, University of New Hampshire

**ABSTRACT:** In science education there has been an increased amount of research investigating the impact of culturally relevant curriculum adaptations on Indigenous students' achievement in standardized assessments. However, little research has focused on Indigenous students' achievement on science standardized tests when Indigenous knowledge is integrated into the test questions. The views that Native and non-Native students have toward mandatory state science assessments have become increasingly more important as a greater number of states prioritize inclusive science testing.

Montana has developed a state science assessment that has incorporated a few test items that assess students' understanding of indigenous science. This study examines both Montana's eighth grade students' achievement on the state science assessment exploring indigenous and White student performance on American Indian items on the Montana State science test and individual indigenous test items to determine any bias that may that exist in items written from culturally relevant standards and if there any patterns in the kinds of distractors (incorrect answers) that the students select. Understanding the connections between student achievement and culturally relevant science test items brings valuable insights to the fields of science education, research on student assessments, and Indigenous studies.

### A139. *Making Place-Based Socio-Scientific Issues Discernible to Urban Middle School Science Teachers* Gayle A. Buck, Indiana University, gabuck@indiana.edu

Kristin L. Cook, Bellarmine University

Ingrid S. Weiland, University of Louisville

ABSTRACT: Socioscientific issues (SSI) instruction has shown great promise, not just in getting teachers and their students interested in science content, but also in showing them the importance of science to society and helping them to become better critical thinkers and citizens. However, researchers have argued that SSI-focused education needs to be situated in students' local communities, connected to their interests and tied to reflections upon their personal views. Place-based pedagogy offers such a connection by promoting learning that is rooted in what is local. The purpose of this participatory action research study was to develop an understanding of a teacher's experience with implementing placebased instruction on SSI and to use this understanding to enhance our understandings of effective professional development. Our findings indicated that our efforts did increase the teacher's attempts to implement place-based instruction on socioscientific issues; however, the findings also reveal several areas in which we can improve our efforts in order to assure that those attempts are more successful. In this poster presentation, we provide our research findings, as well as a complete description of our empirically-based professional development project aimed at making place-based instruction on socioscientific issues practical, effective, and meaningful. 0 0 1 204 1169 Indiana University 9 2 1371 14.0 Normal 0 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-styleparent:""; mso-padding-alt:0in 5.4pt 0in 5.4pt; mso-para-margin-top:0in; mso-para-margin-right:0in; mso-para-marginbottom:10.0pt; mso-para-margin-left:0in; line-height:115%; mso-pagination:widow-orphan; font-size:11.0pt; fontfamily:Calibri; mso-ascii-font-family:Calibri; mso-ascii-theme-font:minor-latin; mso-hansi-font-family:Calibri; msohansi-theme-font:minor-latin;}

## A141. The Relationship between Students' Critical Evaluation Abilities and Plausibility Reappraisal of Climate Change

Doug Lombardi, Temple University, doug.lombardi@temple.edu

Carol B. Brandt, Temple University

**ABSTRACT:** A Framework for K-12 Science Education (NRC, 2012) identifies critical evaluation as a key scientific and engineering practice. Critical evaluation is especially important when examining the connections between lines of evidence and alternative explanations of controversial science topics, such as global climate change. When thinking about climate change and other socio-scientific topics, a gap may exist between what students and scientists find plausible. Dole and Sinatra (1998) theorize that plausibility judgments may be closely related to critical evaluation, and also facilitate knowledge reconstruction from alternative conceptions to scientific understanding. The purpose of this study was to examine the relationship between critical evaluation facilitated by an instructional scaffold called the model-evidence link diagram and students' changes in their plausibility judgments about human-induced climate change. Our analysis revealed that students who drew diagrams and provided explanations with a relatively deep level of critical evaluation experienced a significant shift in plausibility (i.e., from an alternative model implicating the sun as the cause of current climate change toward the scientific model of human-induced climate change). The study suggests that instruction promoting critical evaluation and plausibility reappraisal may be necessary in developing students' scientific habits of mind, especially when thinking about global environmental challenges.

### **Strand 15: Policy** *Poster Session A* 3:15pm – 4:15pm, Ballroom 2, 3, and 4

A143. Technologies of Regulation: A Critical Analysis of Performativity in the Next Generation Science Standards

Darren G. Hoeg, University of Toronto, hoeg\_darren@hotmail.com John L. Bencze, University Of Toronto

**ABSTRACT:** The Next Generation Science Standards (hereafter NGSS) were received with anticipation as the answer to an urgent need to develop globally competitive scientific literacies in American students. An effort to realise such utilitarian science education goals suggests a highly prescriptive form of science education. The NGSS appear to represent such a prescription. Ing a framework of performativity, we conducted a critical discourse analysis critically on the NGSS to evaluate its potential effect on how teachers teach and what students are required to do. Our analysis suggests the scientific knowledge and skills communicated in the NGSS are performative, in that they advance a very specific set of teaching experiences for teachers and learning outcomes for students. Specifically, the standards: empower performance as the right way to do science; limit the potential experiences of teachers and students rather than expand them; place responsibility for pedagogical changes to accommodate the new standards on teachers; empower certain science knowledge while marginalising others; privilege performance as measurable achievement; provide an appearance of instructional flexibility; and, privilege the consumption, rather than the construction, of scientific knowledge and practice.

### Poster Session B 4:15pm – 5:15pm, Ballroom 2, 3, and 4

# Strand 1: Science Learning, Understanding and Conceptual Change *Poster Session B*

4:15pm – 5:15pm, Ballroom 2, 3, and 4

### B2. Learning and Teaching Crosscutting Concepts from Cognitive Perspectives Dongmei Zhang, The University of Georgia, dongmei@uga.edu

Barbara A. Crawford, University of Georgia

**ABSTRACT:** Crosscutting concepts are significant for science education, and have been articulated in national and state science education documents for a long time. However, Crosscutting concepts have not received enough attention from both researchers and science educators. In order to elevate the status, new U.S. K-12 science education framework and Next Generation Science Standards identify these as the second dimension giving as much prominence to this dimension, as to the other two dimensions-----Practices and Disciplinary Core Ideas. In this conceptual paper, we present the importance of crosscutting concepts, the levels of understanding crosscutting concepts, the cognitive process of learning crosscutting concepts, teaching of crosscutting concepts by integrating the other two dimensions, and implications. This conceptual paper may inspire the teaching of crosscutting concepts by proposing a possible learning progression of learning crosscutting concepts. Implications include providing science teachers with possible ways to think about teaching crosscutting concepts and researchers ways to design studies related to reform-based teaching.

B4. Exploring Features of School Scientific Inquiry of Science Core High School in Korea
Sun-Kyung Lee, Seoul National University, sunlee@snu.ac.kr
Jeong-Woo Son, Gyeongsang National University
Myeong-Kyeong Shin, Gyeongin National University of Education
Hae-Ae Seo, Busan National University
Gyuho Lee, Gyeongin National University of Education
Chui Im Choi, Seoul National University

### Hojang Song, Seoul National University

**ABSTRACT:** This study aimed to explore how to characterize high school science inquiry in terms of features of designing studies, transforming observation, reasoning to formulate explanations from evidence and planning procedures. For this research, fifteen science classes were observed, videotaped and transcribed in 13 Science Core High Schools. Analyses of these transcripts were proceeded in three steps: firstly, discourse segments of showing active interactions both in teacher-students and student-student were selected; secondly, according to cognitive processes of inquiry (Chinn & Malhotra, 2002), each segment was analyzed and interpreted; lastly distinctive cases were determined to show essential features of school science inquiry. Based on the analyses, we found four features mentioned above. Teachers' role and educational supports were discussed as well as the practical characters or features of school science inquiry.

B6. High School Students' Understandings of Climate Change

Katherine E. Carson, Curtin University, k.carson@curtin.edu.au

Vaille Dawson, Curtin University

#### Leonie J. Rennie, Curtin University

**ABSTRACT:** Scientific inquiry (SI) is a fundamental part of scientific literacy. Most of the published works addressing students understanding of SI show that students do not understand scientific inquiry. This study investigated high school students' understanding of scientific inquiry in Chile. A sample of 221 students was drawn from 9 classes in two private schools, each from different districts in Santiago, Chile. We used mostly an quantitative method approach looking for a pre-determined view of inquiry elicited by a new open-ended questionnaire: Views about of Scientific Inquiry (VASI). The results showed that most students held an uninformed understanding of most aspects of scientific inquiry. The aspects with the highest percentage of naïve views were: there is no single scientific method; inquiry procedures can influence results; and, explanations are developed from a combination of data and what is already known. Students in highest grades (11th and 12th) showed more informed view of some inquiry aspects. The implications for teaching nature of scientific inquiry in school and in science teacher education are also discussed.

B8. Promoting Mechanistic Reasoning in Early Childhood Science Education

Loucas T. Louca, European University-Cyprus, Louca.L@cytanet.com.cy

Chrystalla Papademetri-Kachrimani, European University-Cyprus

**ABSTRACT:** During the past decade, research in inquiry-based teaching in science has been looking for ways to describe the variability of children's in-class inquiry. In this study we follow research's attention to children's use and understanding of causation as part of inquiry in science education, and analyzed a number of videotaped incidences from authentic early childhood science education activities. Our purpose was to provide evidence of young children's (age: 3,5-5) abilities for mechanistic reasoning in science, as well as to describe the variability in children's mechanistic reasoning, and the contextual possibilities that might have lead to different uses of mechanistic reasoning in pre-school science. A total of 43,5 hrs of videotaped activity sequences in early science education was studied. We analyzed whole-class episodes of student conversation seeking to identify aspects of mechanistic reasoning used by the children. We use this evidence to contend that young, pre-school children are able to develop understanding about the causal mechanism underlying or explaining physical phenomena. Finally, we discuss implications for the role of the teacher and activity design.

### Strand 2: Science Learning: Contexts, Characteristics and Interactions *Poster Session B*

4:15pm - 5:15pm, Ballroom 2, 3, and 4

### B10. *Early Learning about Shadows with Mobile Devices: A Case Study for Preschool Children* Michail Kalogiannakis, University of Crete, mkalogian@edc.uoc.gr

**ABSTRACT:** This research examines the effects of a teaching intervention for teaching shadows to early learners using a range of educational applications for tablets. Children in the control group received only the traditional science instruction about shadows. Children in the experimental group were taught about shadows using tablets. Both the experimental and the control groups consisted of classes from the same participating schools in Greece. Children's science

learning about shadows was assessed using an objective, individually instrument called the Science Learning Assessment (SLA). The first results show that teaching and learning through mobile devices is an interactive process for early learners and has a positive effect for science education and the use of tablets allowed both individual and mutual interaction.

### B12. Characterizing the Views of NOS and OTS of Scientists Teaching Elementary School Science

Matthew Johnson, Penn State University, mmj125@psu.edu

William S. Carlsen, Penn State University

**ABSTRACT:** A pilot study was conducted in an attempt to begin to characterize scientist-teacher partnerships in a formal elementary education setting in a rural mid-west school. Graduate science researchers collaborating with elementary teachers were first interviewed about their beliefs about the nature of science and about their orientations toward teaching science. Two surprising outcomes were that they lacked a sophisticated view of NOS, and despite their daily experience in "doing science," they adhere to the traditional Scientific Method when attempting to teach it. These scientists also seem to overemphasize the importance of observation in knowledge building and have difficulty connecting student conceptions to the learning activities. In classroom observations, the scientists tended to overemphasize the Scientific Method and data collection over knowledge building activities. This study will aid in the development of programmatic supports intended to improve collaboration and outcomes of scientist-teacher partnerships in formal education settings to inform similar scientist-teacher partnerships and their design and implementation.

B14. "I'm a Believer in Both": Documenting the Sense-Making of Teachers and Students About Evolution Elaine Klein, University of Washington, erklein@uw.edu

Veronica Cassone McGowan, University of Washington

Katie Van Horne, University of Washington

Philip L. Bell, University of Washington

**ABSTRACT:** Socio-scientific issues are often posited as polarized topics; evolutionary biology is particularly portrayed in such a manner, given the possible ramifications for conflicting with various belief systems. There is a wealth of contrasting evidence affirming the capability of non-exclusivist people to occupy a "Both/And" position in regard to accepting evolutionary concepts, while also holding theistic beliefs. Despite these findings, a recent study reveals the "cautious 60%" of high school teachers that utilize strategies to avoid controversy when teaching about evolution (Berkman & Plutzer, 2011). This study elucidates what issues arise when experienced high school biology teachers recount their experiences teaching about evolution, and considers the implications of these findings for practice and theory. Through a design-based research and discourse analysis approach, we discuss the complexity of themes that emerged from interviews and bi-weekly meetings with seven high school teachers and students' written work. Discourse themes ranged from the empirical language of science to student agency to personal beliefs and non-exclusivist status. Understanding diverse strategies to engage students around socio-scientific topics is vital information for those working in science education and is especially salient, given the ubiquity of socio-scientific issues included in the Next Generation Science Standards (Achieve, Inc. 2013).

B16. Interactions between High-School Chemistry Teachers and Gifted Students in a Regular Classroom Naama Benny, Weizmann Institute, naama.benny@weizmann.ac.il

Ron Blonder, The Weizmann Institute

**ABSTRACT:** Identifying and characterizing interactions between gifted students and high-school science teachers can give us a rich discretion and patterns of the interaction. This research uses qualitative technique, the Critical Incidents Technique (CIT). The CI that were collected occurred between a chemistry teacher and a gifted students in a regular classroom. The CI's provide insight into the teacher's view of teaching the gifted student in their class. This rich description is needed in order to be able to make recommendations of enhancing teacher's professional development.

### B18. Career to Pleasure in Science: The Influence of Career Motivation to Learning Science in Korean High School Students

Sein Shin, Department of Biology Education, Chonbuk National Univ., hmmds@naver.com Jun-Ki Lee, Division of Science Education, Chonbuk National University Minsu Ha, SUNY Stony Brook **ABSTRACT:** Motivation to learn is an essential element for self-regulated leaning and long term growth of students' academic achievement. This study aimed to test the model of science motivation from career motivation to pleasure of science and apply the effect of gender and students' academic years to the model. A total of 626 students (213 first year, 199 second year, and 214 third year students; 321 male and 305 female students) participated in this study. The science motivation questionnaire II (SMQII), Wang and Berlin's (2010) instrument, and Authors' (2011) scales were used to assess students' career motivation, grade motivation, self-determination, and self-efficacy, attitudes toward science class, perception of relevance of science to their life, and need for learning. Path analysis using structural equation modeling (SEM), MANOVA, and linear regression were utilized. The results of Path Analysis showed that our model for science motivation factors. Differences of science motivation between male and female students and among each academic year were shown. Based upon the findings, further educational implications to increase Korean students' science motivation were discussed at the presentation.

### B20. Capturing the Narratives of Emergent Science Students in Science Learning through Journaling and Oral Narratives

Ann W. Wright, Canisius College, wrighta@canisius.edu

Sue Dale Tunnicliffe, University of London

**ABSTRACT:** The purpose of an ongoing mixed method study is to determine elementary students' understanding of the interrelationships between human biology and health and what is the conceptual change that occurs through various grade levels. To determine the conceptual change, data is being collected from oral interviews, journals, and writing on activity sheets. The results from the study will help build a rationale for integrating discussing, writing, and science into science curricula. Students are from urban and suburban school district located in Western New York and UK (Sue Dale is this correct). Modeling actual methods used by scientists, students use oral and written communication to disseminate information. This information can inform elementary science instruction in the USA and UK. The results of the study indicate communication of science concepts whether written or oral improve scientific literacy builds students' conceptual understanding.

### B22. Science Classroom Norms for the Treatment of Evidence from Authority

### Susan A. Kirch, New York University, susan.kirch@nyu.edu

**ABSTRACT:** In the classical view of education teachers are an authority in authority. In other words, they are seen as an authority with the knowledge students need to acquire and in authority with the ability to direct classroom activities. In elementary school science, the tension between these forms of authority and knowledge re/production can confuse efforts to teach epistemic practices like argumentation. This paper examines the practices of sanctioning interrogations of knowledge claims in an elementary school classroom context. It argues that these practices are part and parcel of a classroom's epistemic culture and have implications for assessments of authority. This contention is illustrated with a study of teacher-student interactions in third and fourth grade classes using an epistemologically motivated curriculum.

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

4:15pm – 5:15pm, Ballroom 2, 3, and 4

### B24. Elementary Teachers' Implementation of Formative Assessment Strategies: Supporting Students' Learning about Water and Earth Materials

Jaime L. Sabel, University of Nebraska-Lincoln, jaime.sabel@huskers.unl.edu

Cory T. Forbes, Univrsity of Nebraska-Lincoln

Mandy Biggers, Penn State University

**ABSTRACT:** A focus on students' ideas remains the foundation of effective science curriculum and instruction. To effectively promote students' science learning, teachers should attend to students' ideas about natural phenomena through the use of formative assessment practices in the classroom. Though past research has shown that this 'high-leverage' instructional practice can positively impact student learning, formative assessment is not commonplace in elementary

classrooms. Elementary teachers therefore need support to learn to effectively implement formative assessment practices and to modify instruction in response to students' ideas. However, few studies have explored teachers' instructional decision-making about what to do, instructionally, with information about students' thinking elicited through formative assessment. To begin to address this gap in the literature, we use video recorded classroom observations, teacher logs, interviews, and other supplemental data to investigate six elementary teachers' learning to employ formative assessment practices to scaffold 3rd- and 6th-grade students' learning about interactions between water and Earth materials, a core, unifying concept in the Earth sciences. Study findings highlight the how teachers evaluate student work to identify trends in student thinking about water and Earth materials interactions and how those trends influence selection and implementation of next step instructional strategies.

B26. Science Inquiry Centered Argumentation Model (ScICAM) for Young English Language Learners Thomas R. Tretter, University of Louisville, tom.tretter@louisville.edu

Yuliya Ardasheva, Washington State University

Lori Norton-Meier, University of Louisville

Sherri L. Brown, University of Louisville

**ABSTRACT:** This study served as an investigation of the promise of positive outcomes on K-2 English language learner (ELL) students' outcomes in science, literacy, and social behavior after two months of implementation of Pseudonym Model (PSEUDO – pseudonym for the project acronym to maintain anonymity of the research team; Authors, 2008)—a systematic teaching approach that integrates literacy instruction in the context of active, inquiry-based science learning. The sample included: 17 elementary teachers and 31 ELL Grade K-2 students. Results indicated that teachers judged the PSEUDO active ingredients appropriate for supporting the learning of their students, and teacher practices (proximal outcomes) with support from the research team and a professional learning community aligned well with the PSEUDO approach, and resulted in increases in ELL student learning (distal outcomes) in science content, science argumentation skills, and literacy skills.

## Strand 4: Science Teaching--Middle and High School (Grades 5-12): Characteristics and Strategies *Poster Session B*

4:15pm – 5:15pm, Ballroom 2, 3, and 4

B28. Contributions of Action Research in 6th and 7th Grade Students' Associations of STSE

Sinem Toraman, Yildiz Technical University, storaman@yildiz.edu.tr

Ünsal Umdu Topsakal, Yildiz Technical University

Aysun Öztuna Kaplan, Sakarya University

Esra Macaroglu Akgul, Yildiz Technical University

**ABSTRACT:** The purpose of the research is to examine the effects of this specific instructional design on students' and their environment's awareness and understandings of socio-scientific issues. This study aims to present science education specified with socio-scientific issues that are organic agriculture, family planning, dependency, donation of organs; provide which contributions to students and local people. Concluding, this study examines how science education including socio-scientific issues affects individuals and the society. This study was designed as an action research. This research was conducted in a village mobile school in Sakarya in Turkey. For the research, an instructional design aims to develop students' STSE associations, was designed and applied in 6th and 7th grades. Participants of the study were chosen with maximum variety method of purposeful sampling. 33 students in 6th grades and 28 students in 7th grades, 11 parents and 4 local people and 1 local chief took part in the research. In the study which was conducted 2011-2012 academic year document analysis, observation and open-ended question form (materials prepared by students, students' letters and researcher's diary) as primary data source and interviewed as secondary data source were used.

B30. Strengthening Science Attitudes: Planetarium-Based Scientific Visualizations for Middle and High School English Language Learners

Thomas R. Tretter, University of Louisville, tom.tretter@louisville.edu Yuliya Ardasheva, Washington State University **ABSTRACT:** This study targeted first-year ELLs' (n=228) science attitudes using planetarium-based scientific visualizations to teach complex, sophisticated science concepts. Student attitudes towards science is a key construct that may serve as an early indicator for later persistence and achievement in science. Results from a pre-mid-post Likert attitude survey and interviews showed middle school students' attitudes significantly increased (Cohen's d=0.43) following a series of 5 planetarium visualizations in a 2-month unit of study, and stabilized at that level in a subsequent unit. High school students showed an increase that was not statistically significant (p

#### B32. *Motivation to Innovate: Inquiry-based Science as Character Education* Sarah Barrett, York University, sbarrett@edu.yorku.ca

**ABSTRACT:** This longitudinal case study explores the ways in which a new science teacher's goals for her students shape the implementation of an inquiry-based science curriculum. As part of a larger multi-case study of new science teachers, a middle school science teacher was followed for two years as she implemented an inquiry-based program designed, in part, to develop her students' character. The focus of the teacher's intention was enhancing personal responsibility in her students (grades 6-8). Specifically, it cultivated perseverance, courage and learning from mistakes. This deliberate connection of inquiry to character education is rarely documented. Thus, this case study is significant for the following reasons: (1) a connection between inquiry and character education flows naturally from the essence of inquiry, (2) making this connection reveals another framework for understanding teachers' motivations for innovation, and (3) connecting character education to inquiry highlights the ways in which science education can be seen as just as integral to being an educated person as literacy (and to some extent numeracy), regardless of the students' ultimate academic and/or career trajectory.

#### Strand 5: College Science Teaching and Learning (Grades 13-20) *Poster Session B*

4:15pm - 5:15pm, Ballroom 2, 3, and 4

B34. Risks of Nanotechnology: An International Study of the Perceptions of Engineering and Science Students
M. Gail Jones, North Carolina State University, gail\_jones@ncsu.edu
Grant E. Gardner, Middle Tennessee State University
Ron Blonder, The Weizmann Institute
Antti Laherto, University of Helsinki
Virginie Albe, ENFA
Gina Childers, North Carolina State University
Manuela Paechter, University of Graz

**ABSTRACT:** This study examined engineering and science undergraduate students' perceptions of the risks of nanotechnology and their views of the importance of communication about nanotechnology advancements. Participants (n= 265) were from Austria, Finland, Israel, France and the USA. Results showed that students viewed risks of nanotechnology differently depending on whether it was an application in their environment or related to human health. There were significant differences by country for perceptions of whether or not it is justifiable to further develop applications. Students viewed the voluntariness of exposure to risk as key in health applications. When students perceived that it was not ethically justifiable to develop nanotechnology applications, they placed the responsibility to communicate risks with the government, campaigning groups and nanotechnologists.

B36. *The Nature of Experiences Responsible for the Generation and Maintenance of Interest in STEM* Christina S. Melki, Indiana University, csmelki@indiana.edu

Adam V. Maltese, Indiana University

Heidi Wiebke, Indiana University

**ABSTRACT:** With the ever-evolving fields of science, technology, engineering and mathematics (STEM), it is important to maintain an influx of students to further the disciplines. While many students have an interest in STEM fields early in their lives, the amount that pursues it as a career dwindles rapidly. Therefore, it is important to identify the factors that cause individuals to become interested in STEM and develop that interest into a career. To analyze this, we developed

a survey that we administered to colleges, universities, and via the Scientific American website. From our data, we found that there are few differences between individuals that pursued STEM fields and those that did not. For all respondents, interest was most frequently sparked during elementary school, with prominent factors coinciding with the events and people that were most frequently encountered such as school classes/activities, parents, and teachers. However, innate interest and parents were the most commonly cited by individuals that maintained their pursuit of STEM fields. Though few differences amongst individuals were identified, many of the results indicate there are further avenues to explore in STEM persistence, including surprisingly influential factors such as various media and math/logic games.

B38. Discourse Between Men and Women During PBL Engineering Group Work

Anne Marie Casper, Colorado State University, aramaticasper@gmail.com

Meena M. Balgopal, Colorado State University

Rebecca Atadero, Colorado State University

Karen Rambo-Hernandez, Colorado State University

Darrell Fontane, Colorado State University

**ABSTRACT:** Students in STEM-related fields benefit from small group work. However, the gender composition of groups may influence learning outcomes, particularly in male-dominated fields such as engineering. We conducted an exploratory study, using a qualitative case study approach, and used video analysis to study how women interact with male classmates during small group PBL work. Students in a sophomore undergraduate engineering course were assigned to different groups for three assignments. Each 5 person group was made up of 0-2 women and 3-5 men. We used constructivist grounded theory to developed inductive codes to analyze the discourse in the videos. We found that women in the 1-woman groups initiated discussions less, initiated and participated in conceptual discussions less, and their contributions were acknowledged less by there male peers, than their counterparts in 2-women groups. Particularly due to the lessened engagement with conceptual discussion demonstrated by women in 1-woman groups, our findings indicate that it is better to have two women than one woman in a group.

### B40. *Early Exploration of an Online Peer-group Homework System in an Introductory Physics Course* James F. Kisiel, California State University, Long Beach, j.kisiel@csulb.edu

**ABSTRACT:** In response to the challenges associated with improving student retention in science and engineering majors and the limited opportunities for students to interact with peers in large-enrollment classes, physics faculty at a large public master's university developed Social Homework (SHW)—a Facebook-like discussion tool designed to support meaningful student learning by encouraging in-depth discussions of key problems and peer engagement. Initial analysis of student use of the strategy suggests that female students are more likely to engage in these on-line group problem-solving sessions than their male counterparts. Although designed to appeal to tech-savvy socially-networked students, familiarity and use of Facebook and other social media, as well as common classroom strategies such as i-Clickers and discussion boards, was not an indicator of student engagement with the Social Homework platform. Despite the fact that the student outcomes were strongly tied to instructor efforts and implementation, within-class analysis reveals that lower performing students (self-reported B and C students) may benefit significantly more from engagement in Social Homework than their higher-performing peers. Suggestions for further study will also be discussed.

### B42. *Healthcare Students*`Levels of Scientific Literacy and the Impact of Contextual Teaching on Scientific Literacy

Inga Ploomipuu, University of Tartu, ingaploomipuu@nooruse.ee

Miia Rannikmae, University of Tartu

### Jack B. Holbrook, University of Tartu

**ABSTRACT:** Scientific literacy (SL) related skills are important in health care education, so the students become competent specialists. However the high school background knowledge and skills of the students is questionable. Therefore it was necessary to evaluate healh care students' levels of scientific literacy, to develop and assess a course that could raise these levels, to determine students' self-perceived level of SL and their motivation to study science related subjects. The objects of the study were 1st year healthcare students. Questionnaires were interdisciplinary, had a relevant scenario and scenario-based questions that measure aspects of SL and questions related to motivation and self-assessment. Group of volunteer students was chosen to conduct the course after which the level of scientific literacy was measured

again and a focus-group interview was carried out. Preliminary findings indicate that the highest level of SL was in decision making that required some transition skills, lowest in complex of decision making, creativity and socio-scientific reasoning. These levels have a positive change after implementation of a STS course. Students' motivation of learning science was low as they failed to see the relevance of SL to their professional studies. More precise data will be provided after further analysis

B44. *The Use of Physical Models of Protein Structures to Probe for Learning and Reasoning Difficulties* Sara L. Johnson, Purdue University, saraljohnson@gmail.com

Richard C. Garratt, São Carlos University

Nancy J. Pelaez, Purdue University

Trevor R. Anderson, Purdue University

**ABSTRACT:** Biochemistry educators make extensive use of external representations (ERs) to help students visualize the submicroscopic world of biochemical structures, including proteins. Despite broad acceptance, little is understood about the effectiveness of ERs for promoting student learning about protein structure. Thus, this is an important area of research requiring urgent attention. In this study, we investigate the effectiveness of a physical model kit, Protein Folder, and a protein structure chart, The Protein Chart, at probing for student understanding of protein structure. Twenty-six students, enrolled in a biochemistry course, participated in a two week unit, which made use of the ERs to teach about protein structure. To investigate the educational effectiveness of the ERs, we identified student difficulties resulting from worksheets, quizzes, tests and interviews. We classified difficulties using the conceptual-reasoning-mode (CRM) model. This work revealed four novel difficulties students encounter when learning about protein structure. Identification of these difficulties allows educators to anticipate obstacles their student can face and may lead to eventual improvements in the use of ERs for teaching about protein structure.

B46. Preferred Mentorship Practices as Reported by Students in Undergraduate Research Experiences Russell N. Balliet, Indiana University, runeball@indiana.edu

Joseph A. Harsh, Indiana University

Adam V. Maltese, Indiana University

**ABSTRACT:** Within the sciences, hands-on undergraduate research experiences (UREs) are one of the most common educational devices available to sustain students' interest in and prepare them for STEM careers. The goal of this study is to present a broader picture of effective URE mentorship practices, and to provide further information to address the question commonly posed by our STEM colleagues about how to design or improve these experiences in support of student learning. Semi-structured interviews conducted near the beginning and end of the URE were analyzed for three major themes using an open-ended iterative approach: what students expect, what students reported as being valuable, and what students still feel is lacking in the context of mentorship practices. Our results reveal that students value early training, effective teaching, frequent student-mentor interactions, and supportive and collaborative environments. Furthermore there are opportunities to improve upon project organization, less-than-ideal mentor-student interactions, and experiences that fail to aptly challenge students. The results of this analysis will prove useful to faculty and administrators in the refinement of UREs to aid in the development of student skills and the training of novice mentors (graduate student and postdoctoral researchers) that often work closely with URE participants at larger institutions.

### Strand 6: Science Learning in Informal Contexts *Poster Session B*

4:15pm - 5:15pm, Ballroom 2, 3, and 4

B50. Understanding Learners and Learning of General Relativity

Bruna Irene Grimberg, Montana State University, grimberg@montana.edu

Joey Shapiro-Key, Montana State University

**ABSTRACT:** A Shout Across Time is a three-act multimedia live theater show to disseminate Einstein's theory of general relativity and its implications. The show includes a dance choreographed to portraying in black holes' space-time. The second act features live interviews with leading scientists on experimental and theoretical physics, and the third act is

a multimedia performance combining a live orchestra, digital sounds of what physicists believe gravitational waves would make, and a film. This event attracted an audience with a wide range of expertise in physics, and artistic and scientific interests; more females (46.4%) than males (39.9%); and mostly out-of school people (59.7%). Based on pre and post survey data, 95.4% of the audience reported that their interest in physics and astronomy increased. Similarly, by comparing pre and post-event responses to science questions, the audience increased their understanding of fundamental concepts in general relativity and gravitational waves. Data was analyzed by gender, level of expertise in physics, and artistic/scientific inclination; results show that the enhancement of comprehension and interest is sustained across all these groups. This presentation addresses the "understanding learners and learning", identified as one of the pressing topics discuss in order to advance the informal science education field.

## B54. Marrying Education and Neuroscience Methods Illuminates Expert-Novice Meaning-making Differences from a Scientific Visualization

### Kathryn Stofer, University of Florida, stofer@ufl.edu

**ABSTRACT:** Science communication with data visualization is not a trivial undertaking. Efforts to improve such communication present an opportunity to examine a task from both a neuroscience and an educational perspective, something both groups of researchers have long been hoping to do. This study used clinical interviews and eye-tracking with concurrent interview on multiple versions of data visualizations to examine a) the influence of particular scaffolds on novice and expert meaning-making, and b) the effectiveness of bringing together disparate disciplinary traditions using the same task. Seventeen non-science-major undergraduates were compared to 12 oceanography experts as they made meaning from global satellite visualizations on three ocean topics with no scaffolding, added geographic labels, altered colors, altered titles and units, or all three scaffolds. Novices were less adept at academic meaning-making overall, but showed facility with using elements of the visualizations, improved with scaffolding, and improved with practice at the task, evidenced in interviews, eye-tracking patterns, and significantly lower eye-tracking dwell times using truncated linear regression (all p < .05). Surprisingly, experts also showed difficulty with some time-related elements of the task. The use of the two methods allowed not only triangulation of the data but also insights that neither method alone provided.

#### B56. Mentoring a Student Led Robotics Team

Nathan R. Dolenc, University of Virginia, nrd3fp@virginia.edu Claire Mitchell, University of Virginia

Robert H. Tai, University of Virginia

**ABSTRACT:** Mentors play important roles in determining the working environment of out-of-school time clubs. On robotics teams, they provide guidance in hopes that their protégés progress through an engineering process. This study examined how mentors on one robotics team who defined their mentoring style as "let the students do the work" navigated the challenges of a "build season" and participation in regional competitions. What were some of the challenges faced by mentors and students? How did they cope when students played the largest role in team and design decisions? The mentor-student interactions captured in the research showed mentors playing supporting roles while students took command of all aspects of building the robot. The students on the team found themselves self-directing, learning by doing, and having fun with like-minded peers.

### B58. The M in STEM - Developing Scientific and Mathematical Literacy through an Interdisciplinary, Inquiredbased Science-camp

Louise Bindel, Martin-Luther-University Halle-Wittenberg, louise.bindel@biodidaktik.uni-halle.de Martin Lindner, Martin-Luther-University Halle-Wittenberg

**ABSTRACT:** The poster offers an overview on the development of answers related to Scientific and Mathematical Literacy in a summer-holiday science-camp, lasting five days. A treatment group working on climate change was confronted with authentic mathematical tasks in addition to their scientific workshop, whereas the control group was only doing experiments. The combination of activities between math and science enables a development of parameters, which were measured by a combination of questionnaires and interviews. The study shows the effect of the workshop and reports the usability of the research methods as well.

#### B60. A Collaborative Evaluation of an Informal Science Education Program

Vanessa Vernaza-Hernandez, University of South Florida

Walter J. Rosales, University of South Florida

**ABSTRACT:** During the last years the informal science education programs have gained an important role in the science education arena and in the development of students scientifically literate. As a result the number and variety of informal science education programs have increased. For instance, entities like zoos, museums and aquariums have created informal science programs in order the students can learn about special science topics. An aquarium in the southeast of United States, as part of it Youth Education Program, has created a Family Science Day with the purpose the students and their families can learn about different marine science topics. This presentation will present the results of an external and formative evaluation that had the purpose to determine how the Family Science Day helps to increase students' environmental knowledge, specifically in respect for marine animals. In addition, we will discuss the importance of use a Collaborative Evaluation Model for evaluate informal science education programs.

#### Strand 7: Pre-service Science Teacher Education Poster Session B

4:15pm – 5:15pm, Ballroom 2, 3, and 4

#### B62. Evolution Education: A Preservice Teacher's Changing Identity

Nicholas A. Linke, University of Missouri - Columbia, nalvxd@mail.missouri.edu

Patricia J. Friedrichsen, University of Missouri-Columbia

**ABSTRACT:** Focusing on preservice teachers is the most significant way to impact and improve evolution education for K-12 students (Berkman & Pultzer, 2011). This case study investigated potential changes in a preservice teacher's identity in response to a hybrid evolution course, which included content and pedagogy for teaching evolution. Gee's analytical framework on identity was used to distinguish the participant's identities and analyze the different influences on her identities (2000). The participant entered the course with multiple identities including fundamentalist Christian elementary student, Catholic, and "science minded lab rat." Five majors factors impacted the participant's changing identity: 1) class discussion on addressing the social controversy, 2) group presentations, 3) instructor modeling, 4) weak exam scores, and 5) a final position paper advocating for evolution education, The participant emerged at the end of the course incorporating new identities that used the context of evolution as a means to be a resolver of student–student conflicts and facilitator of student identity formation. The implications of the participant's change in identity are discussed.

### B64. *Interactive Computer Simulation on Biology Teachers' Understanding of Homeostasis Concepts* Vivien M. Chabalengula, University of Virginia, mweenechabalengula@gmail.com

Frackson Mumba, University of Virginia

Rasheta Fateen, Southern Illinois University Carbondale

**ABSTRACT:** The purpose of this study was two-fold (1) to determine the effects of a homeostasis computer simulation on pre-service high school biology teachers' understanding of homeostasis and its related concepts such as thermoregulation, hypothermia and hyperthermia, and (2) to determine participants' perceptions of the simulation. Twenty-two pre-service teachers enrolled in a high school science methods course at a large university in the Midwestern USA participated. Data was collected using a homeostasis computer simulation found on exlorelearning.com, and which included a pretest, actual simulation, posttest, and perception questionnaire. Data was analyzed using percentages, t-test and open coding. Results showed the following three trends: students' conceptual understanding of homeostasis and its related concepts improved after using the simulation, and they achieved higher test scores in the posttest; students performed better to pictorial questions that reflected daily activities compared to text-based factual questions; and majority of the students cited manipulation of variables as one of the simulation design features that helped them comprehend homeostasis and its related concepts. The implications of these results to pre-service teacher education and computer simulations are discussed. Key Words: computer simulation, homeostasis, understanding, perception

#### B66. Pre-service Teachers' Scientific Literacy Level

Adam Alsultan, Southern Illinois University Carbondale, alsultan@siu.edu Vivien M. Chabalengula, University of Virginia Frackson Mumba, University of Virginia

**ABSTRACT:** This study investigated elementary education pre-service teachers' scientific literacy (SL) levels. A sample comprised 40 pre-service teachers at a mid-sized U.S. university in the Midwest. Data was collected using a 30-item modified version of the Test of Basic Scientific Literacy (TBSL). The TBSL tested pre-service teachers' understanding of science content covering concepts in Earth Science (ES), Health Science (HS), Life Science (LS), and Physical Science (PS), as well as knowledge of Science, Technology and Societal issues (STS) and the Nature of Science (NOS). The results indicated that the pre-service teachers satisfactory SL knowledge levels. However, what science teacher educators should emphasis on is to empower pre-service teachers with teaching abilities in the NOS in order to improve their proficiency in this field. Implications for science teacher education and recommendations for future research are discussed. Keywords: Scientific literacy; Nature of Science; Science, technology, and society.

B68. Using Teacher Noticing to Assess Science Teacher Pedagogical Content Knowledge Development Matty Lau, New York Hall of Science, mlau@nysci.org

David E. Kanter, New York Hall of Science

Sherryl Graves, Hunter College- CUNY

**ABSTRACT:** Researchers have argued that good science teachers have a solid foundation of strong pedagogical content knowledge (van Driel & Berry, 2011). Researchers have argued that good science teachers have a solid foundation of strong pedagogical content knowledge (van Driel & Berry, 2011). Such teachers, confident in their PCK, are well positioned to help all students increase their knowledge and skills by giving them the space within which to present their ideas, make mistakes, process, discuss with peers, ask why, have a discussion, and then try again (Ball & Cohen, 1999; Grossman, Schoenfeld, & Lee, 2005; Remillard & Geist, 2002). Ball, Thames, and Phelps (2008) noted that while the term PCK has been around for more than a decade, little has been done to advance our understanding of this construct. In particular, it is not wholly clear what it looks like and as a result how to measure it. In this paper, we explore a methodology for measuring a teachers' pedagogical content knowledge. Our research question is: What, if any, changes in teacher noticing can be observed in teaching residents enrolled in a one semester content course aimed at pedagogical content knowledge development.

# B70. Science Teaching Identity and Identity Work of Three Differently-positioned Beginning Elementary Teachers

Lucy Avraamidou, University of Nicosia, Cyprus, lucyavraamidou@gmail.com

**ABSTRACT:** Grounded within Wenger's social theory of identity and with the use of a narrative inquiry approach, this collective case study aimed to address the following questions: a) What kinds of identity work do three differently positioned beginning elementary teachers engage in over time within various contexts? and, b) How are these beginning elementary teachers' identity works shaped by their participation in various communities? Several kinds of data were collected over a period of an academic semester: interviews, self-portraits, journal entries, drawing assignments, biographical assignments, lesson plans and classroom observations. Filtered through their prior science learning experiences, the participants positioned themselves differently and exhibited three different kinds of identities: Maria's identity emphasized scientific inquiry, Evelyn's identity placed emphasis on more affective aspects of science learning and at the heart of the account of Michael's identity was learning in informal learning environments. These findings are offered through a discussion around three claims: a) science life histories pave the way to authoring a science teaching identity; b) participation in various communities of practice cause major shifts on science teaching identity work; and, c) experiences in teacher preparation influence a science teaching identity trajectory.

# B72. An Inquiry into a Teacher Education Programme That Supports Student Engagement in Science Paul Davies, Institute of Education London, p.davies@ioe.ac.uk

Shirley A. Simon, Institute of Education London

**ABSTRACT:** Increased student engagement in science has positive effects on perceptions of science, academic achievement and the continuation of studying science after compulsory school. A key feature of promoting engagement is

the role that the teacher plays in motivating students by designing and creative learning experiences that are relevant to the learner. In this study, we critically examine a range of initiatives that we have developed on our initial teacher education programme to support pre-service teacher's acquisition of the skills and approaches which promote the designing of these types of experience for high school students. Our inquiry reveals the importance of theoretical considerations in education design and its potential impact on teachers.

### Strand 8: In-service Science Teacher Education *Poster Session B*

4:15pm – 5:15pm, Ballroom 2, 3, and 4

### B74. Integrating Nanoscience and Technology in the High School Science Classroom: Face-to-Face vs. Asynchronous Professional Development

Douglas W. Huffman, University of Kansas, huffman@ku.edu John D. Ristvey, McREL

**ABSTRACT:** This study focuses on a research and development project designed to support high school teachers with planning and integrating nanoscience and technology (the big ideas of nanoscale science and engineering) lessons into their existing curricula in significant ways using an instructional design framework (Designing Effective Science Instruction). Through a Discovery Research K–12 National Science Foundation (NSF) grant, the project developed and tested two different professional development approaches (fully face-to-face and asynchronous group/self study) in which participants learned how to improve their pedagogy to effectively incorporate nanoscience concepts into their unit and lesson plans. This paper will compare the face-to-face versus asynchronous group/self study approaches to professional development, and the extent to which each approach helped teachers integrate nanoscience concepts in the classroom.

#### B76. Enacting STEM in Teacher Development

Rachel Ruggirello, Washington University in St. Louis, ruggirello@wustl.edu

Phyllis Balcerzak, Washington University in St. Louis

**ABSTRACT:** Various iterations of STEM have been in the forefront of national educational reform of science and math teaching over the last two decades. Most recently STEM is being viewed as the integration of the sciences, math, technology and engineering to solve authentic problems, rather than an individual collection of related subjects. This approach to educating students about core STEM subjects requires teachers who have expertise in content, pedagogy, and the integration of STEM content. This chapter discusses the complexity of issues that emerged during STEM programs designed for teachers in both a university and two K-12 middle schools. Common themes are analyzed for implications to teacher preparation and professional development programs. The chapter concludes with the description of an approach to STEM teacher preparation that calls for a reorganization of the knowledge base from the STEM disciplines and professional learning programs that emphasize collaborative processes and links between content.

#### B78. Teachers' Learning about Assessment: Possible Professional Learning Trajectories

Heejung MIN, Chongryang middle school, isflora@hanmail.net

Seoung-Hey Paik, Korea National University of Education

Nam-Hwa Kang, Korea National University of Education

**ABSTRACT:** The purpose of this study was to understand secondary science teachers' professional learning about assessment as an integrated part of science instruction. Research questions addressed the degree to which teachers engaged in the new idea of assessment and possible trajectories for teachers to take in developing new classroom assessment practices. A total of 10 secondary science teachers, from 3 to 23 years of teaching, participated in this study. All the teachers participated in a three-week professional development course on assessment and six of them were interviewed after three months while they were teaching in schools. The findings showed the teachers' deep engagement in the concept of assessment from a constructivist view of learning as shown in their discussions and essays. Given the high level of engagement in the new concept of assessment, the teachers demonstrated different levels of engagement in new practices of assessment. Based on common words the teachers used to describe their learning, seven critical steps for

new practices were identified. These were divided into three categories: knowledge acquisition, belief change and practice change. While all the teachers passed the knowledge acquisition level, only four teachers were at the practice change level. Further research topics are discussed.

B80. Determining the Effectiveness of Enacted PD Course Based on Identified Teacher's Needs

Ana Valdmann, University of Tartu, anavaldmann@gmail.com

Jack B. Holbrook, University of Tartu

Miia Rannikmae, University of Tartu

**ABSTRACT:** The purpose of this study is to establish an effective PD programme to promote teacher's self -efficacy with respect to implementing motivational inquiry-based teaching based on a theoretical three-stage model. To this end, the professional needs of each teacher were identified by means of a validated teacher needs questionnaire covering identified pedagogical content knowledge expectations, plus follow up teacher interviews. The PD focus was determined by interviewing teachers who had been through similar PD programmes in the past. Findings suggest enactment of teaching and reflective feedback on classroom implementation as important components for raising teacher confidence in using the approach, while the course itself should relate further to developing competence in theoretical education ideas. Key terms: professional development, inquiry-based teaching, three stage model, teaching-learning materials.

# B82. Examining Two School Districts' Approaches to STEM Professional Development: A Qualitative Study Merryn Cole, University of Kentucky, merryn.cole@uky.edu

#### Jennifer A. Wilhelm, University of Kentucky

**ABSTRACT:** We describe two school districts involved in a partnership enhancement project where school districts received awards to support mathematics and science education reform. This qualitative study examined the differences in the two approaches to professional development in terms of student outcomes and likelihood of sustaining collaborative partnerships. Both schools chose to design their professional development around the new standards; one school focused on engineering due to the Next Generation Science Standards, while the other focused on incorporating the Common Core Literacy Standards in science as well as addressing the new required biology end of course exam. While one school implemented a one-day science conference for the district supplemented by regular meetings for science teachers, the other planned five professional development days focusing on three different goals. Nearly all the participants in both districts mentioned the importance of the collaborations both within their districts and with higher education partners. Early data suggests both districts improved student outcomes as a result of the professional development, but more time is needed to see whether these gains are meaningful or if they are blips in the data.

B84. *How does Teachers' Participation in an Research Experience Shape their Students' Science Learning* Sibel Bahbah, Florida State University, sibel.uysal@gmail.com

Sherry A. Southerland, Florida State University

Barry Golden, University of Tennessee

Ellen M. Granger, Florida State University

**ABSTRACT:** This study examines the link between teacher professional development and student learning, through exploring the impact of teachers' participation in one of two different Research Experiences for Teacher (RET) Programs on their elementary students' science learning. Participant teachers attended a six week summer workshop to work with scientists in research: one program focused on conducting authentic science research (SciRes) and a second focused on understanding scientific inquiry (SciPed). The results show that teachers' participation in both programs improved their students' self-efficacy, but only those teachers participating in the SciPed program improved their students' scientific process skills. Neither program increased their students' content knowledge. The implications of these findings will be discussed.

B86. A Study of the Impact of Professional Development on Hispanic Student Performance on State Mandated Assessments of Science

Carla C. Johnson, Purdue University, carlacjohnson@purdue.edu Jamison D. Fargo, Utah State University **ABSTRACT:** This paper reports the findings of a study of the impact of the Professional Development model on student achievement on state-mandated assessments of science in the U.S. Two schools (one intervention and one control) participated in the case study where teachers from one school (Burns) received the intervention across a two-year period while teachers at the other school received no program and continued business as usual (Johnson). The PD framework includes a focus on the core conceptual framework for effective professional development (Desimone, 2009) as well as an emphasis on culturally relevant pedagogy (CRP) and other effective science instructional strategies. Findings revealed that participation in PD had a significant impact on student achievement for Burns Elementary with the percentage of proficient students growing from 25% at baseline to 67% at the end of the two-year program, while the comparison school did not experience similar growth. Implications for future research and implementation of professional development programs to meet the needs of teachers in the realm of CRP in science are discussed.

B88. Metaphors in Teaching Exhibited by First-year Science Teachers in Online Mentoring Dialogues Eunjin Bang, Iowa State University, ejbang@iastate.edu Sissy S. Wong, University of Houston Julie A. Luft, University of Georgia

**ABSTRACT:** This case study explores first-year secondary science teachers' metaphorical concepts within the context of dilemmas the teachers encountered when utilizing constructivist practices. Through the conceptual metaphor theory lens, this study used the yearlong archived, online threaded dialogues of eleven first-year science teachers. Using a case study method, this proposal guides the in-depth exploration and explanation of the design of the study, the operationalization of the terms involved, and their philosophical significance. The initial findings indicate that first-year science teachers generated topics related to pedagogical and cultural dilemmas the most. Multiple source domains were identified in each dilemma category, as well as schematic elements. Further findings of the study will be reported upon the acceptance of this proposal, as this study is a work-in-progress.

### Strand 9: Reflective Practice *Poster Session B*

4:15pm – 5:15pm, Ballroom 2, 3, and 4

## B90. *Heather's Story: Using Autoethnography to Open Communication in Public Understanding of Science* Heather Rudolph, University of Georgia, hrudolph@uga.edu

**ABSTRACT:** This paper highlights segments of my autoethnography to demonstrate how life as a child and young adult with severe rheumatoid arthritis can be an interesting and accurate scientific account of this chronic disease, emphasizing the human side of science. Writing it as autoethnography is a good way of opening communication with the public about science because one purpose of autoethnography is to open conversations about life (Ellis & Bochner, 2006). Over ninety percent of the American population will not pursue science careers so as science educators and researchers we need to connect with the public well enough to respond when they ask "why should I learn this?" (Shamos, 1995). Hughes, Pennington and Makris (2012) promote autoethnography as an empirical research endeavor, supporting their position using American Educational Research Association (AERA) standards for reporting empirical social science research. Autoethnography can be used to form a bridge between the public and academia to research and shed light on intricacies of the human condition.

#### B92. Foundational Skills of Inquiry

Jack V. Sears, Downtown Little School, jackvansears@gmail.com

### Jenny D. Ingber, Bank Street College of Education

**ABSTRACT:** Abstract This Educational Action Research study (EAR), using Grounded Theory, investigates the foundational practices of inquiry in early childhood, specifically ages 3-5. This study specifically explores the practice of asking questions as outlined by the Next Generation Science Standards Framework (NRC, 2012). In this study we recorded and analyzed audio recording of three teachers and their interactions with their students to determine, one, how these teachers might improve dialog with children to develop the foundations for future scientific inquiry through the

practice of asking questions, and two, to develop tools that can provide support to other early childhood educators to develop, in their students, the foundation for future scientific inquiry through the practice of asking questions.

#### **Strand 10: Curriculum, Evaluation, and Assessment** *Poster Session B* 4:15pm – 5:15pm, Ballroom 2, 3, and 4

## B94. Assessing Evolutionary Understanding within the Context of Humans: Exploring Reasoning Patterns of Biology and Biological Anthropology Students

#### Elizabeth P. Beggrow, The Ohio State University, beggrow.7@osu.edu

**ABSTRACT:** When it comes to the teaching, learning and assessment of science, research has shown in a variety of domains that context makes a difference (e.g., Chi et al. 1981). More specifically regarding evolutionary biology, research has demonstrated students' evolution knowledge and misconceptions vary depending on the specific contextual features of assessment items (Nehm & Ha 2011). The teaching and learning of human evolution has been advocated for (e.g., Pobiner 2012), but the role human context plays on assessment has not been explored empirically. Using a multiple-choice, a constructed response (composed of either items about humans or non-human animals) and a Likert-scale assessment, this study investigates the differences in evolutionary reasoning patterns demonstrated by undergraduates enrolled in either an introductory biology (n=223) or biological anthropology (n=152) course. Despite biological anthropology's unique feature of situating evolution within the context of humans, preliminary analyses indicate no significant differences in scores between students from each course for either human or non-human contexts. Additional analyses will explore the composition of the key concepts and non-normative ideas used by students as well as incorporate students' affective measures into an integrated analysis to further examine the role human contextual features play in evolutionary reasoning.

B96. The Impact of Elementary Science Classroom Assessments on Teacher Decision-Making Jeni R. Davis, University of South Florida, jenidavis@usf.edu ABSTRACT:

B98. Undergraduate Science Curriculum Development: Using Delphi Methodology to Identify Biochemistry/Chemistry Concepts Central to Biology Majors Rethabile R. Tekane, Purdue University, rtekane@purdue.edu Trevor R. Anderson, Purdue University

Nancy J. Pelaez, Purdue University

**ABSTRACT:** The purpose of this research was to describe how an exemplary elementary teacher used research recommended classroom assessments during science class instruction. In a secondary analysis of a previous study, the present study focused on the broader question, what can we learn about the use of classroom assessments by examining the practices of an exemplary elementary teacher who utilized research suggested classroom assessments? Initial analyses reveal three categories of instructional decisions impacted by classroom assessments: (1) decisions of when to respond to a student's performance; (2) decisions of how to respond to a student's performance; and (3) curriculum decisions. While attending to superficial features of students' performances such as completion or correctness, it seemed as though the teacher's intent was much more on monitoring the students' performance instead of eliciting the students' ideas. This study raises the question if the instructional decision-making is less robust than in cases in which more substantive features such as content, depth, detail, and reasoning are dealt with.

B100. What Ideas About Nanotechnology Should Be Taught In School Science? Based on Delphi Study Sohair Sakhnini, Weizmann Institute, asakhnini@gmail.com

Ron Blonder, Weizmann Institute

**ABSTRACT:** Nanoscience is an important new field in modern science. Therefore, the question what "ideas-aboutnanotechnology" should be taught in high-school science remains an open question. In the current study we seek to answer this question, based on a community of experts in nanotechnology and science education by applying a threeround Delphi study methodology. Nine categories of concepts were identified. Each concept is accompanied by its explanation, definition, why it is important to be taught, and suggestions of how it should be taught. (e.g., nano-electronics, nano-medicine, nano-filtering and nanorobots). Four concepts emerged in the Delphi study, which were not identified before: dimensionality, functionality, fabrication approaches of nanomaterial, and the making of nanotechnology. We also identified 19 nanotechnology applications that were recommended to be taught in high-school nanotechnology program (e.g., Nano-electronics, Nano-medicine, and Nano-filtering Nanorobots). Differences between the concepts and applications suggested by the two communities of experts were found. The final results of the Delphi study will provide a tool to examine different nanotechnology programs that were reported thus far and to make recommendations for designing a nanotechnology program for high-school students that includes the basic concepts and applications of nanotechnology.

B102. How to Teach Big ideas: A Theoretical Framework and Teaching Modules for Practice Eunmi Park, Gwangnam high school, watw33@hanmail.net Heojeong Yoon, Global Institute for STS Education Jivoung Kim, Doonchon Middle School Yoonha Lee, Daeyoung Middle School Dami Bang, Catholic University of Korea Jieun Park, Ewha Womans University Juyeon Song, Korean Educational Development Institute ABSTRACT: This study aims to develop a theoretical framework to construct Big ideas and teaching modules for its educational practice. Big ideas are overarching principles and foundational ideas that could contribute to broader conceptual understanding of natural phenomena. Understanding Big ideas not only helps students to assimilate individual facts and theories, but also helps students to build a holistic understanding of domain specific knowledge. Big ideas may be cross-disciplinary, but they are more narrowly conceived of "Big ideas" in science in this study. Big ideas were constructed by following four steps: generation of tentative Big ideas, classification of science content standard into tentative Big ideas, justification of Big ideas, and concretization of Big ideas. In this study, 'Diversity', 'Structure', 'Interaction', and 'Changes' were identified as four Big ideas. All the scientific facts, disciplinary concepts, and interdisciplinary concepts of every scientific domain integrated in a Big idea was represented as a form of knowledge pyramid. Essential questions, which guide the teaching and learning of Big ideas, were developed. Among the four Big ideas, we selected 'Structure' and developed a set of instructional module to provide a guideline to elementary and middle

B104. Investigating the Cognitive Validity of a Performance Assessment Using Think Alouds Jan Heidrich, Leibniz Institute for Science Education (IPN) Kiel, heidrich@ipn.uni-kiel.de Knut Neumann, Leibniz Institute for Science Education (IPN) Kiel Stefan Petersen, Leibniz Institute for Science Education (IPN) Kiel

school teachers on how to teach Big ideas in science class.

**ABSTRACT:** Scientific inquiry is one central aspect of science education. The ability to engage in scientific inquiry includes performing scientific investigations. Successfully performing scientific investigations means (I) to correctly apply a series of (inquiry) skills, (II) in a logical order and (III) using the right strategy. Current assessment instruments for evaluating inquiry performance often show problems with respect to cognitive validity. The aim of the presented project is to develop an assessment that can generate cognitive valid data about how well university level physics students can perform scientific investigations. Investigation of cognitive validity requires an analysis of reliability and a matching of performance with a reference. Analysis based on think alouds was used as reference. In the study N=11 participates carried out a developed performance assessment. Their perfomance was assessed using either only the lab-notebook, a video recording of their actions without audio or the full video including a think-aloud. The reliability is calculated for all three analyses. Correlations between analysis and reference are calculated. The results show, that the performance assessment can generate cognitive valid data for two of the three above mentioned aspects of performing scientific investigations with reference analysis and for one of three aspects with other analyses.

#### B106. STEM Solar Lab. An Innovative Approach to Learning Science Concepts

Martina Nieswandt, University of Massachusetts, Amherst, mnieswan@educ.umass.edu Michael Lehan, Diversified Construction Services, LLC.

**ABSTRACT:** This study asked how science students' content knowledge and interest in science and specific scientific topics developed as a result of being engaged in a specially designed curriculum using inquiry-based instructional materials on solar energy, its technology and applications – the STEM Solar Laboratory. The STEM Solar Laboratory consists of solar panels mounted above ground for STEM learning and instructional materials organized around six key themes: (1) The Sun as an Energy Source; (2) Energy Transformations in Solar Collectors. (3) STEM Solar Lab Siting and Land Use. (4) Building and Installing a STEM Solar Lab. (5) Monitoring Electricity Production and Use. And (6) Science, Technology, Engineering and Society Interconnections. In order to answer our research question ("How do middle and high school science students' content knowledge and interest in science/scientific topics developed as a result of being engaged in the STEM Solar Lab?") we utilized a pre-post-test design with experimental and control groups. Results of show that the STEM Solar Lab has the potential to increase students' science content knowledge and interest in science and technology. However, the data also reflect challenges with new curricula of state-of-the-art topics when not implemented over a longer period of time.

B108. The Examination of A Pullout STEM Program for Urban Upper Elementary Students

Daniel L. Dickerson, Old Dominion University, ddickers@odu.edu

Angela Eckhoff, Old Dominion University

Craig Stewart, University of Memphis

Shanan Chappell, Old Dominion University

Stephanie Hathcock, Old Dominion University

William McConnell, Old Dominion University

**ABSTRACT:** The purpose of this study is to determine whether a pullout STEM program (STARBASE) makes reading and math scores decrease and examine its impact on urban 4th, 5th, and 6th grade students' and their parents' attitudes and perceptions regarding STEM education and careers. We employed a mixed-methods, case study approach that involved two published and one indigenous instrument composed of Likert scales, semantic differential scales, and openended items, along with structured interviews. Results indicate that it is possible for reading, math, and social studies scores to be unaffected when implementing a STEM pullout program, as adjusted trends (for ethnicity and socioeconomic status) are not statistically different from those of non-STARBASE school divisions in the area. Additionally, the Black/White achievement gap, as measured by standardized test scores, was substantially closed over the last decade within STARBASE schools. The semantic differential scales and the Likert-type items showed no meaningful change. Student qualitative responses were overwhelmingly positive. Students wanted more STARBASE time in the regular school year, while parents wanted more STARBASE time after-school and during the summer. Students, particularly Black students, also wanted an increase in career education opportunities. Implications regarding curricular changes aimed at STEM education and model adoption are addressed.

### Strand 11: Cultural, Social, and Gender Issues

Poster Session B

4:15pm – 5:15pm, Ballroom 2, 3, and 4

B110. Teacher Voices on Participatory Action Research (PAR) in Science Classrooms: A Critical Race Theory Analysis

Deb Morrison, University of Colorado, educator.deb@gmail.com

**ABSTRACT:** Educational inequity is persistent in science education, specifically with relation to race. This study examines a year-long teacher professional development course designed for Teach for America that uses participatory action research (PAR) guided by critical race theory (CRT) to engage teachers in critical consciousness raising and educational equity praxis. Specifically, this work tells the counter-narratives of how early career science teachers challenge traditional science pedagogy through enacting action research curriculum projects in their classrooms that center learning around students' interests, share power in the classroom, and produce actionable outcomes to influence

students' lived experiences. As part of these stories, teachers share their struggles as well as their successes, thus highlighting areas where teachers engaging in racial critical consciousness raising need support to continue to develop their awareness and move these understandings into practice in their classrooms. While many of the teachers found this work extremely challenging in the face of their own views of science teaching and learning, all science teachers in the study have stayed in teaching beyond the required tenure in Teach for America.

#### B112. Changing Perceptions about Engineering in a Year-long Girls in Engineering Program

Tirupalavanam G. Ganesh, Arizona State University Ira A. Fulton Schools of Engineering, tganesh@asu.edu **ABSTRACT:** This study examined the perceptions of 60 sixth-grade girls who participated in a yearlong project designed to explore engineering and the work of engineers. Project activities focused on the social relevance of engineering through design activities such as designing a "harmless" coke can holder, solar oven, solar energy station, wind energy station, and mechanical animation. In addition students reverse engineered a wind-up toy explore interactive exhibits on prosthetics and bioengineering at a science center. Opportunities to interact with female mentors from undergraduate engineering programs and industry were provided. Data were collected pre-post program using a National Academies (2008) survey (with permission from the National Academies) to elicit participants' perceptions of problems as good examples of engineering and whether the examples of engineering created interest in them. Data analysis was conducted using comparisons of frequency statistics and nonparametric hypothesis testing. Statistically significant changes were found pre to post program in participants' perceptions of problems as good examples of engineering and those examples that they found appealing. Participants indicated that they found socially relevant engineering problems like harnessing solar energy, creating machines for blind to see, protecting water supply, building alternative fuel cars, protecting the rainforest, and diagnosing health problems appealing.

#### B114. Muslim Students' and Teachers' Views on Evolution – A Review

#### Khadija Fouad, Indiana University, kfouad@indiana.edu

**ABSTRACT:** This review examines both polling and qualitative studies on Muslim students' and teachers' views of evolution. Most literature on views of evolution deals with views of Christian and non-religious students and teachers. Elucidation of Muslims' views allows teachers and professional developers to take these into account when designing lessons for Muslim students and teachers. Analysis of the reviewed studies reveals that Muslim students may reject human evolution while fully accepting non-human evolution. Most Muslims do not perceive conflict between science and religion, nor have difficulties with an ancient Earth. Muslims hold diverse views of views of evolution and of the relationship between religion and science. Some use non-literal interpretations of religious texts to allow compatibility between evolution and religious beliefs, while others' literal interpretation of religious texts precludes acceptance. Some hold intermediate positions compromising scientific understanding to make it compatible with their religious convictions. Most studies recommend nature of science be taught alongside evolution so Muslims understand the importance of theories in science and do not succumb to naïve realism concerning explanatory power of scientific ideas. To validate religious views, one study recommends including a dialog where students can air and clarify their viewpoints in a non-judgmental setting.

#### B116. Science through the Lenses of Immigrant Elders: Perceptions of Conflict and Acceptance Nancy Albrecht, University of Minnesota, albr0137@umn.edu Phasker Unadhyay, University of Minnesota

Bhaskar Upadhyay, University of Minnesota

**ABSTRACT:** The bridge between a student's home culture and that of classroom science may create challenges for students and families, especially those from recent immigrant cultures. As a result, science learning in schools may require a form of cultural border crossing. Given this, as educators, how do we make these borders more porous? This poster focuses on the perspectives of Somali elders and parents associated with U.S. high school science. Designed as a qualitative interview study, the guiding questions include: 1) what are the unique values, traditions and experiences that Somali students bring to school science? 2) what are the unique challenges that Somali students encounter with classroom science; and 3) what are the implications for teachers of Somali-American students? Initial results indicate that Somali adults have complicated perceptions of school science which include both conflicts and acceptance with current pedagogy and content. Implications for teachers and researchers who work with Muslim immigrant students and families are discussed.

B118. Tibetan Buddhist Monastics Studying Western Science: Negotiating Buddhist Theology and Western Science

Tenzin Sonam, University of Arizona, tenzinsonam@email.arizona.edu Bruce Johnson, University of Arizona

**ABSTRACT:** The presumption among science education researchers and general public is that religious tradition in the east, particularly Buddhism, is compatible with Western science. Recently, Western science is being introduced along with traditional curriculum at Tibetan Buddhists monasteries in India, and a small group of those monks have been studying undergraduate science at an American university for the last three years. How do monastics with deep training in Tibetan Buddhist scholastic traditions make sense of Western science? Using ethnographic interviewing methods, this preliminary study looks at the experience of one of the monks, trying to understand how he conceptually settles the difference and similarities that he finds in the scientific theories with his theological beliefs. This would then help us answer the larger question of the extent to which these two worldviews are compatible.

### Strand 12: Educational Technology

*Poster Session B* 4:15pm – 5:15pm, Ballroom 2, 3, and 4

B120. A Case Study Contrasting Students' Exploration of a Complex Causal Scenario in a Virtual World Caroline J. Courter, University North Carolina at Wilmington, cjc6476@uncw.edu
Tina Grotzer, Harvard University
Katarzyna M. Derbiszewska, Harvard University
Michael S. Tutwiler, Harvard Graduate School of Education
Amy M. Kamarainen, New York Hall of Science
Shari Jackson Metcalf, Harvard University

Chris J. Dede, Harvard University

**ABSTRACT:** Students tend to simplify systems and complex causal concepts when reasoning about complex systems (Jacobson, 2001; Penner, 2000; Raia, 2008) and about ecosystems behavior, in particular (Authors, 2003; Hmelo-Silver & Pfeffer, 2004) However, a growing body of research promises that it is possible to teach students to reason about systems concepts (Danish, Peppler, Phelps, & Washington, 2011; Hmelo-Silver, Marathe & Liu, 2007; Authors, 2011). Most research has focused on what students' reasoning looks like when they are given an assessment that explicitly cues them to reason about complex causal phenomena. Virtual worlds offer the opportunity to investigate students' exploratory behaviors and how they attend to complexity without such cueing. The research here used a virtual world to investigate students' patterns of exploration and problem-solving. Students also experienced a field trip supported by augmented and virtual reality curriculum components programmed into a mobile device. The results suggest that student exploratory behavior grew more focused and meaningful over time in connection with the hypotheses that they were considering and that students revealed increased understanding of the value of reasoning about change over time and distant variables.

B122. The Impact of Autocorrelation: Clustering and Student Outcomes in a Multi-User Virtual Environment Assessment

Michael S. Tutwiler, Harvard Graduate School of Education, mst216@mail.harvard.edu Tina A. Grotzer, Harvard University Katarzyna M. Derbiszewska, Harvard University Amy M. Kamarainen, New York Hall of Science Shari Jackson Metcalf, Harvard University Chris Dede, Harvard University

**ABSTRACT:** Quasi-experimental studies, common in science education, often assign entire groups of students to various treatment or control conditions. This natural clustering of students leads to the possibility of auto-correlation, in which similarities within groups biases the outcomes of statistical analyses. In this poster, we examine the relationship

between the clustering at the team, period, and teacher level and the variance in a given outcome for students who used an ecosystems-based multi user virtual environment. We detected substantial variance contribution at the team level.

B124. Integration of 3-D Interactive Simulations into Science Curricula

Craig Turczynski, Norfolk State University, c.m.turczynski@spartans.nsu.edu

Dana Hayes, Norfolk State University

Michael Kozhevnikov, Norfolk State University

**ABSTRACT:** The goal of the present research is to develop and integrate Virtual Reality (VR) -based interactive simulations into classroom and online science curricula. This approach revolves around the idea that learning physics is most effective in an interactive learning environment involving two related components that are usually kept separate: a real-world experiment and a computer-based visualization. The proposed virtual learning environment (VLE) features a flexible dynamic 3-D simulated environment with real-time interaction and high flexibility in user-controlled parameters. In the proposed VLE, the learner can change certain parameters in the simulations in order to explore the linkages that exist between various physics concepts and to investigate possible outcomes. Five undergraduate students learned Newtonian mechanics concepts in an interactive virtual reality simulation. The analysis of students' responses and protocols revealed that the most serious difficulties students' exhibited were with the acceleration concept. After learning the relationships between motion concepts in VR simulations, students' performance improved significantly. The results of this pilot study support our hypothesis that carefully designed virtual reality environments are capable of providing the students with an effective learning tool.

B126. Virtuality and Reality – Results from Research on Learning with Digital Media in Outdoor Education Martin Lindner, Martin-Luther-University Halle-Wittenberg, martin.lindner@biodidaktik.uni-halle.de Alexander Finger, Martin-Luther-University Halle-Wittenberg

**ABSTRACT:** This poster gives an overview on the results from our research on various outdoor activities supported by virtual tools, gathered over the last three years. These methods include data logging, identification of animals and plants with software, virtual guided field trips and orientation with the help of GPS. The data was gathered through various methods from test groups varying between 10 and 200 participants. The data was statistically evaluated. Results show a considerable influence of electronic media on motivation, but indicate technical problems as well. We also noted a fascination created by the electronic media, which might be hindering an original encountering with nature. All in all, to hype electronic media for outdoor education is not supported by our data.

B128. Future Worlds: An Interactive Museum-based Sustainability Exhibit

James Minogue, North Carolina State University, james\_minogue@ncsu.edu Eleni Lobene, North Carolina State University Jonathan P. Rowe, North Carolina State University Kirby Culbertson, North Carolina State University Justin Phillips, North Carolina State University Rachel Earnhardt, North Carolina Museum of Natural Sciences Maggie Stalls, North Carolina Museum of Natural Sciences Bradford W. Mott, North Carolina State University James C. Lester, North Carolina State University

**ABSTRACT:** This interactive poster session chronicles the iterative development and testing of FUTURE WORLDS, a critical issue-based informal science education exhibit. Our multi-user multi-touch cyberlearning system enables users to collaboratively explore alternate environmental choices that impact a virtual watershed that is on an unsustainable path. The virtual watershed is plagued by several examples of unsustainable farming practices and learners are challenged with reducing the farms' environmental impacts. The proposed poster session will present Year 1 findings, describe the Year 2 evolution of our software and evaluation approaches, and present Year 2 findings. FUTURE WORLDS is being designed, built, and evaluated with a clear focus on the six interrelated Strands of Informal Science Learning (NRC, 2009). Additionally, its science content and user experiences are undergirded by several powerful crosscutting concepts (NRC, 2011) including the examination of cause and effect relationships, systems modeling, and stability and change over time.

# Strand 13: History, Philosophy, and Sociology of Science *Poster Session B*

4:15pm - 5:15pm, Ballroom 2, 3, and 4

## B130. Women's Entrance into NASA: A Portrait of the Women Astronauts of the Space Shuttle Era Heather B. Page, New York University, hbp208@nyu.edu

**ABSTRACT:** Examining the history of women astronauts has implications for science teaching beyond celebrating their achievements as astronauts, which has value, but also recognizing the dialectical relationship between social and cultural change and human achievement. The early years of NASA were focused on military flying and the physical sciences, fields devoid of women. Astronauts, all of whom were male, were viewed as heroes and national treasures. Using data sources such as personal interviews and popular media this paper examines the admission of women into the space program, examining the participation of female astronauts from the inception of NASA through the Space Shuttle program. This paper also examines how astronauts were depicted in popular media and culture, and the disparity of these images between the sexes. Using sociocultural theory, this study examines how the first class of female astronauts viewed their participation in our national space program highlighting the tension the women experienced wanting to be known for their skills as an astronaut while being categorized as women. This historical account has implications for science teaching, as teachers can provide students with role models that combat stereotypical views of scientists as white and male.

## B132. Towards a Theoretical Framework on the Relations between NOS Understanding and Science Content Learning

Hanno Michel, Leibniz IPN Kiel, hanno.michel@physik.rub.de Irene Neumann, Leibniz IPN Kiel

**ABSTRACT:** Besides viewing knowledge about the nature of science (NOS) as important for its own value with respect to scientific literacy, an adequate understanding of NOS is expected to improve science content learning by fostering the ability to interrelate scientific contents and thus coherently adopt scientific content knowledge (Driver et al., 1996). However, there is a lack of systematic investigations, which clarify the relations between NOS instruction and learning achievement in science, including the affective, motivational, and cognitive variables and processes that might mediate these relations. This paper presents a theory-based framework which shall serve as a grounding for such investigations. The framework has been derived from a thorough literature review and addresses the relations between (1) NOS and epistemological beliefs (EB), (2) NOS/EB and science content learning, (3) NOS/EB, motivation, and learning achievement, (4) NOS/EB, interest, and learning achievement, and (5) NOS/EB, self-concept, and learning achievement. The paper outlines the development of the framework as well as a respective study to empirically investigate the framework.

B134. Empirical Study on Interdependencies between Physics Teacher's Notions about Science and Methods of Instruction

Lydia M. Schulze Heuling, KeBU Freiburg Universität Freiburg Pädagogische Hochschule Freiburg, lydia.heuling@wvf.uni-freiburg.de

Silke Mikelskis-Seifert, IPN Kiel Pädagogische Hochschule Freiburg

Matthias Nückles, Universität Freiburg

**ABSTRACT:** This research study examined Physics teachers' notions about science and Methods of Instruction. It was organised in three parts. Firstly an explorative interview study aimed to elicit Physics Teachers' Methods of Instruction (MoI) and their Notions about Science (NaS). In the following a descriptive category system of MoI and NaS was derived from the explorative interview study (N=38) and confirmed by interrater reliability. Building upon this category system a questionnaire for quantitative measurement was developed and tested. Thirdly, after successful piloting, thirdly, the study was conducted in Switzerland, Austria and Germany (n>200). The central concern of the main survey is to look for interdependencies between MoI and NaS followed by profile shaping and interdependency analysis. In this talk, the category system, the questionnaire and the first results of the large scale study are to be presented.

## B136. A National Study of Turkish Grade 10 Students' and Science Teachers' Conceptions of Scientists and the Interactions between Science, Technology, and Society

Fouad Abd-El-Khalick, University of Illinois at Urbana-Champaign, fouad@illinois.edu Nihal Dogan, Abant Izzet Baysal University

**ABSTRACT:** This study assessed grade 10 Turkish students' and science teachers' conceptions of scientists and interactions between science, technology, and society, and examined whether these conceptions were related to selected variables [e.g., student gender, geographical region, socioeconomic status (SES), and parents' education; teacher disciplinary background, years of teaching experience, and type of teacher training program]. Stratified random sampling was used to generate a representative national sample comprising 2,087 students and 378 science teachers: A response rate of 96% was achieved. After establishing their validity in the Turkish context, participants were administered a questionnaire comprising 11 modified "Views on Science-Technology-Society" items to assess their views of the target domains. Participant responses were categorized as "naïve," "have merit," or "informed" and the frequency distributions for these responses were compared for various groupings of participants. A majority of participants held naïve views of the target domains, and teacher views were mostly similar to those of their students. Some views were related to a subset of the aforementioned variables, including student enhanced economic and educational capitals of their households, as well as the SES status of their cities and geographical regions, which point to significant cultural underpinnings of students' and teachers' documented views.

### **Strand 14: Environmental Education**

Poster Session B

4:15pm – 5:15pm, Ballroom 2, 3, and 4

### B138. Enabling Scientific Observations of the Natural World Using an e-Trailguide

Heather Toomey Zimmerman, Penn State University, heather@psu.edu

**ABSTRACT:** Enabling children to observe their world in disciplined, scientific ways is a difficult task (Eberbach & Crowley, 2009). However, deep observation is arguably the fundamental basis for all science-related endeavors, including observation and recordings of the natural world. While technology has typically been identified as being a detractor from directly experiencing and adequately observing nature (Ruchter et al., 2010), this study argues for the potential of mobile technologies in enhancing and better enabling children to observe and record their observations of biota along one nature trail at an environmental center. Using video-based methodologies (Derry et al., 2010), we documented 83 summer campers between the ages of 8 and 10 using an iPad-based e-trailguide specifically designed for the nature trail where this study took place. After analyzing the video records, we noted several different ways in which the e-trailguide enhanced the campers' scientific observations of the local landscape and associated organisms. When using the e-trailguide, campers engaged more deeply with their surroundings through extended exploration time and prompted discussions with one another. Additionally, the e-trailguide's "interactives" (i.e., sketchpad for drawing) enabled collaborative documentation, or drawings, of authentic and impromptu observations of plants and animals seen along the trail.

# B140. *Chinese Students' Argumentation and Epistemology about Global Climate Change* Shiyu Liu, University of Minnesota, liux0631@umn.edu

Gillian Roehrig, University of Minnesota

**ABSTRACT:** Climate change education in China is closely tied to the nation's environmental protection policies, but there is a lack of attention to the importance of enhancing students' understanding of scientific findings on climate issues and promoting their skills in communicating about such information. The present study investigates Chinese secondary students' argumentation on the topic of global climate change as well as the epistemological understandings that guides their reasoning. Sixty-six tenth-grade students participated in this study and a written assessment was developed to evaluate their skills in making arguments, counterarguments and rebuttals regarding the complexity and uncertainty of climate science. Our findings revealed that the majority students viewed simple claims of their perspectives as sufficient arguments. Most of them simply stated their beliefs when asked to evaluate competing scientific findings and claims without providing further explanations of their reasoning. It was also shown that most students held absolutists epistemology: they believed in the certainty of expert views and did not acknowledge other alternative claims. This work

provides important information regarding Chinese students' skills in reasoning and arguing with scientific findings on climate issues. It constitutes our first step to facilitate climate change education in China.

#### B142. *The Evolution of a Controversy: How Science Teachers have Led the Charge in Public Education* Robert W. Danielson, University of Southern California, robert.danielson@usc.edu Gale M. Sinatra, University of Southern California

**ABSTRACT:** Drawing on public records, we re-create a timeline which outlines the struggle of various interest groups to influence what is taught in the public school. This presentation will document the historical debate surrounding the teaching of evolution in the public school, and illustrate the parallels between the strategies used to undermine evolution and those used to undermine human-induced climate change. Classifying climate change curriculum as "controversial" - and thereby subject to the "controversial issues" policy present in many public school districts - would mandate that science teachers present currently accepted scientific theories alongside pseudo-science. We argue that students taught controversial explanations alongside scientific explanations: at risk of losing out on STEM degree and employment opportunities, may not be able to participate fully in an educated democracy, and will require additional education to participate in the global knowledge economy.

### Tuesday, April 1, 2014

### **Plenary Session #2**

Thirteen Questions about Science Education 8:30am – 10:00pm, Ballroom 1 Presiders: Lynn Bryan, Purdue University Valarie Akerson, Indiana University Discussant: Kenneth Tobin, CUNY Panelists:

Ana M. Bercerra, Just Communities/Cumunidades Justas (co-sponsored with Equity & Ethics Committee) Timothy Knight, Indianapolis Metropolitan Police Department (co-sponsored with CADASE RIG) H. Richard Milner, University of Pittsburgh

Shirley Steinberg, University of Calgary

**ABSTRACT:** This plenary session is inspired by the book, *Thirteen Questions: Reframing Education's Conversation* (Kincheloe & Steinberg, Eds., 1994). Each chapter of *Thirteen Questions* addresses a different critical "dialogue" about education through the compelling responses of a variety of educational thinkers/scholars. While the book is nearly two decades old, the questions-and dialogues that these questions are meant to stimulate-are very much relevant today as they were then. A plenary panel consisting of community leaders and education experts will respond to a select number of the original thirteen questions, reflecting on how far we have come in the 20 years since the publication of *Thirteen Questions* and dialoguing about these questions in the context of today's educational climate.

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

#### **Presidential Sponsored Session**

Symposium – Book Study – "Start Where you are But Don't Stay There: Understanding Diversity, Opportunity Gaps, and teaching in Today's Classrooms" by Dr. H. Richard Milner

10:30am-12:00pm, Commonwealth 2

Presider: Bryan Lynn, Purdue University

Presenter: H. Richard Milner, University of Pittsburgh

**ABSTRACT:** Following his presentation as a member of the panel for the second plenary session, Dr. H. Richard Milner IV, the Dr. Helen Faison Chair in Urban Education in the Center for Urban Education at the University of Pittsburgh, will offer a book study on his book, *Start where you are but don't stay there: Understanding diversity, opportunity gaps, and teaching in today's classrooms* (Harvard Education Press, 2010).

Strand 2: Science Learning: Contexts, Characteristics and Interactions
Symposium – Studying Argumentation in a High School Biology Classroom: Understanding the Temporal Development of Dialogue
10:30am-12:00pm, King's Garden 1
Presenters:
Ellice Ann Forman, University of Pittsburgh, ellice@pitt.edu
Virginia Ramirez-Deltoro, University of Pittsburgh
Adam Loretto, University of Pittsburgh
Lisa M. Brown, University of Pittsburgh

Barbara Barnhart, University of Pittsburgh at Greensburg

Linda Deafenbaugh, University of Pittsburgh

Cindy Passmore, University of California, Davis

Sue Johnson, University of California, Santa Barbara

Gregory J. Kelly, Penn State University

#### Cody Foster, North Monterey County High School

**ABSTRACT:** Although scientific argumentation in classrooms has become an important learning goal, educational researchers have just begun to understand how argumentation can be scaffolded by teachers and appropriated by students. This symposium aims to describe changes in classroom dialogue and student learning that occurred in the final units of a 9-week elective evolutionary biology course from the perspectives of insiders (e.g., the classroom teacher) and outsiders (e.g., classroom researchers). The first two presentations will report results from discourse analyses conducted on five classroom lessons at the end of three instructional units. These papers will focus on changes in the teacher's scaffolding or in the students' arguments. Our findings indicate that the teacher controlled classroom talk in the first unit but that students' arguments predominated and evolved in the second and third units. The third presentation will present complementary evidence from written pre- and post-assessments of students' understanding of the Darwinian model. The fourth presentation will be the responses of the original classroom teacher to our findings. Finally, a discussant will comment on the findings from each of the previous presentations. All of the presenters will draw implications of this work for classroom research and professional development in science education.

#### Strand 3: Science Teaching--Primary School (Grades preK-6): Characteristics and Strategies Aspects of Learning Processes in the Elementary Science Classroom 10:30am-12:00pm, Brigade

**Presider:** Irene U. Osisioma, California State University, Dominguez Hills

# The Impact of Contradictions Associated with Elementary Science Instruction: What Can We Learn? Julianne A. Wenner, University of Connecticut, julianne.wenner@uconn.edu

Julie M. Kittleson, University of Georgia

**ABSTRACT:** Challenges associated with teaching science at the elementary grades are well documented. Such challenges include: lack of science content knowledge, a scarcity of physical resources, and a dearth of science professional development. Certainly these barriers alone are sufficient to impede the progress of science education reform. However, these are but a few pieces of the puzzle; in order to fully capture the reality of elementary science instruction, we argue that context must be considered as well. We use a Cultural Historical Activity Theory (CHAT) lens to examine the context surrounding elementary science instruction in order to add a necessary dimension of understanding to the body of literature on this subject. In particular, using CHAT to highlight contradictions within a system has the potential to show how to improve elementary science instruction as well as how to capitalize on existing opportunities for growth. Findings from our study indicate many systemic contradictions elementary teachers encounter that hinder quality science instruction. However, we also have evidence of teachers successfully pushing for change within the system so they may improve their science instruction.

### Analyses of Learning Process Sequences – A Video Study in Elementary School Science Classes Christina Krumbacher, University of Duisburg-Essen, tina.krumbacher@uni-due.de Hans Ernst Fischer, University Duisburg-Essen

**ABSTRACT:** The structure of a lesson is a decisive, essential prerequisite for students' acquisition of knowledge. Oser and Baeriswyl (2001) describe 14 basis models as possible lesson structures. To enable successful learning processes, it is assumed that key teaching steps need to be taken within a lesson. Three basis models have been found to be most important for science teaching: learning-through-experience, problem-solving and concept-building. Which basis model suits a particular lesson depends on the respective teaching goal. Recent studies show that science lessons in German elementary schools lack such structures. In order to evaluate the effects of a learning-process oriented teaching style in elementary science lessons, an intervention based on Oser's basis models has been planned. A teaching unit in which all three basis models are implemented was taught in five primary school classes (Grade 4). The implementation of basis

model steps has been evaluated using video analysis. Cognitive abilities, reading competence, motivation and interest have been controlled. The learning achievement, measured with a pre-post test, was highly significant (p < .001) with a medium to large effect size (d= .77). The three basis models and the results of the video-analysis will be introduced in this presentation.

Towards a Pedagogical Content Knowledge for Literacy Instruction in Science Diego Xavier Roman, Stanford University, dxroman@stanford.edu Brian M. Donovan, Stanford University Michelle Friend, Stanford University Jonathan Francis Osborne, Stanford University

Alexis Patterson, Stanford University

**ABSTRACT:** Reading, writing and talking are fundamental to science. Hence, literate practices are not some adjunct to science but constitutive of its practice. However, the forms of discourse, its language and the genres of communication are inherent to the discipline. Such a disciplinary language, like all reserved languages, has evolved because it is functionally effective. Any technical language though sets up a barrier for the neophyte student and has the power to intimidate. Learning science, therefore, demands that the student learn a new language and new modalities of expression. All teachers of science are, therefore, teachers of a language. Scaffolding students with any language requires a knowledge of the grammar of that language, the challenges it poses for the learner, and the instructional strategies that support student learning – all of which form an essential dimension of teachers' pedagogical content knowledge. In this paper, drawing extensively on the research from the field of functional linguistics and research on the teaching of reading, we outline the basic elements of such knowledge which should be required by any teacher of science.

*Learning through Modeling in K-6 Science Education: Re-Visiting the Modeling-Based Learning Cycle* Zacharias C. Zacharia, University of Cyprus, zach@ucy.ac.cy

Loucas T. Louca, European University-Cyprus

**ABSTRACT:** Despite the abundance of research in Modeling-based Learning (MbL) in science, to date there is only limited research on MbL practices among novice modelers. Specifically, there is no information whether young, novice modelers (grades K-6), follow the same modeling steps and practices during MbL as those described in the literature for older students. Using data from a variety of contexts and student ages, this study's purpose was to develop from the ground up a detailed description of the modeling practices that K-6 students follow during MbL. While maintaining the epistemological foundations of the MbL cycle modeling practices described in the literature, we followed ground research approaches to revise the descriptions of the MbL cycle practices/steps. Our findings revealed that novice modelers follow a different route when enacting MbL than that described in the literature. We found that the content and the context of the various modeling practices/steps differ, as well as the sequence in which these modeling practices occur. As a result, we propose a revised MbL cycle for novice modelers, that includes four steps: (a) investigating the physical phenomenon/system under study, (b) constructing a model of the phenomenon/system, (c) evaluating the model, and (d) developing a revision plan.

### Strand 4: Science Teaching--Middle and High School (Grades 5-12): Characteristics and Strategies *Investigating Teachers' Knowledge and Practice*

10:30am-12:00pm, King's Garden 5

Presider: Claudia Vergara, Universitty Alberto Hurtado

An Exploration into Science Teachers' Subject Matter Knowledge and Knowledge of Students' Natural Selection Alternative Conceptions

Margaret M. Lucero, Santa Clara University, mlucero@scu.edu

Anthony Petrosino, University of Texas - Austin

**ABSTRACT:** Evolution is the foundation on which biology is based; however, it is home to many deeply-held alternative conceptions. Little research exists that explores the relationship between science teachers' subject matter knowledge (SMK) and their awareness and knowledge of their students' ideas on evolution and its main mechanism of

natural selection. These components of a science teacher's knowledge base—SMK and pedagogical content knowledge's (PCK) awareness and knowledge of student ideas/areas of difficulty—can be valuable resources for helping students learn different science concepts, like natural selection. This exploratory study reports an attempt to describe the relationship between these components of a teacher's knowledge base through the participation of four biology teachers within the same department and how this relationship may either support or question underlying assumptions about SMK and PCK. This was done mainly through teacher interviews in which each teacher answered SMK-type questions and predicted what their students' most common natural selection alternative conceptions were through the use of a concept inventory. Data sources also included student responses on a concept inventory. Findings revealed some inconsistency within the SMK-knowledge of students' ideas relationship among these teachers and certainly suggest potential avenues for future inquiry.

# First Semester Changes in Teaching Practice in an Argument Based Inquiry Professional Development Brian R. Pinney, University of Iowa, brian-pinney@uiowa.edu

Brian M. Hand, University of Iowa

**ABSTRACT:** Recent science education efforts have moved to the inclusion of newly defined practices including argument (NRC, 2012). This case study examines the changes that occur in teaching practice in a rural Midwestern sixth grade classroom undergoing the teacher's first semester of argument based inquiry professional development. This study uses an analytic framework for examining the dialogical components of whole class discussion as they change throughout the semester. Emergent themes that help to clarify this framework are also discussed. Changes to how the teacher handled whole class discussion were mostly oriented around the inclusion of more student ideas, challenging student understanding of science terms instead of simple acceptance of terms, and movement toward more dialogue in discussions instead of monologue. Changes relating to the development or inclusion of argument for the inclusion of argument based inquiry practices called for in the Next Generation Science Standards are proposed. This study also highlights the development of teaching practice oriented around argument inclusion is a step wise process.

Measuring Pedagogical Content Knowledge of Argumentation through the Development of a Teacher Argumentation Assessment

Katherine L. Mcneill, Boston College, kmcneill@bc.edu Maria Gonzalez-Howard, Boston College Rebecca Katsh-Singer, Boston College Suzanna Loper, Lawrence Hall of Science

**ABSTRACT:** Argumentation is a key component of science that should be integrated into k-12 instruction. Despite the recent emphasis on argumentation, little work has focused on teachers' knowledge of argumentation. We make the case for developing a high quality assessment for teachers' pedagogical content knowledge (PCK) of scientific argumentation to better assess the needs of teachers as well as to evaluate the quality of their teacher education experiences. We present our initial efforts to conceptualize, develop and test a measure of teachers' PCK of argumentation. Our development and piloting process builds off the model proposed by Hill and her colleagues (2008), which includes the following steps: 1. Conceptualization of the Domain, 2. Design of Items, 3. Pilot Testing Items and 4. Cognitive Interviews. In this paper, we present the design of 8 vignettes, each of which included four multiple-choice items and one open-ended item. In addition, we share the results from our pilot test with 103 teachers and cognitive interviews with 24 teachers. This analysis suggests the importance of using argumentation related item choices as distractors as well as the challenge of designing answer choices that assesses a deep understanding of the scientific practice rather than surface level features.

Strand 4: Science Teaching--Middle and High School (Grades 5-12): Characteristics and Strategies
Symposium – Teaching and Learning Science for English Language Learners
10:30am-12:00pm, King's Garden 3
Presider: Hayat Hokayem, Texas Christian University
Presenters:
Molly Weinburgh, Texas Christian University, m.weinburgh@tcu.edu

Cecilia Silva, Texas Christian University Alan Oliveira, State University of New York Sara Salloum, Long Island University Carol Stuessy, Texas A&M Mary Head, Texas A&M

**ABSTRACT:** Teaching science for all and finding the best way to include English Language learners is one of the goals of science education. In this symposium, the presenters will discuss their theoretical perspectives and their empirical work about teaching and learning science for English language learners. Whether from a cognitive or socio-cultural perspectives, each participant will present the affordances and challenges of working with English Language learners. National and international cases will be presented and future trajectories and possibilities of work in this field will be discussed.

### Strand 5: College Science Teaching and Learning (Grades 13-20) Aproaches to Chemistry Instruction

10:30am-12:00pm, Rivers **Presider:** Anna Lewis, University of South Florida

## Foundations for a Learning Progression on Chemical Synthesis: Conceptual Sophistication and Modes of Reasoning

 $Melissa\ Weinrich,\ University\ of\ Arizona,\ weinrich@email.arizona.edu$ 

Vicente A. Talanquer, University of Arizona

**ABSTRACT:** In order to support the development of learning progressions about central ideas and practices in different disciplines, we need detailed analyses of the implicit assumptions and reasoning strategies that guide students' thinking at different educational levels. In the particular case of chemistry, understanding how new chemical substances are produced (chemical synthesis) is of critical importance. Thus, we have used a qualitative research approach based on individual interviews with first semester general chemistry students (n=16), second semester organic chemistry students (n=15), advanced undergraduates (n=6), first year graduate students (n=14), and PhD candidates (n=15) to better characterize the evolution of students' conceptual sophistication and modes of reasoning about chemical synthesis. Our results reveal a great variability in the cognitive resources and strategies used by students to make decisions, particularly at intermediate levels of expertise. The specific nature of the task had a strong influence on the conceptual sophistication and mode of reasoning that students exhibited. Nevertheless, our data analysis has allowed us to identify common modes of reasoning and assumptions that seem to guide students thinking at different levels in their training. Our results should facilitate the development of learning progressions that help improve chemistry instruction, curriculum, and assessment.

Mapping Students' Ideas about Chemical Reactions at Different Educational Levels

Fan Yan, University of Arizona, fanyan@email.arizona.edu

Vicente A. Talanquer, University of Arizona

**ABSTRACT:** Understanding chemical reactions is a core educational goal of chemistry courses at all educational levels. Nevertheless, research in science education has revealed that many students struggle to understand chemical processes, and that they express a wide variety of alternative conceptions as they learn about this topic. Improving teaching and learning about chemical reactions demands that we develop a clearer understanding of student reasoning in this area and of how this reasoning evolves with training in the discipline. Our study was designed to a) explore the types of reasoning about chemical reactions expressed by college and graduate students with different levels of training in chemistry, b) identify common reasoning patterns in the explanations generated by such students, c) identify and characterize major constraints in student reasoning about chemical reactions, and d) characterize potential learning pathways in the understanding of such processes. Main findings indicate that although significant progress is observed in student reasoning in some areas, there are major conceptual difficulties that seem to persist even at the more advanced educational levels. The results of our study are relevant to educators interested in learning progressions, assessment, and conceptual development.

Benefits, Costs, and Risks Analysis as a Crosscutting Concept in Chemistry Education Steven Cullipher, University of Massachusetts Boston, steven.cullipher@gmail.com Melissa Weinrich, University of Arizona Hannah Sevian, University of Massachusetts Boston

Vicente A. Talanquer, University of Arizona

**ABSTRACT:** As chemists, the choices we make in our professional practice have implications both inside and outside the laboratory. While some of these implications are sometimes emphasized in the curriculum, others are less so. In the course of training the next generation of chemists, it is becoming ever more important that they understand and have an ability to analyze the implications of their work. We refer to this as benefits, costs, and risks (BCR) analysis. We outline the development of a learning progression describing learning pathways of undergraduate and graduate students to experts, aiming to uncover assumptions that shape reasoning and constrain learning about the disciplinary crosscutting concept of BCR in the domain of chemistry. We present the results of two instruments. With these instruments we have uncovered three levels of conceptual sophistication in chemistry thinking: intuitive, hybrid, and academic. It is our hope that a learning progression for BCR will positively influence the development of curricula and instructional materials to further enhance students' ability to reason about BCR.

Effect of Modified Process–oriented Teaching on First Year University Students' Understanding of Stereochemistry Concepts

David F. Treagust, Curtin University, d.f.treagust@curtin.edu.au

Venkat R. Vishnumolakala, Curtin University

Daniel Southam, Curtin University

Mauro Mocerino, Curtin University

**ABSTRACT:** The study investigated first year chemistry students' understanding of stereochemistry concepts following a modified-POGIL (Process Oriented Guided Inquiry Learning) context that included group work. Most of these chemistry students had not previously studied stereochemistry. The quasi-experimental post-test and delayed post-test design involved a 5–item two-tier Stereochemistry Diagnostic Test to ascertain the extent to which students' understanding of stereochemistry concepts changed in the POGIL influenced classroom environment. The researcher-developed and faculty-validated instrument was administered individually and two weeks later administered to groups of 2-4 students as a delayed post-test. Results of a paired sample t-test analysis indicated that students' understanding in the delayed-test improved significantly when those students were able to participate in POGIL learning compared to their individual scores. The percentage of students' correct responses in each of the five items improved from 17% in the post-test to 41% in the delayed post-test. An interesting finding from this research is that although the POGIL-style teaching did not appear to benefit the students in the post-test, when given the opportunity to engage in small group POGIL work, the learning gains increased markedly in the delayed post-test.

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

**Cognitive Teaching and Learning Approaches** 

10:30am-12:00pm, King's Garden 4

*Examining the Impact of Animations and Viewing Sequence on Learners' Understanding of Hadley Cell Circulation* 

Daniel W. Harris, Salisbury University, dwharris@salisbury.edu

**ABSTRACT:** Research examining animation use for learning has proven inconclusive. This study sought to determine whether animation inclusion in an authentic context improved student understandings of Hadley Cell circulation. The study also sought to determine whether the timing of animation examination improved conceptual understanding. An experimental design administered in an undergraduate science lecture and laboratory course compared four different learning conditions: text and static diagrams with no animations, animation use prior to the examination of text and static diagrams. Additionally, procedural data for each condition were collected and analyzed for self regulated learning (SRL) behaviors to determine whether qualitative differences existed between cognitive processes. Results
indicated that animation use did not improve understanding across all conditions however learners able to employ animations while reading and examining the static diagrams showed evidence of higher levels of system understanding. Procedural data found few differences between groups with one exception---learners given access to animations during the learning episode chose to examine and coordinate the representations more frequently. These results indicated a sequence effect to improve understanding of Hadley Cells in atmospheric circulation.

### *Explaining Instructional Decision Making by Analyzing a Geology Instructor's Use of Metaphors* Glenn Dolphin, University of Calgary, grdolphi@syr.edu

#### Sharon Dotger, Syracuse University

**ABSTRACT:** This investigation explores why a geology instructor implemented only certain aspects of a curricular intervention. It utilizes a promising analytic approach to determine how the instructor structured the context of his teaching, his students, and course content. Results from audio recorded meetings and classroom observations show that Eric (pseudonym) described teaching, learning and the role of knowledge within the context of two different metaphors; the puzzle metaphor and the fieldtrip metaphor. The puzzle metaphor has Eric giving bits and pieces (facts) of a puzzle (theory) to students. Students had to connect the pieces into a coherent whole. The fieldtrip metaphor placed Eric as guide through the terrain of knowledge via a predetermined path, pushing and pulling students along, and avoiding barriers until they covered the required ground. The metaphors paralleled each other in terms of the instructor's understanding of teaching, learning and scientific knowledge. Both metaphors belie an objectivist understanding of knowledge. Based on this understanding, it was reasonable for Eric to direct the class mainly through lecture, in contrast to the student-centered and inquiry-based activities called for by the intervention. One implication is curriculum development needs to happen with the context of the user in mind.

#### Scientific Reasoning Skills among Non-Science Majors at a Community College

Steve Bennett, Michigan State University, benne455@msu.edu

#### Amelia Wenk Gotwals, Michigan State University

**ABSTRACT:** This study assesses the evidence-based reasoning skills of non-science majors at a community college. Six laboratory assignments in an introductory science course were redesigned as inquiry labs requiring the students to write summaries using a "claim – evidence – reasoning – rebuttal" format. Mixed methods were used to assess students' abilities to write evidence – based claims. Students' were somewhat successful using scientific reasoning on tests, but struggled using scientific reasoning for labs. Some students' used a lab report format that allowed them to support their claims solely with data rather than scientific reasoning. Possible explanations for the low reasoning scores on labs and higher reasoning scores on tests are discussed along with implications for laboratory coursework.

Undergraduates' Cognitive Resources for Understanding Environmental Literacy

Katherine Nilsen, University of California, Santa Barbara, katynilsen@gmail.com

Ashley Iveland, University of California, Santa Barbara

Ethny Stewart, University of California, Santa Barbara

Julie A. Bianchini, University of California, Santa Barbara

Danielle Boyd Harlow, University of California, Santa Barbara

Jennifer Thorsch, University of California, Santa Barbara

**ABSTRACT:** We investigated three undergraduate science courses on environmental literacy. We drew from a knowledge in pieces perspective on learning to identify the small ideas, or cognitive resources, that undergraduates enrolled in these courses initially held. We also examined how these resources contributed to undergraduates' interpretation of environmental concepts presented in the courses. To do so, we qualitatively analyzed video recordings of class sessions, interviews, pre and post surveys, and course assignments. We identified three cognitive resources that undergraduates drew on: (1) materials are available for use either now or later, (2) actions are guided by intentions, and (3) when less is needed (to function), less will be used. In our implications, we suggest ways science instructors can build from undergraduates' cognitive resources to better promote being environmentally literate citizens.

#### **Strand 6: Science Learning in Informal Contexts**

Related Paper Set – Scientists, Educators, and Publics in Engagement: Who Learns From Whom?

10:30am-12:00pm, Benedum

### Discussant: John Baek, NOAA

**ABSTRACT:** Scientists, educators, and publics are all part of science communication. Yet all three groups harbor assumptions about the others. It is a commonplace notion that researchers are not always good communicators, but many are truly good teachers. At the same time, people without academic science expertise are not without knowledge and skills at making sense of complex science. These assumptions all three groups bring often result in a "dumbing down" and deficit-model approach to outreach that de-values not only the process but also all those involved. These four papers examine issues of science outreach from multiple perspectives. Paper one explores funds of knowledge and expertise that novice and expert visualization readers bring to bear as well as struggles of each group. Paper two discusses challenges educators face working with scientists on outreach. Paper three embraces the scientist as learner, examining their starting points when learning new skills of outreach. Finally, paper four reports successes of bringing educators and scientists together to build outreach products designed collaboratively. By understanding the weaknesses and strengths of each group involved in science communication, education, and outreach, we can more equally value all partners and more readily accomplish our mutual goals.

*Experts Aren't Perfect, and Novices Aren't Perfectly Awful* Kathryn Stofer, University of Florida, stofer@ufl.edu

Scientists Embracing Outreach Means Changing Cultures and Convictions Celeste F. Barthel, Oregon State University, celeste.barthel@oregonstate.edu

*Scientists Learning Through Engagement in Outreach with Adult Learners* Laura H. Good, Stanford University, doverl@onid.orst.edu

Seeing is Believing: The Role of Data in Changing Scientists Views of Learners and Engagement Shawn Rowe, Oregon State University, shawn.rowe@oregonstate.edu

Strand 7: Pre-service Science Teacher Education *Practices in Teacher Education Programs* 10:30am-12:00pm, King's Garden 2 **Presider:** Gail Richmond, Michigan State University

Developing a Statewide Community of Practice for Science Education Faculty Mollianne G. Logerwell, George Mason University, mlogerwe@gmu.edu David E. Long, George Mason University

**ABSTRACT:** Historically science teacher educators have existed at the margins of education colleges, or on the fringes of science departments. Not a 'real scientist' in the eyes of many scientists and 'too science-y' for many education faculty, science education faculty often don't quite fit. As a consequence, faculty have often found themselves isolated within their institutions and have limited access to the support of colleagues with similar responsibilities and interests. The goal of [PROGRAM NAME]'s [ACADEMY], one component of a four-pronged statewide effort to build systematic capacity for improving science teaching and learning, is to provide an environment in which science teacher educators collaborate, learn and share new research, and establish a support network for science teacher education. Results indicate that providing opportunities for faculty to experience new science teaching strategies and network with peers can have farreaching impacts on participants' professional growth and the experiences offered to pre-service teachers in their programs.

Examining a New Teacher Preparation Program's Effect on Preservice Teachers' Views of Nature of Science

### Huseyin Colak, Northeastern Illinois University, h-colak@neiu.edu

Christian A. Carstensen, University of Illinois at Chicago

**ABSTRACT:** This study outlines the ongoing development and results to date of a revised program designed to improve elementary educators' understanding of science content and their views of the nature of science (VNOS). This new program has been designed as part of an effort to improve the content knowledge and quality of elementary educators entering a large urban school district. Improvement in participants' NOS views was prioritized in the development of the science content and methods courses. The NOS instruction utilized the explicit/reflective approach. Pre- and post- course VNOS questionnaires were administered to preservice teacher candidates to measure growth. The questionnaires were scored on the following seven nature of science concepts: science is empirical, inferential, tentative, creative, subjective, socially and culturally embedded, and makes use of theories and laws. Initial scores have shown growth on the empirical, tentative, inferential, and socially and culturally embedded nature of science concepts. The participants did not show much change in other concepts. In these concept areas with little change, participants' reasonable prior knowledge may have limited growth potential. Conversely, this may indicate that content knowledge does not facilitate nature of science acquisition. Further studies are need to elucidate this phenomenon.

#### A STEM Pre-service Teacher Preparation Program: Where Scientific and Technological Literacy Meet Timothy P. Scott, Texas A&M University, tim@science.tamu.edu

#### Perkins P. Abigail, Texas A&M University

**ABSTRACT:** In our study, we evaluated a STEM teacher preparation program for technological, pedagogical, and content knowledge (TPACK) implications for 21st century learning. Aimed to increase the number of qualified teachers certified in secondary math and science, the program implemented a rigorous curriculum featuring cutting-edge technology and STEM-focused content that created a community where in-service public school teachers and pre-service teachers worked in unison to grow academically and professionally. We employed the TPACK Questionnaire to program participants and to a control group to measure if and how TPACK-related self-efficacies differed by group. Findings from ordinal analysis indicated that of the seven TPACK knowledge categories (technology knowledge, content knowledge, pedagogical content knowledge), four contained responses with statistically significant associations: technology, technological pedagogical, pedagogical, and content. These results suggest that the program scholars' knowledge about content and pedagogy in their areas of certification was above that of the control group. For those pre-service programs interested in fostering a scientifically and technologically literate citizenry, we hope to provide perspectives on possible educative effects from integrating ever-changing technologies into the classroom with pedagogy and content knowledge.

#### Investigation of the Influence of Professional Competence on the Quality of Scripts

Anita Stender, IPN Kiel, Stender@ipn.uni-kiel.de

Maja Brueckmann, Zurich University of Teacher Education (PH Zurich)

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

**ABSTRACT:** Past research on teacher professional development assumes that teachers with high professional knowledge are able to create high quality instruction. However teachers do not reflect their professional knowledge for immediate decisions in complex classroom situations, they rather fall back on practical routines- so called scripts. Ideally these scripts should be based on the professional knowledge. Teachers develop these scripts during lesson planning, by combining their professional knowledge with their beliefs, motivation and self-regulation to structure the intended action in classroom. So beliefs, motivation and self-regulation as other aspects of professional competence are additional influences on the quality of scripts. This study aims at the analysis of the influence of aspects of professional competence on the quality of scripts. Professional competence and the quality of scripts were surveyed with an online-questionnaire. This instrument was administered to a sample of N=148 students, in-service teachers and teachers. The findings suggest that motivation and self-regulation are important factors for the quality of scripts and that professional knowledge plays a minor role.

#### **Strand 8: In-service Science Teacher Education**

Related-Paper Set – Trajectories of Teacher Change: Activating and Influencing Teacher Resources for Enacting Instruction around Scientific Practices

10:30am-12:00pm, Sterlings 1

**ABSTRACT:** The Next Generation Science Standards (NGSS) ask teachers to provide opportunities for students to develop scientific understanding through authentic engagement in scientific practices. For many teachers, enacting this vision constitutes a revolutionary change in their classroom practice. Teacher change is an evolutionary process that develops over time as teachers interact with professional development opportunities and communities of support. We attempt to trace trajectories of teacher change by examining interactions among multiple factors that facilitate or impede change. We start from an assumption that teachers have productive resources about teaching and learning and that teacher change involves interactions among these existing resources, the professional development opportunities that may activate or shift these resources, and the contexts in which teachers enact new pedagogical approaches. We present findings from four professional development contexts designed to help teachers enact instruction around scientific practices. Each study attempts to characterize the patterns of teacher change that were observed and elucidate the mechanisms that may underlie such change. This work speaks to the need to design professional supports for teachers in ways that will capitalize on the resources they have for enacting the vision of science put forward by the NGSS.

Reflecting on Change: How Teachers Conceptualize the Shift to Practice-based Science Instruction Arash Jamshidi, University of California, Davis, ajamshidi@ucdavis.edu Arthur Beauchamp, University of California, Davis Julia Svoboda Gouvea, University of California, Davis Rich Hedman, California State University, Sacramento Cynthia Passmore, University of California-Davis

Shifting to Authentic Scientific Inquiry: Unpacking Three Stories of Teacher Change Jen Richards, University of Maryland, College Park, jrich@umd.edu Ayush Gupta, University of Maryland, College Park Andrew Elby, University of Maryland, College Park

Changing Contextual Discourses to Support the Improvement of Science tTeaching Jessica J. Thompson, University of Washington, jjthomps@u.washington.edu Sara Hagenah, University of Washington

How Teachers' Understanding of Models and Modeling Influence Shifts in their Science Instruction Julia Svoboda Gouvea, University of California, Davis, jmsvoboda@ucdavis.edu Arthur Beauchamp, University of California, Davis Rich Hedman, California State University, Sacramento Arash Jamshidi, University of California, Davis Wendell H. Potter, University of California, Davis Lin Xiang, University of Kentucky Cynthia Passmore, University of California, Davis

#### **Strand 9: Reflective Practice**

*Methods and Approaches in Reflective Practice* 10:30am-12:00pm, Duquesne **Presider:** Janell Nicole Catlin, Columbia University

### A Critical Review of Methodological Approaches and Strategies for Elicited Metaphor-based Research in Teacher Education

Eulsun Seung, Indiana State University, esseung@gmail.com Soonhye Park, University of Iowa Jinhong Jung, Northern Illinois University

**ABSTRACT:** The purpose of this study was to provide a comprehensive review of the methodological approaches and strategies used in elicited metaphor research and further to identify methodological issues associated with it. Thirty six selected articles were first grouped into two categories by their purpose for using elicited metaphors: a) use of metaphors as a methodological tool to understand teacher beliefs, knowledge and practice and b) use of metaphors as an intervention tool to improve teachers' professional knowledge or practice. Next, individual studies were analyzed in terms of metaphor elicitation methods and analysis methods. Results revealed several methodological issues associate elicited metaphor research: a) many studies used a single metaphor elicitation method which could weaken the validity of researchers' interpretations; c) efforts to establish the trustworthiness of the study were neither made nor mentioned in many studies; d) most studies used teacher metaphors as a research tool to uncover teacher beliefs not as an intervention tool to change teacher beliefs and practice which might limit the impact of the research on teacher education communities.

#### Deepening Reflective Practice Through the Use of Action Research in Secondary Science Teacher Education Rita Hagevik, The University of North Carolina at Pembroke, rita.hagevik@uncp.edu

**ABSTRACT:** This study examined the role of action research in promoting critical reflective thinking among ten secondary preservice science teachers engaged in a year-long program. Data from collaborative discussions, final written documents, presentations, and follow-up surveys revealed that conducting action research (a) engaged them in inquiry into their own practice, (b) was a means to reflect upon and determine ways to change their teaching practices, and (c) promoted critical reflection in a collaborative learning environment. Results underscore the importance of preservice teachers critically reflecting to gain insights teaching and student learning as they are engaged in action research.

#### The Impact of Formative Assessment on Diverse Learners: An Action Research Study

#### Rachelle A. Haroldson, Science Museum of Minnesota, rharoldson@smm.org

**ABSTRACT:** Addressing the learning demands of diverse groups of students and implementing a range of assessments, including formative assessment, are part of the recent conceptual framework for K-12 science education. Research questions in this study focus on the impact of formative assessment on the learning of diverse students and the resulting changes in teaching practice through action research. Four themes emerged across all of the formative assessment strategies that suggest a positive impact on the engagement of diverse learners: assessment prep, clarification, individualized to the learner, and informs the learner. Implications for secondary science teachers working with diverse learners looking to transform their approach are discussed.

#### Comparing the Effectiveness of Two Types of Diagnostic Instruments

Hye-Eun Chu, Nanyang Technological University, hyeeun.chu@gmail.com

**ABSTRACT:** The purpose of this research is to investigate an efficient type of diagnostic instrument to assess Year 8 students' conceptual understanding of heat and temperature before or after their instruction. Two different types of instruments were used in this study: Type 1, consisting of multiple-choice items with open-ended justifications and Type 2, consisting of two-tier multiple-choice items. Each of the instruments was administered to two separate cohorts of 173 and 143 Year 8 students of similar achieving ability. Findings indicated that Year 8 students were better able to show their understanding in the two-tier multiple-choice items. Also, both types of instruments provided similar information about

students' alternative conceptions. Hence, by using two-tier multiple-choice items in diagnostic assessment, teachers are provided with a convenient alternative for identifying their students' understanding of particular concepts.

#### Strand 10: Curriculum, Evaluation, and Assessment

### *Symposium – New Instruments for Studying the Impacts of Science Teacher Professional Development* 10:30am-12:00pm, Smithfield

Presider: Eric R. Banilower, Horizon Research, Inc.

#### **Presenters:**

Peggy Trygstad, Horizon Research, Inc., ptrygstad@horizon-research.com

Eric R. Banilower, Horizon Research, Inc.

Patrick S. Smith, Horizon Research, Inc.

Courtney L. Nelson, Horizon Research, Inc.

**ABSTRACT:** The logic model that implicitly drives most professional development (PD) efforts asserts that PD leads to changes in teacher knowledge and beliefs, which leads to improved classroom practice, and ultimately, better student outcomes. However, efforts to study the impacts of PD programs are often hampered by the scarcity of high-quality instruments. This symposium will describe the development of a set of learning-theory aligned instruments including: coupled teacher and student content assessments that measure conceptual understanding in each of four topics at two different grade levels (upper elementary and middle school); a survey of teacher beliefs about effective science instruction; and a classroom observation protocol. The audience will be invited to ask questions and share their feedback on the instruments. Panelists and attendees will also consider potential uses for the various instruments in future science education research.

#### Strand 11: Cultural, Social, and Gender Issues

## **Related Paper Set** – Accessing Children's Scientific Thoughts through Student-Generated Representations 10:30am-12:00pm, Birmingham

Presider: Maria Varelas, University of Illinois at Chicago

**ABSTRACT:** This paper set looks to highlight creative approaches examining the scientific beliefs, experiences, and understandings of students from historically marginalized communities, both in classrooms and in research. We foreground various research spaces that utilized generative practices of making, specifically drawing and choreography, as unique opportunities for accessing children's thinking about science and scientists. By highlighting the interplay between student-generated representations and discussions regarding these representations, these papers look to inform future research as well as pedagogical approaches for working with students whose voices have been marginalized or are missing from science, and, in some cases, from the science education research agenda.

Research and Classroom Spaces for Creative Visions of Scientists among African American Third Graders Leon Walls, University of Vermont, lwalls@uvm.edu Gale A. Seiler, McGill University

*Improvisation, Interculturality, and Signifying in Developing Scientific Representational Practices* Christopher G. Wright, University of Tennessee, Knoxville, cwrigh48@utk.edu

Cultivating, Creating, and Critiquing Representations in an ArtScience Studio Eli Tucker-Raymond, TERC, eli\_tucker-raymond@terc.edu Beth Warren, TERC Ann S. Rosebery, TERC

*Children's Understandings of Forest Ecosystems* Megan Bang, University of Washington Jasmine Alfonso, Northwestern University Douglas Medin, Northwestern University

#### Strand 11: Cultural, Social, and Gender Issues

Symposium – Positioning Equity in Formative Assessment Research and Practice: Using Assessment to Support Science Learning for All Students

10:30am-12:00pm, Fort Pitt

#### **Discussants:**

Jerome M. Shaw, University of California - Santa Cruz

Edward G. Lyon, Arizona State University

Preetha K. Menon, UC Santa Cruz

Marcelle Siegel, University Of Missouri-Coluimbia

Deb Morrison, University of Colorado at Boulder

Erin M. Furtak, University Of Colorado

**ABSTRACT:** Formative assessment has been touted as a critical classroom activity to make the teacher and students aware of individual learning progress, while facilitating students' science learning. This symposium aims to awaken an important dialogue in science education – the role of formative assessment in promoting equitable teaching and learning. We discuss four research projects that position equity as central to formative assessment. Author 1 reports on the development and piloting of a classroom observation rubric to discuss how researchers can use equity as a lens to conduct systematic observations of secondary science teachers' formative assessment practices. Author 2 shifts from a methodological to a conceptual focus by presenting an innovative model of formative assessment that integrates science content and language development to ensure equitable learning opportunities for English language learners. Next, Author 3 presents exemplar cases to highlight science teachers' equitable formative assessment practices through a sociocultural lens. Finally, Authors 4 and 5 discuss science teachers' and students' talk during formative assessment activities to highlight points of overlap between formative assessment and equitable teaching practices. Collectively, we make the argument that formative assessment research and practices is enhanced when attending to equity issues.

#### Strand 12: Educational Technology

*Interactive Technologies for Increased Engagement* 10:30am-12:00pm, Sterlings 2 & 3 **Presider:** Jillianne Code, University of Victoria

Adapting Interactive Technology to Younger Science Learners with a New Framework for Differentiating Classroom Interventions

J. Bryan Henderson, Stanford University, jbryanh@stanford.edu

**ABSTRACT:** The use of clicker voting technology to promote interactive student engagement is becoming increasingly widespread in postsecondary science classrooms. However, concerns persist about the efficacy of this technique for younger science learners. To systematically investigate these concerns, the same instructor taught four different physics classes in four different ways for each of two years at a diverse high school. This permitted differing implementations of clicker use for younger science learners (n = 250) to be adjudicated empirically. After controlling for the instructor, multiple student covariates, and the time of day that experimental treatments were implemented, students given an opportunity to verbally discuss their clicker votes with each other significantly outperformed students that instead received a supplemental lecture between clicker votes.

What Do Students' Explanations Look Like When They Only Use Peer Generated Data? Joseph S. Krajcik, Michigan State University, krajcik@msu.edu Ibrahim Delen, Michigan State University, delenibrahim@gmail.com Wan-Tzu Lo, University of Michigan, Ann Arbor Alex Kuhn, University of Michigan, Ann Arbor Steven Mcgee, Northwestern University Jennifer Duck, The Learning Partnership Chris Quintana, University of Michigan

**ABSTRACT:** Explanations studies underlined importance of using evidence in support of claims. However, few studies focused on students' use of peer generated data in this process. In this study, students collected data from a local water source and then bring those data back to the classroom to create scientific explanations by using claim-evidence-reasoning model on a new mobile application called Zydeco. A middle school science teacher from a Midwest town participated with four sixth grade classes (n=109). After collecting their own data, students created explanations by analyzing the data they collected, and comparing the data they collected with an existing data collected by another school (peer generated data). By comparing the health of these two water sources students created two scientific explanations, we examined the quality of claims and reasoning statements when they used the data they collected and only peer generated data. Students participating in this study included less supportive details (e.g. water quality indicator rankings, what indicators mean for water quality) when creating explanations by using only peer generated data.

*Player and In-Game Characteristics That Support Collaborative Learning within an Educational Online Science Game* 

Camellia Sanford, Rockman et al, camellia@rockman.com

Joshua Halterman, Rockman et al

**ABSTRACT:** The ever-increasing popularity of video games has raised questions about their role in generating meaningful learning experiences. Despite constructivist views on the benefits of collaboration, research on educational gaming has focused primarily on measuring content knowledge gains rather than the potential of games to facilitate collaborative learning experiences. This study examines how player characteristics and in-game tasks can affect the frequency, duration, and location of collaborative interactions. The relative complexity of in-game tasks and players' tendencies to provide help to each other were found to be significant contributors to collaborative exchanges. Furthermore, the total amount of collaborative talk incidents that an individual player engaged in during gameplay significantly predicted their post-game content knowledge. Taken together, these findings suggest that peer-peer collaborations during educational gameplay are impacted by player characteristics and the nature of the task, while the collaborative exchanges themselves facilitate positive learning outcomes.

#### **Strand 14: Environmental Education**

Integrating the Environment into Elementary Education

10:30am-12:00pm, Heinz **Presider:** Sarah J. Carrier, North Carolina State University

# Development and Validation of an Alternative Assessment for Ecological Learning in Elementary Students Michael Dentzau, Columbus State University, dentzau\_michael@columbusstate.edu

**ABSTRACT:** This research looks at the development and validation of a drawing assessment used with elementary aged students to measure content knowledge gains of the key, scientifically identified components of a natural ecosystem local to the population after participation a multi-day informal science environmental education (EE) program. Participants included 699 4th Grade students who drew their understanding of the longleaf pine ecosystem pre and post attendance at the EE program. The drawings were evaluated based upon a rubric that addressed key ecosystem features of the community and which was validated for content by professional ecologists and determined to have high interrater reliability among 3 independent reviewers. The rubric and assessment captured statistically significant and meaningful shifts in understanding of the ecosystem from pre to post attendance at the Center. In addition, the rubric and assessment were determined to be equally effective in capturing knowledge growth among females, males, dominant groups and non-dominant groups. The implications for teaching and learning, including preservice education are discussed.

Knowledge, Skills, or Attitudes/Beliefs: The Context of Agricultural Literacy in Upper Elementary Science Curricula

#### Farah L. Vallera, Lehigh University, fav203@lehigh.edu Alec M. Bodzin, Lehigh University

**ABSTRACT:** Americans lack sufficient environmental literacy, particularly in concepts and processes relating to agriculture. This may be due to teachers' lack of knowledge of agricultural concepts and the curriculum they are using. We conducted a content analysis of the most widely adopted current upper elementary U.S. science textbooks and curriculum programs to determine the extent and context in which agricultural literacy concepts are presented to students in primary education using ten overarching categories aligned to the Food and Fiber Systems Literacy (FFSL) Framework (1998) and A Framework for K-12 Science Education (2012). Identifying the degree and context in which the concepts are presented is important in determining whether agricultural literacy is being introduced comprehensively and coherently in current science curriculum. The findings revealed a lack of curriculum coherency within and across each overarching agricultural topics, rather than to teach transferable skills or alter attitudes/beliefs related to agricultural literacy and environmental conscientiousness. Implications for the design of the next generation of science curriculum to promote agricultural literacy are discussed.

#### Finding a Place for the Outdoors in Elementary School Science

Linda P. Tugurian, NC State University, ltuguri@ncsu.edu

#### Sarah J. Carrier, North Carolina State University

**ABSTRACT:** Use of the outdoors in school-based science instruction may help address waning student interest in science and in science careers, yet the outdoors remains an underutilized resource in school science instruction. In this research, we seek to better understand educational stakeholders' views of the outdoors in the context of elementary school science, with the hope of more clearly understanding what it means to situate elementary science nearly exclusively indoors. Qualitative analysis of interviews conducted with 5th grade students, parents, teachers, and administrators at two suburban elementary schools reveals a disconnect between adults' intent and interest in teaching science outdoors and realized use of the outdoors in elementary science. Children have difficulty recognizing the relationship of the outdoor world around them to the science they are learning at school. Instead, they see science as a classroom-bounded activity, associating forays into the outdoors at home and at school with "exploration," "fun," and "play." The failure of the educators to align science instruction with children's view of the world around them may contribute to children's diminishing interest in science at school. Place-based approaches may help address children's inability to see the relationship of elementary school science to the outdoors.

#### Concurrent Session #8 2:30pm – 4:00pm

#### Equity and Ethics Committee Sponsored Session

Symposium – A Panel Discussion

2:30pm-4:00pm, Commonwealth 2 **Presider:** Felicia M. Mensah, Teachers College, Columbia University **Presenters:** Jerome Shaw, University of California, Santa Cruz Deborah Roberts-Harris, University of New Mexico Leon Walls, University of Vermont

**ABSTRACT:** There are many issues impacting the education of our children in today's schools. In this session, representatives from the Pittsburgh school district will discuss local issues that have national impact on our children's education, specifically children from diverse economic, cultural, linguistic, and social backgrounds.

#### **Publications Advisory Committee Sponsored Session**

### *Symposium – What Might Science Education Learn from Science Communication Research?* 2:30pm-4:00pm, Heinz

**ABSTRACT:** This invited session aims at challenging the artificial separation between science education and science communication by identifying and expanding upon mutual trends based on shared research interests. Heather Toomey Zimmerman will speak about public meanings and images of science. Evan Szu and Jonathan Osborne believe the substantial shaping power of popular television and film is often overlooked as one of the drivers of student interest in science careers. Noah Feinstein will explore the differing perspectives of science education and science communication by examining two situations of interest to both fields: interpreting science news, and attending a science café. Ayelet Baram-Tsabari will address the need for applying science education know-how in science communication training for scientists. Finally, Bruce Lewenstein will speak of the connection (or lack thereof) between science education and science communication in the US policy making, drawing on recent attempts to reorganize federal funding for the two areas.

#### Public Meanings of Science Concepts

Heather Toomey Zimmerman, Penn State University, haz2@psu.edu

The Impact of Popular Media on the "Pipeline" of Future Scientists and Public Engagement with Science Evan Szu, Stanford University, evan.szu@gmail.com Johathan Osborne, Stanford University

*Science Education Know-How in Science Communication Training for Scientists* Ayelet Baram-Tsabari, Technion – Israel Institute of Technology, ayelet@technion.ac.il

*Now and Later: The Differing Significance of Time in Education and Communications* Noah Feinstein, University of Wisconsis, nfeinstein@wisc.edu

*The Connection between Science Education Communication in US Policy Making* Bruce V. Lewenstein, Cornell University, b.lewenstein@cornell.edu

#### Strand 2: Science Learning: Contexts, Characteristics and Interactions Related Paper Set – STEAM: Incorporating Art in STEM education To Promote Identity Formation and Engagement in Scientific Practices

2:30pm-4:00pm, King's Garden 2

**Presider:** Brigid Barron, Stanford University

Discussant: Nancy Vye, University of Washington

**ABSTRACT:** Art and science share many overlaps in terms of both common practices and habits of mind. Visual-spatial thinking is heavily used to model abstract scientific concepts and is also widely recognized as a central aspect of creating art. Experimentation takes place across both the sciences and art—scientists form hypothesis, record results, and communicate those results to the public. Similarly, artists experiment with mixing colors, various painting or sculpting techniques, and publicly show their work in public shows. Despite these similarities, much is yet to be learned about how teaching science through art affects science learning. In particular, more empirical work needs to be done on how youth with art-related identities connect to science learning and form science-related identities. In this related paper set, we explore opportunities for identity formation when science is taught with an arts focus, or STEAM-based science education (STEAM-Science, Technology, Engineering, Art, and Mathematics). In this related paper set, we ask the questions: (1) how does a STEAM-based approach to science instruction support STEM-related identity formation and science learning? (2) What are opportunities in science education for pursuing STEAM-related research programs?

#### Tuesday, April 1, 2014

Colors of Nature: Connecting Evolutionary Biology, Optical Science, and Arts Education to Promote STEMrelated Identity Work in Middle School Girls Carrie T. Tzou, University of Washington Bothell, tzouct@northwestern.edu Laura Conner, University of Alaska Fairbanks Stephen Pompea, National Optical Astronomy Observatory Mareca Guthrie, University of Alaska Fairbanks

*Exploring the Water Cycle in 4th Grade through Performance Art* Veronique Mertl, Mertl Learning & Educational Consulting, vm.mertl@gmail.com Tammy Tasker, Mertl Learning & Educational Consulting

Connecting to Science through Art: Examples from a Citizen Science Project Brigid Barron, Stanford University, barronbj@stanford.edu Caitlin Martin, Stanford University Veronique Mertl, Mertl Learning & Educational Consulting

STEAM and STEAM Learning in Museums and Libraries: Current Trends in Investigations of Learning and Identity Development Sandra Toro, Institute of Museum and Library Services

### Strand 3: Science Teaching--Primary School (Grades preK-6): Characteristics and Strategies The Next Gen of Elementary Science: Testing, Conceptions, and Practices

2:30pm-4:00pm, Rivers **Presider:** Bridget T. Miller, University of South Carolina

Teacher Change in Primary Grades Inquiry Science Classroom Practices Following Professional Development Joan Kaderavek, University of Toledo, joan.kaderavek@utoledo.edu Scott C. Molitor, University of Toledo Geoffrey Milewski, The University of Toledo Regina Rotshtein, The University of Toledo Tamala North, The University of Toledo Hoangha Dao, University of Toledo Nicholas J. Liber, University of Toledo Charlene M. Czerniak, The University of Toledo ABSTRACT: This paper describes an application of the Systematic Coding of Inquiry Instruction in Early LearNing

Classroom Environments (SCIIENCE). The SCIIENCE coding system was designed to objectively capture the presence and frequency of specific best practices outlined in the K-12 Science Frameworks as they occur within a science lesson. The goals of the SCIIENCE system are to (a) provide a standardized tool for assessing the quality of science instruction in a classroom setting for children grades PK-3, (b) capture the instructional practices that engage students in the lesson, promote scientific studies, encourage higher-level thinking, and (c) provide a feedback mechanism for guiding professional development (PD) of PK-3 teachers. In this paper, we use the SCIIENCE coding tool to investigate the efficacy of summer PD by comparing the quality of science and inquiry lessons delivered by teachers before and after the PD session. Our results indicate improvements in some inquiry practices, with a need to further strengthen teacher performance in other areas during future PD sessions. Therefore the SCIIENCE coding tool allows us to quantitatively assess the efficacy of our PD sessions, and has provided valuable feedback on inquiry practices that need require additional emphasis during future PD sessions. Elementary Teachers Conceptions and Practices: Fostering Students' Use of Scientific Models with the Water Cycle

Tina Vo, University of Iowa, Ms.TinaVo@gmail.com Cory T. Forbes, Univrsity of Nebraska-Lincoln Christina V. Schwarz, Michigan State University Laura Zangori, Univrsity of Nebraska-Lincoln

**ABSTRACT:** As the focus of science education reform shifts towards scientific modeling as a means to help students make sense of complex concepts and processes, much of emphasis remains at the secondary level, despite evidence of elementary students' abilities to work effectively with models. Little research has thus far been conducted to explore elementary teachers' conceptions and implementation of scientific modeling in the classroom. As elementary teachers are asked to support students' model-based reasoning about complex processes such as the water cycle, it is important to learn more about the interplay between their ideas and instructional practices. This exploratory qualitative multiple-case study investigates 3rd-grade teachers' conceptions of scientific modeling and examines how they engage students in modeling in their classrooms. Our findings indicate teachers conceptualize students' work with models and modeling in distinct ways and engage in unique forms of instruction to support students' use of models to make sense of water-related phenomena.

Elementary Education in the Outdoors: Addressing Gender, Ethnicity, and Testing

Sarah J. Carrier, North Carolina State University, sarah\_carrier@ncsu.edu

Margareta M. Thomson, North Carolina State University

Linda P. Tugurian, NC State University

**ABSTRACT:** Science educators' goals to equip students with knowledge about science and practices for exploring the natural world build a base for personal decision-making. Environmentally related decisions hold heightened relevance with today's changing climate, contributing to the importance of building students' science and environmental literacy early. The present study examined two elementary schools' science programs with a focus on each school's efforts to include outdoor experiences and environmental education (EE) to elicit student interest and to connect science to students' lives. We further explore gender and ethnic differences in students' views of the natural world both inside and out of the classroom. We consider reform efforts in science education in an examination of teacher beliefs, school cultures, attitudes about the environment, and students' backgrounds related to student science experiences at two elementary schools. Quantitative and qualitative data reveal a need to enhance science instruction in elementary schools and provide students opportunities in the natural world related to science instruction. Further gender and ethnic differences emphasized a need to design science instruction for all students. Standardized testing persists as a hindrance to science time and authenticity.

#### Strand 6: Science Learning in Informal Contexts Drawing on Community Resources and Concerns to Engage Youth with STEM 2:30pm-4:00pm, Brigade Presidem Lymp D. Diarking, Oregon State University

Presider: Lynn D. Dierking, Oregon State University

Discovering Place: Developing Community Connections through an Informal STEM Summer Experience for American Indian Youth

Marcie A. Galbreath, University of Idaho, galb4114@vandals.uidaho.edu Anne Kern, University of Idaho

**ABSTRACT:** This case study investigates the affordances and barriers that an informal multi-week science, technology, engineering, and mathematics (STEM) experience provided American Indian (AI) youth in connecting them to their communal place. Elders, community members, and university staff co-developed and facilitated hands-on activities designed to deepen community connections for participating youth. Students created a variety of artifacts including digital stories of thier place, which provided participants the opportunity to demonstrate what they learned during the first week of camp and how they understand their place. This study is part of a larger three-year project called Back to the Earth (BTTE). Back to the Earth is a NSF Innovative Technology Experiences for Teachers and Students (ITEST) project designed to engage students in grades 4-6 on two neighboring AI reservations. The program objective is to engage

students in an integrated STEM experience that merges Indigenous Knowledge (IK), place, and historical significance with Western science to provide a platform for building leadership, identity, as well as build a STEM workforce in the two communities. The place of focus for this study is the regional watershed shared by both communities linking them physically and culturally.

The Use of Community Resources to Promote Science Learning Chanyah Dahsah, Michigan State University, dahsahc@gmail.com Chaninan Pruekpramool, Srinakharinwirot University, Thailand Theerapong Sangpradit, Srinakharinwirot University, Thailand Joseph S. Krajcik, Michigan State University

**ABSTRACT:** The funds of knowledge students bring with them is a powerful resources for promoting students meaningful learning. However, learning is concentrated mainly in the school context and not connected to community. This research taps into the funds of knowledge based in community resources in a local Thailand community to support the development of science ideas. This was done by integrating science learning with community learning resources to develop learning activities that can serve as resources for schools and the community. Five science learning stations were developed through collaboration between researchers and community members. The stations include Adobe Clay House, Charcoal & Wood Vinegar, Bio-Extraction, Alternative Energy, and Community Forest. The results indicate that the science learning stations actively engage students in learning activities to promote students understanding of important science ideas. The materials blend in community funds of knowledge, support students in understanding science content and promoting positive attitude to learn science.

It is more than Just Science: Engaging Youth in Scientific Explorations through Solving Social Justice Problems in their Own Neighborhoods Dennis Debay, Manhattanville College, debay@bc.edu Mike Barnett, Boston College Sheron Mark, Loyola Marymount University David Blustein, Boston College Catherine Wong, Boston College Amie Patchen, Boston College Lin Zhang, Boston College James Haley, Boston College

**ABSTRACT:** Our Social Justice for Talented Emerging Minds (SjTEM) program is rooted in the students' communities, focusing on utilizing scientific skills and research to solve social and environmental justice problems (food deserts, brownfields, etc...) in their neighborhood, with a particular emphasis on areas within their communities that have experienced environmental degradation. Through the use of state-of-the-art technology tools (e.g., Geographic Information Systems (GIS), hydroponics and aquaponics), site visits, and interviews with community members on their interests and needs, the students developed plans to reclaim and improve their community and grow the resources available to people who live in their communities. In this presentation we will share the longitudinal research that we have been conducting on minority youth interest toward science, their interest in pursuing a STEM career, and the long term outcomes of youth over time in regards to whether their interest in a STEM field was sustained.

### The Potential of a Citizen Science Project to Develop Students' Science Literacy

#### Leonie J. Rennie, Curtin University, l.rennie@curtin.edu.au

**ABSTRACT:** This paper presents the findings of a case study that explored how a citizen science project designed to promote students' access to science beyond the classroom was able to contribute to their development of science literacy. The state-wide citizen science project related to the control of "powdery mildew," a plant pathogen affecting the yield and quality of barley crops. The mixed-method case study combined teacher surveys by email (given their wide geographic distribution), face-to-face interviews with scientists involved in the project, and examination of the resources prepared for teachers and students. Data analysis explored teachers' perceptions of how what students did and learned during their experiences in growing barley and returning mildew samples to the scientists contributed to the skills and abilities that underpin scientific literacy. Teachers reported that students performed curriculum-relevant, inquiry-based science

activities in a context made meaningful because it contributed to a significant project beyond their classroom. Experiencing how science was used in agriculture encouraged students to recognize the multidisciplinary and social nature of real world science, and helped them to build the abilities and skills that contribute to a science literacy that enables them to cope effectively with science beyond the classroom.

### Strand 7: Pre-service Science Teacher Education

*Effective Practices in Learning-to-Teach Science* 2:30pm-4:00pm, Duquesne **Presider:** Irene U. Osisioma, California State University, Dominguez Hills

Investigating the Effect of Science Writing Heuristic Laboratory Report Format on Critical Thinking Meltem Irmak, Gazi University, meltemsavas@gmail.com Hilal Yanis, Gazi University

Jale Ercan, Gazi University

**ABSTRACT:** In this study, it was tried to figure out the effect of Science Writing Heuristic (SWH) approach on critical thinking skills of pre-service science teachers (PSTs). In this regard, the following research questions were attempted to answer: (a) Is there a significant difference in critical thinking skills of pre-service science teachers (PSTs) after completing a general chemistry laboratory course with SWH? (b) Which core critical thinking skills exist in SWH reports of PSTs? Mixed method research was used by implementing pre-test post-test design and content analysis. The study was conducted with 32 freshmen pre-service science teachers who were enrolled in the general chemistry laboratory course. In order to collect quantitative results, the Cornell Critical Thinking Test (CCTT) Level X which was developed by Ennis and Millman (2005) was used. SWH was utilized to guide the scientific investigations of the students. A significant increase has occurred in participants' critical thinking skills from pretest to posttest. In order to justify these findings, the SWH reports were analyzed to seek for any core critical thinking skills and sub-skills. Qualitative and quantitative data were consistent with each other which mean that SWH is a beneficial tool in developing critical thinking skills.

### Peer Teaching Feedback Discussions and Moves to Notice Ambitious Science Teaching: Opportunities for Collective Analysis

Amanda Benedict-Chambers, Missouri State University, benedictchambers@missouristate.edu

**ABSTRACT:** Preservice teachers, particularly at the elementary level, face extraordinary challenges in teaching science in the ways outlined in the new standards. They need practice-oriented opportunities to investigate and manage the challenges associated with teaching and learning science in these ambitious ways. This paper uses the construct of teacher noticing (Van Es & Sherin, 2008) to examine how novice teachers noticed and grappled with the challenges of integrating science content and scientific practices in Peer Teaching lessons in an elementary science methods course. Qualitative data analyses of 48 Peer Teaching feedback discussions indicated that the feedback sessions afforded opportunities for two types of discussions. In the Joint Sensemaking Discussions, novices collectively analyzed the work of science teaching and learning by enacting moves to problematize instruction, articulate reasoning, and share insights to manage the challenges. In contrast, in the Disjointed Sensemaking Discussions, participants enacted moves to evaluate discrete science teaching and learning topics. These feedback sessions primarily centered on procedural aspects of students' engagement in scientific practices. This study suggests that teacher educators can leverage the opportunity for collective analysis by encouraging novices to enact moves to problematize instruction, articulate reasoning, and share insights in feedback discussions.

Examining Preservice Elementary Teachers' Abilities to Attend to Students' Scientific Thinking Stacy McCormack, Indiana University, smccorma@indiana.edu Susan Hawkins, Indiana University Meredith A. Park Rogers, Indiana University Maria Zoretic-Goodwin, Indiana University Banu Avsar Erumit, Indiana University Christina S. Melki, Indiana University

#### Heidi Wiebke, Indiana University

Mi Yeon Lee, Arizona State University

**ABSTRACT:** There is some debate in the literature that beginning teachers need to first develop their image of self as teacher before they can begin to focus on student thinking. It is this debate that established the premise for our study. Utilizing a case study approach we reviewed three preservice elementary teaching teams (or cases) to understand how they responded to students' comments following an initial probe into students' scientific reasoning. This approach afforded us the opportunity to examine the issue from the perspective of different grade levels as well as various phases of instruction. Our findings indicate that these preservice teachers demonstrate attention to student thinking but acknowledged student comments more than attended to students' responses, which translated into limited changes to instruction to support students' scientific reasoning. When preservice teachers did attend to student thinking, they did so mostly for the purpose of directing students to a specific instructional goal. Additionally we observed greater instances of attending to student thinking in 5th grade as opposed to kindergarten and second, and differences in attention during different phases of instruction. Implications for supporting preservice teachers with learning to attend to student thinking, while in the act of teaching, will be provided.

#### Learning to Teach Elementary Science: Using Video Analysis as a Reflective Tool SueAnn I. Bottoms, Oregon State University, sueann.bottoms@oregonstate.edu Brian Hartman, Oregon State University

**ABSTRACT:** Noticing is a practice that has been studied as a way to help preservice teachers learn to pay attention to what is important and to make connections between practice and theory. Noticing has been described as a way to shift preservice teachers (PST's) to important aspects of classroom interactions. This work-in-progress situates elementary PST in an afterschool 4-H science, technology, engineering, and mathematics (STEM) program and uses video as a tool to promote reflection and analysis of their developing practice. Specifically, we look at the role of the lesson analysis framework (LAF) in preservice teacher noticing of the practices of science teaching and learning. Preliminary results show that PSTs using the LAF noticed specific events and tied observations to science practices. PSTs who didn't use the LAF noticed only general aspects of science practices. This result is important to science teacher preparation because it points to the potential of using video reflections to facilitate the development of PSTs ability to reflect upon and learn from their developing practice as teacher of elementary science.

#### **Strand 7: Pre-service Science Teacher Education**

# Symposium – Preparing Next Generation STEM Teachers for Careers in High-Need Schools: Developing Critical Dialogue, Negotiation, Partnership

2:30pm-4:00pm, King's Garden 3

#### **Presenters:**

Gail Richmond, Michigan State University, gailr@msu.edu Ralph C. Dershimer, University of Michigan Maria M. Ferreira, Wayne State University Marcia K. Fetters, Western Michigan University Allison Young, Western Michigan University Beth W. Kubitskey, Eastern Michigan University Nelson Maylone, Eastern Michigan University

**ABSTRACT:** High-need schools are more likely to employ new teachers who are much more likely to leave within their first few years. The inability of students to depend upon having the same teachers from year to year contributes significantly to the lack of academic achievement. Our five institutions were provided an opportunity to design new graduate-level certification and induction programs to prepare and support individuals with STEM-related backgrounds for careers in high-need secondary schools in our state. Because the complexity of this process is substantial; because some of this territory was uncharted for us; because we often have different values and priorities; and because we hoped these programs might serve as models for teacher preparation, we needed to develop sustainable partnerships. Negotiating common goals from our individual visions was critical and yielded rich design features and learning opportunities within and across our institutions. Using key features of PLCs, each institution shares strategies and findings associated with

meeting challenges of developing and implementing residency-focused teacher preparation and induction programs. These include university faculty collaboration on program design; integration of clinical experiences into coursework; developing partnerships for professional support of mentors & candidates; and building community through a cohort model.

#### Strand 8: In-service Science Teacher Education *Effects of Professional Development on Knowledge of Content and Modeling* 2:30pm-4:00pm, Smithfield

Presider: Christine R. Lotter, University of South Carolina

From Using Models to Developing Models: Professional Development that Pushes on Teacher Thinking Daniel Capps, University of Maine, daniel.capps@maine.edu Jonathan Shemwell, University of Maine Lauren Barth-Cohen, University of Maine Shirly Avargil, University of Maine

**ABSTRACT:** The scientific practice of modeling is a focal point in the current reform movement in science education. Although modeling is central to scientific inquiry, the effort to incorporate the use and development of models in the standards and eventually the classroom will likely pose challenges for K-12 teachers. This study examined a professional development experience for 6th grade teachers that engaged them in two, content-rich investigations centered on the scientific practice of modeling. Analysis of data indicates that participant teachers performed significantly better on a content knowledge post-assessment than a group of comparison teachers. More importantly, the experience of engaging deeply in a single component of the new reform, modeling, supported teachers in gaining more complex views on the scientific practice of modeling and questioning their previous instruction related to the practice. Results from this study will help to inform professional development efforts under the Next Generation Science Standards.

*Effect of a Curricular and Professional Development Intervention on Elementary Teachers' Science Content Knowledge* 

Brandon S. Diamond, University of Miami, b.diamond@bio.miami.edu Jaime Maerten-Rivera, University of Miami

Okhee Lee, New York University

**ABSTRACT:** Teacher knowledge of science content is an important but rarely studied construct. An intervention, including a fifth grade science curriculum and professional development, was implemented over 3 years. Its effects on teacher science content knowledge, as measured by a science knowledge test and self-reported science knowledge from a questionnaire scale, were examined using longitudinal multilevel modeling. The study included 283 fifth grade teachers with measures collected prior to the intervention and after one, two, and three years of the intervention to examine change in teacher knowledge. Results indicate that time had a significant positive effect on teachers' science knowledge test scores and self-reported science knowledge with much of the change occurring after Year 1. Questionnaire responses had a statistically significant increase due to time after the second year, but test scores did not. Additionally, the intervention significantly improved self-reported science knowledge, but had no significant effect on test scores. Year 3 analysis is in progress at the time of proposal submission.

The Effects of In-service Learning Process Sequence Teacher Training on Student Knowledge in Physics Simon Zander, University Duisburg-Essen, simon.zander@uni-due.de

Heiko Krabbe, University Duisburg-Essen

Hans Ernst Fischer, University Duisburg-Essen

**ABSTRACT:** In-service physics teacher trainings that positively affect student knowledge are needed in order to improve teaching in schools. We conducted a one-year in-service, coach-led teacher training on learning process-based lesson sequencing. After the training the lessons reflected the goals of the in-service teacher training: In a pre-post control group design, students from the intervention group showed significantly higher levels of knowledge than the students from the control group (d = 0.32).

The Effects of Celestial Motion Model on Science Teachers' Investigation of Apparent Celestial Motion Sopita Jansri, Mahidol University, Kungphy@hotmail.com

Watcharee Ketpichainarong, Innovative Learning

**ABSTRACT:** This paper describes the usage of celestial motion model to improve conceptual understanding of science teachers in basic concepts of apparent celestial motion. The study was conducted with 45 science teachers in the teacher training program in Thailand. These science teacher were explored the concepts by using celestial motion model. They spent most of time in constructing the celestial motion model, groups discussing, analyzing, and attempting to explain their observations on inquiry process. This research gathered both quantitative and qualitative data in order to answer research question. The results indicate that most of the science teachers had a very limited understanding of the sun' apparent motion. The results of conceptual test indicated that science teachers had the posttest higher scores than the pretest significantly. For the perceptions of science teachers towards using the celestial motion model found that science teachers agreed that the celestial motion model could help them to improve their understanding in apparent celestial motion and astronomy phenomenon. This model used available material, easy to build by themselves and had effective teaching and learning in the classroom.

The Impact of an Immersive Professional Development Program on In-Service K-8 Teachers' Abilities to Provide Procedural Knowledge and Conceptual Understandings of Inquiry in the Classroom Margaret D. Nolan, Boston University, noland@mersd.org

Peter Garik, Boston University

Emily C. Allen, Boston University

Donald DeRosa, Boston University

Andrew Duffy, Boston University

Manher Jariwala, Boston University

Nicholas Gross, Boston University

Bennett Goldberg, Boston University

**ABSTRACT:** The Impact of an Immersive Professional Development Program on In-Service K-8 Teachers Abilities to Provide Procedural Knowledge and Conceptual Understandings of Inquiry in the Classroom We report here on the impact of an immersive professional development program on teachers' abilities to construct lesson plans that engage students in the procedural and conceptual aspects of inquiry. Prior studies confirmed the value of the immersive program. However, questions remain regarding the depth of inquiry teachers are able to effectively implement with their students. This research study focuses on quantitatively assessing the level of inquiry K-8 teachers plan as a result of attending the immersive course. The RTLPI Areas of Strength suggest that the Immersion Program had a statistically significant impact on shifting teachers' abilities to plan lessons that are student focused and engages learners in the procedures of scientific inquiry. The RTPLI Areas of Weakness findings suggest that although the Immersion Program had a significant impact on shifting teachers written lessons towards engaging students in deeper inquiry experiences, the teachers abilities in these areas was sufficiently low and although improved was not descriptive of reform based lessons. These results suggest the importance of allowing flexibility in the content curriculum for K-8 teachers.

#### Strand 8: In-service Science Teacher Education

Taking a Closer Look at Assessment and Curriculum

2:30pm-4:00pm, King's Garden 5 **Presider:** Deb Morrison, University of Colorado at Boulder

Teachers' Perceptions of Pacing Guides as a Tool to Teach Science: Case of Constrainted Professionalism Grant E. Gardner, Middle Tennessee State University, Grant.Gardner@mtsu.edu M. Gail Jones, North Carolina State University Laura Elizabeth Robertson, East Tennessee State University Sarah W. Robert, NCSU **ABSTRACT:** Pacing guides were originally developed as a tool to assist busy teachers in creating lesson plans allowing them to sequence and teach the required curriculum in a timely manner. In the recent era of high stakes testing, pacing guides have gradually evolved to align more closely to state and federal assessments. This study examines the perceptions of pacing guides of a group of science teachers in the southeastern United States through both quantitative surveys and qualitative semi-structured interviews. Data demonstrates that teachers utilized the pacing guides frequently but their was high variability in the method of use between teachers. Pacing guides were also perceived to have high value in the classroom but were also noted as being highly divorced from the realities of day-to-day teaching. Implications of this work on use of pacing guides to teach science are discussed.

#### Investigating and Exemplifying High School Chemistry Teachers' Assessment Literacy Kemal Izci, Van Yuzuncu Yil University, kikrc@mail.missouri.edu Marcelle Siegel, University of Missouri-Coluimbia

**ABSTRACT:** Limited studies have been conducted about using assessment to support chemistry teaching. Therefore, the purpose of this case study was threefold: a) to investigate high school chemistry teachers' perceptions of classroom assessment, b) to reveal their assessment knowledge, and c) to examine their assessment practices during their instruction of atomic structure and electron configuration. Four inservice chemistry teachers participated in this study. Semi-structured interviews, a pre-survey, observations, field notes, and artifacts were employed as data sources. Study findings indicated that, in theory, all of the participants' perceptions and knowledge of assessment aligned with current views of assessment to support learning and instruction. However, in the practical realm, the participants demonstrated varying degrees of sophistication of assessment use while teaching atomic structure and electron configuration. Based on the results, the study exemplifies and provides characteristics of chemistry teacher assessment practices, which are organized around three main components: a) assessment design, b) assessment practice, and c) reflection and action on assessment results. The contribution of this study lies in its exemplifications of assessment literacy in practice and is unique in offering empirically based characterizations of assessment literacy at various levels to aid teacher educators and researchers to support assessment literate teachers.

#### Negotiating the Use of Formative Assessment for Learning in the Era of Accountability Testing Xinying Yin, California state university-San Bernardino, xinying1128@gmail.com Gayle A. Buck, Indiana University

**ABSTRACT:** The purpose of this collaborative action research was to explore how science educators can negotiate the tension between integrating formative assessment (FA) for students' learning and meeting the need for standardized summative assessment (testing) from a critical perspective. Six major themes of the negotiation process emerged from this study, including: (1) clarifying teaching objectives, (2) restructuring instructional activities, (3) designing effective FA activities, (4) negotiating time constraints, (5) modifying tests and (6) negotiating with students in doing FA. By embracing the importance of teaching students' conceptual understandings of standards as part of her educational goal, gaining the skills to implement both divergent and convergent FA activities and using modified tests, the teacher made using FA for conceptual understanding and preparing students for tests coherent in her instruction. Students' engagement in learning was enhanced and their conceptions about learning and summative assessment became more consistent with conceptual understanding. This study added to our understandings about the relationship between formative assessment and summative accountability tests in science education and classroom teachers' conceptions and practices in making the relationship more coherent for learning. It also provided implications for science teacher professional development of formative assessment and for educational accountability policies.

#### Strand 8: In-service Science Teacher Education *Teacher Conceptions and Conceptual Change* 2:30pm-4:00pm, Sterlings 2 & 3

Conceptions of Teaching among Turkish and American K-8 Science Teachers Hasan Deniz, University of Nevada, Hasan.deniz@unlv.edu Elif Adibelli, University of Nevada, Las Vegas

#### Abeera P. Rehmat, University of Nevada, Las Vegas Mustafa Sami Topcu, Yildiz Technical University

**ABSTRACT:** Previous studies established a close link between teaching conceptions and epistemological beliefs. Unfortunately, the authors were not able to locate studies exploring the relationship between teaching conceptions and epistemological beliefs across different cultures. Therefore, two research questions guided this study: (1) Do conceptions of science teaching differ in Turkish and American contexts? (2) Are conceptions of science teaching related to epistemological beliefs about science in both Turkish and American contexts? The sample of this study comprised of 43 Turkish and 53 American inservice teachers. The data of this study was collected through the School Physics Teachers' Conceptions of Teaching questionnaire (Gao & Watkins, 2002) and Epistemic Belief Inventory (Schraw, Bendixen, & Dunkle, 2002). The Wilcoxon-Mann-Whitney tests indicated that Turkish teachers significantly supported traditional and blended teaching conceptions more than American teachers. Spearman's  $\rho$  correlations indicated that regardless of culture conceptions of teaching science were related to some epistemological beliefs. This study has implications for science teacher educators in the design and development of teacher education programs. Teacher education programs should aim at developing appropriate conceptions of teaching science and fruitful scientific epistemological beliefs if they wish to bring about changes in science teaching practices aligned with current science education reforms.

*Exploring How Industry Experiences Impact Teachers' Conceptions of Relevancy and Authenticity Related To Teaching Practices* 

Sanlyn Buxner, University of Arizona, buxner@email.arizona.edu Beau Vezino, University of Arizona Elise Bostic, South Mountain High School Bruce Johnson, University of Arizona Tenzin Sonam, University of Arizona Julia K. Olsen, University of Arizona

**ABSTRACT:** Ongoing innovation in STEM education continually calls for educators to make content relevant and authentic for their students. Although those terms are widely used in the literature and in reform documents, there are many possible interpretations about what each of those might mean and about how to bring them into the science classroom. Additionally, it is unclear what teachers believe each of these concepts means for their students. In this study, we investigated the meaning of relevancy and authenticity to a group of in-service teachers enrolled in a specialized industry partnership program. We found that through their internship experiences, teachers' concepts of relevancy expanded to include plans for planning for students' futures and giving them more control in the classroom. We also found that teachers' concepts of authenticity shifted towards making more connections from their workplaces to their classrooms. Teachers planned to alter their instruction by using project-based learning centered on real world problems, integrating skills they learned in the workplace, and bridging the gap between the workplace and classrooms. This study shows that by combining real work experiences with explicit instruction teachers are able to make connections between their industry experiences and their classroom practices.

Investigating Science Educators' Conceptions of Climate Science and Learning Progressions in a Professional Development Academy

Emily Hestness, University of Maryland, hestness@umd.edu J. Randy McGinnis, University of Maryland Wayne Breslyn, University of Maryland Robert C. McDonald, University of Maryland Chrystalla Mouza, University of Delaware Nicole Shea, University of Delaware Katy Wellington, University of Maryland

**ABSTRACT:** We present a mixed methods study investigating a model of professional development. The context was a weeklong summer Professional Development Academy (pseudonym) that focused on the use of learning progressions in climate change education. We examine the research questions: 1) How did participants evolve in their understandings of climate change through participation in the professional development academy? 2) How did participants understand learning progressions as potentially informative for their science teaching practices related to climate change? Participants

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(N=28) in the Academy were middle school (n=16), high school (n=6), higher education (n=2), and informal science educators (n=4) from two U.S. Mid-Atlantic states. Findings from climate science content knowledge assessment showed that participants improved their scores from pre (mean score: 9.6; S.D. = 2.5) to post (mean score: 10.8; S.D. = 1.8) out of a possible 14 points. Our analysis of the qualitative data suggested that participants demonstrated a range of conceptions of learning progressions, from less developed to well developed, and a range of views on potential utility of learning progressions in their teaching contexts. We synthesize implications of our study for science teacher professional development, highlighting the challenges of incorporating learning progressions into professional development.

#### *Linking Research about Conceptual Change and Teaching Practice in Primary Schools* Marie-Noel Bety, Universite de Montreal, marie-noel.bety@umontreal.ca

**ABSTRACT:** Primary school teachers often hold similar alternative conceptions to their students (e.g. about electricity) and generally teach science in a transmissive way (Duit, Treagust and Widodo, 2008). However, research shows that teaching using conceptual change (CC) is more efficient than traditional teaching (Lee and She, 2010). We designed a teacher education workshop to bridge the gap between CC research fields and regular teaching practices. Here we report on the influence of this CC workshop on primary school teachers' learning and practice. The workshop was developed using a contemporary understanding of CC pedagogical implications (Bêty and Potvin, 2011), teaching strategies promoting CC in electricity (Engelhardt and Beichner, 2004), and efficient teacher training parameters (Blank and de las Alas, 2010; Joyce and Showers, 2002). A design experiment method (Artigue, 1988; Harvey and Loiselle, 2009) was used to hone the quality of the workshop in three iterative trials, first with experts and then with two groups of teachers. Content analysis (Paillé and Mucchielli, 2005) was applied to qualitative performance metrics gathered for each trial and used to improve the workshop design. This led to a progressive increase in teacher understanding of electricity concepts and CC-oriented teaching strategies over the trials.

# The Development of In-Service Science Teachers' Pedagogical Content Knowledge Related to Interdisciplinary Science Inquiry

Erica L. Smith, State University of New York at Buffalo, elsmith4@buffalo.edu

Xiufeng Liu, State University of New York At Buffalo (SUNY)

**ABSTRACT:** This study is situated in a NSF-funded teacher professional development project, the Interdisciplinary Science and Engineering Partnership (ISEP), between the university and a school district in the North Eastern United States. This project affords an opportunity to understand the processes and conditions in which science teachers develop interdisciplinary science inquiry knowledge and how that is translated into their pedagogical content knowledge (PCK). As part of that study and within the framework of PCK, this study explores (1) the extent to which the involvement of inservice teachers in authentic research experiences impacts their interdisciplinary science inquiry PCK, and (2) the factors that contribute to or constrain the development of interdisciplinary science inquiry PCK. This study utilized a mixed method, explanatory research design. Results showed that teachers participating in the ISEP project demonstrated various levels of change in regards to their PCK, understanding of ISI, and implementation of ISI in classroom practices. The core features of ISEP identified as impacting this change included (1) the summer research connection, (2) collaboration with STEM students, (3) an active learning environment, and (4) duration. The above findings have implications for planning and conducting effective in-service science teacher education.

#### Strand 11: Cultural, Social, and Gender Issues

Symposium – Teaching and Learning Science in a Neoliberal Context

2:30pm-4:00pm, King's Garden 4

#### **Discussants:**

G. Michael Bowen, Mount Saint Vincent University Alexandra Schindel Dimick, University at Buffalo Jean R. Aguilar-Valdez, St. Olaf College Zoe E. Buck, University of California Santa Cruz Trish Kahle, University of Chicago **ABSTRACT:** Neoliberalism is most commonly associated with economic and governing policies that attempt to maximize individual and corporate entrepreneurship. This logic has spread beyond economic policy to include nearly every aspect of state policy, including formal and informal education, through deregulation, privatization, measurement, evaluation, and the reduction of state expenditures on social services. As the presenters in this symposium will demonstrate, these policies and practices extend into both formal and informal contexts and influence science teaching and learning for diverse stakeholders. The presenters will demonstrate, however, the influence of neoliberalism on science education is not static but is experienced and contested in various ways that are impacted by people's positional identities, including race, socioeconomic status, and gender. Drawing from qualitative data working with communities that are typically marginalized within science education and within the context of neoliberal policies, the participants in this session will draw upon the voices and testimonios of teachers, students, science learners, and museum educators to problematize the neoliberal policy and practices seen in science education. Importantly, the presenters will utilize their analyses to speak back to these detrimental practices and recommend alternatives in science education that promote inclusive, anti-oppressive science teaching and learning.

#### **Strand 12: Educational Technology**

#### **Online Learning Communities**

2:30pm-4:00pm, Fort Pitt **Presider:** Brian C. Baldwin, University of North Georgia

## Using Student-Created Videos about Alternative Energy to Support Argumentation in High School Science Classrooms

Jennifer L. Weible, Penn State University, jlw1086@psu.edu Heather Toomey Zimmerman, Penn State University

**ABSTRACT:** Sociocultural learning theory is used to study the effect of students' use of Web 2.0 tools to support their participation in the science practice of argumentation. We analyze video data (~35 hours), and data from social bookmarking, wiki, and podcasts from learners (n=34 tenth and eleventh graders) as they participated in a unit on alternative energy in a high school chemistry class. We adopt three pedagogical goals (a) youth make their thinking visible, (b) make sense of the information and articulating their understandings, and (c) participate in argumentation. Our findings suggest that students improved their understanding of the content about alternative energies, appropriated practices of argumentation such as counter-argument, and considered the role of the actual audience in design and construction of their arguments. In addition, although students understood the process of constructing scientific arguments, they choose to use emotional appeals and photographs to sway others to their side.

#### Social Discourse Patterns: When Scientists Partner with Students Online

Abigail C. Perkins, Texas A&M University, acperkins@neo.tamu.edu

Carol L. Stuessy, Texas A&M University

**ABSTRACT:** How relationships between scientist-mentors and student-teams function within a community of practice to facilitate students' processes of meaning making through inquiry is explored. Our objective is to capture the patterns in the scientist-mentors' and student-teams' dialogues as a group case study within a sociocultural framework, focusing on asynchronous text-based communication between scientist-mentors and student-teams to characterize ways scientists mentor students through the inquiry of authentic science experiments. Communication between scientist-mentors and assigned student-teams occurred on the PlantingScience online learning community, which consociates scientists' and students' cultures via collaboration. Results indicate scientist-mentors guided student-teams through investigations by asking questions, providing advice, and sharing real-life experiences. Student-teams socially embraced scientist-mentors as more knowledgeable others, accepting mentors as science experise and answer posed questions. We identified dialogue trends with respect to student-team performance, as measured by an online inquiry performance instrument. Higher performing student-teams had both scientist-mentors who asked more questions and team members who answered more scientist-mentor questions posed. Dialogues from both the scientist-mentors and the student-teams exhibited predominant social components reflective of meaningful learning and emergent authenticity.

#### Chemical Interactions in Learning Facebook Groups

Shelley Rap, Weizmann institute of science, shelley.rap@weizmann.ac.il Ron Blonder, Weizmann Institute of Science

**ABSTRACT:** The purpose of this research is to examine whether and under what conditions the Facebook environment is suitable for learning chemistry. Facebook provides a platform for interaction; hence, it has potential for shared learning and allows students to collectively participate in the discussions. We have examined what type of chemistry learning exists through Facebook groups, how is it performed, and we evaluated whether the interactions through the discourse facilitate meaningful learning. The research population includes chemistry teachers and their students, who are members in chemistry Facebook groups. In the paper we will show the different types of interactions that were observed within the chemistry Facebook groups and we will demonstrate learning episodes that were identified in the chemistry Facebook groups. The learning that had occurred throughout the episodes was characterized using Sfard's theoretical framework regarding learning (commognition). The teacher's role in the learning interactions via Facebook groups will be discussed. The current study opens a window to the potential of social networks as learning platforms. These research results will identify the conditions under which meaningful chemistry learning accrued in Facebook groups and will provide recommendations for teachers' professional development.

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

Philosophy of Science

2:30pm-4:00pm, King's Garden 1

Presider: Catherine M. Koehler, Southern Connecticut State University

#### An Examination of Tacit Knowledge and its role in Science Classrooms Rory Glass, University of Albany - SUNY, rglass@albany.edu

**ABSTRACT:** This proposal provides an examination of the role tacit knowledge plays in understanding, and examines a model to make such knowledge identifiable. To do this I first consider the needs of society, the ubiquity of information in our world and the future demands of the science classroom. I propose the use of more implicit or tacit understandings as foundational elements for the development of student knowledge. To justify this proposition I consider a wide range of philosophical and psychological perspectives on knowledge. Then review the recent Model of Scientific Knowledge (Glass, 2013), which was based in large part on a similar model created by Paul Ernest (1998a; b). Finally, I consider the work that has been done by those in fields beyond education and the ways in which tacit knowledge can be used as a starting point for knowledge building.

# Graduate Students' Ideas about Science and the Nature of Knowing Generated by a Sci-Fi Film John Y. Myers, University of Illinois at Urbana-Champaign, jymyers2@illinois.edu Fouad Abd-El-Khalick, University of Illinois at Urbana-Champaign

**ABSTRACT:** This exploratory study aimed to explicate the sorts of (a) ideas about science and various ways of knowing generated by the science fiction (SF) film, Contact, among viewing graduate students; (b) epistemic stance(s) (cf. Sobchack, 1992) with which participants view film; and (c) interactions between the generated ideas, epistemic stances, and spectators' backgrounds. Participants were 19 doctoral students whose major disciplines included science education, philosophy of science, physics, astronomy, and the humanities. Participants viewed Contact, wrote a "critical review," and were then interviewed about their ideas on nature of science (NOS) and knowing that were related to their viewing experience. How participants viewed Contact interacted with what they perceived. For example, participants in astronomy and the humanities typically identified themselves in the film story, whereas participants with a NOS background noticed, for example, naïve portrayals of the social NOS from a formalist perspective (i.e., no identification; the film world does not match the real world). These findings suggest that there is a multi-dimensional theory-ladenness that each spectator brings to viewing SF film. This study can extend prior research toward developing an empirically-derived methodology to analyze SF film content and its potential impact on student learning of NOS and epistemology.

# American High School Biology Classroom Practices from 1935 - 1960: Implications for Today Julie Bokor, University of Florida, jbokor@ufl.edu

**ABSTRACT:** This paper uses teacher accounts to reveal what biology content was taught in America's high schools from 1935 – 1960 and how the content was shaped during these crucial years in response to a rapidly changing American society. The historical research method is used to critically analyze three practitioner journals: School Science and Mathematics, The American Biology Teacher, and The Science Teacher. Sequential phases of analysis were used for each article leading to within and across journal findings. Economic factors were evident in the 1930s and early 1940s as teachers utilized natural resources available such as collected plants and animals for both live study and dissection. During the War, funds and American focus were diverted to the war effort, and the taught curriculum shifted to functional learning rather than science content. As the U.S. arrived in the Atomic Age, the desire to retain economic and political might shifted the education focus to more rigor in the schools and reform in science education. We are currently experiencing another science education reform in what Obama referred to as "Our generation's Sputnik moment." Using lessons from the past, we can strive to advance science education research and inform future practices and policies.

#### A Framework for Defining Physical Concepts

Chee Leong Wong, Nanyang Technological University, AlphonsusWong@gmail.com

Hye-Eun Chu, Nanyang Technological University

#### Kueh Chin Yap, Nanyang Technological University

**ABSTRACT:** There seem no underlying common features among definitions of physical concepts. Thus, there was no known framework which helps scientists, science educators and students to define physical concepts. However, numerous physicists and educators have spoken against inadequate definitions and definitional problems which impede understanding of physical concepts. The aim of this research is to develop a framework for defining physical concepts. The methodology in this study is based on grounded theory approach (Creswell, 2002). That is, this study seeks to identify scientists and science educators' preference on certain features of definition. They may not be objective, systematic and consistent. Findings indicated that the common features of definition were object, ontology, nature, cause, theory, equation and condition. They can be related to four definitional problems which are precision, circularity, context and completeness in knowledge. The proposed framework is based on the common practices of scientists and educators in defining physical concepts. This does not mean current practices should remain status quo and no further improvement is necessary. This framework may help to achieve greater consistency in defining physical concepts for classroom learning and assessment.

#### Strand 14: Environmental Education

*In-service Teachers and Climate Change* 2:30pm-4:00pm, Benedum **Presider:** Xavier Fazio, Brock University

Toward the Development of an Internet-based Resource for Teaching about Global Change: Results from the Needs Assessment Survey

Molly AM Stuhlsatz, BSCS, mstuhlsatz@bscs.org Minda Berbeco, National Center for Science Education Lisa D. White, University of California Museum of Paleontology Mark S. McCaffrey, National Center for Science Education Audrey Mohan, BSCS Christopher Wilson, BSCS

**ABSTRACT:** During the spring of 2013 we conducted a needs assessment survey to inform the development of a web resource dedicated to helping teachers and students understand global change. The needs assessment was targeted at middle school through college teachers in the United States. The survey attempted to determine what content related to global change and climate change are currently being taught, what instructional materials are being used in the classroom, whether or not teachers have received or feel a need for professional development concerning the topic, and whether teachers are pressured to avoid teaching climate science or pressured to teach "both sides" of the science. A total of 1651

people responded to the survey. Results reveal that over 80% of middle school through college educators responding to the survey currently teach about global change or climate change, and a high percentage of teachers see the topics of global change and climate change as very important. Additionally, only 9.9% of educators have experienced pressure to not teach climate science. These data, along with recommendations from advisors from the teaching and scientific community will be used to develop the web-based teaching resource.

Using Photo Elicitation Interview to Conceptualize In-Service Secondary School Science Teachers' Knowledge for Climate Change

Devarati Bhattacharya, University of Minnesota, Minneapolis, devarati@umn.edu

Engin Karahan, University Of Minnesota

Shiyu Liu, University of Minnesota

Gillian Roehrig, University of Minnesota

**ABSTRACT:** Photo Elicitation Interview (PEI) were used for assessing in-service secondary school teachers' conceptual understanding about global climate change (GCC). We selected PEI over attitude surveys and multiple-choice assessments because we believe that evaluating knowledge about GCC requires an understanding of the system as a whole instead of isolated approaches. Hence we used images from NASA image collection and local climatology websites to have a holistic discussion about climate change with our teacher participants. During the process of discussion we asked specific questions associated with these images that were developed and aligned with Essential Principles for Climate Literacy as developed by National Oceanic and Atmospheric Administration, 2009. These interviews were conducted with ten teachers, were transcribed and subjected to thematic analysis using N-Vivo software to reveal trends within teachers' overall understanding of GCC. All ten participants of this study displayed their strongest knowledge towards climate literacy principles 6 and 7 related to the causes and implications in a GCC scenario. There was a general lack of appreciation for feedbacks that occur within the climate system. Several misconceptions that have been previously reported in various studies (ozone causes global warming, long wave and short wave radiations) were also revealed here.

Arguing about Global Climate Change: In-Service Teachers' Argumentation and Epistemology on Climate Issues

Shiyu Liu, University of Minnesota, liux0631@umn.edu

Gillian Roehrig, University of Minnesota

Anne Loyle-Langholz, University of Minnesota

Devarati Bhattacharya, University of Minnesota, Minneapolis

**ABSTRACT:** The present study investigates the nature of in-service science teachers' reasoning and argumentation on the topic of global climate change and the epistemology they hold. Thirteen secondary science teachers participated in this study and a written assessment was developed to evaluate their skills in making arguments, counterarguments and rebuttals regarding the complexity and uncertainty of climate science. Our findings showed that teachers were able to employ genuine evidence to support their claims, but they often only described the phenomena without in-depth reasoning about the causal relationships involved. Also, teachers made more valid arguments when asked to support their own perspectives compared to generating counterarguments and rebuttals against alternative beliefs. Besides, the epistemological understandings teachers held impacted the quality of their reasoning and argumentation: those who accepted the uncertainty of expert views and acknowledged the co-occurrence of opinions were able to construct more counterarguments and rebuttals. This work expands the ongoing discussions in environmental education about what knowledge and skills teachers need to teach environmental issues and prepare students for future decision making. It constitutes our first step to facilitate reasoning and argumentation in climate change education and provides important implications for future design of teacher professional development programs.

**Strand 14: Environmental Education** 

**Pre-service Teachers and Sustainability, Service-learning, and the Environment** 2:30pm-4:00pm, Sterlings 1

Presider: Erica Blatt, College of Staten Island, CUNY

# *Preservice Elementary Teachers' Identity Development in an Environmentally-Focused Service-Learning Course*

Rachel E. Wilson, Appalachian State University, wilsonre3@appstate.edu Leslie Bradbury, Appalachian State University

**ABSTRACT:** The purpose of this presentation is to explore how a pre-methods service-learning experience with preservice elementary teachers (PSETs) influenced their science learning and teaching identities. As teacher educators, we are concerned about our PSETs' preparation for teaching science in ways that meet the ambitious expectations for elementary teachers. We are interested in how an environmental service-learning course influences PSETs' ideas about science teaching and learning, and how such a course could serve as a meaningful support in the development of positive teaching identities. Our interest in service-learning for PSETs is in the promise that this type of community-based experience holds for getting them to think about science learning as a cultural and contextual process that has relevance for their lives. We recruited elementary education majors in spring 2013 and collected data that would allow us to explore PSETs' descriptions and interpretations of their past and present experiences with science learning and teaching contexts. The implication of this research is that in the context of this course, even though the instructor models teaching science in a way that fits with students' learning identities, students are not incorporating some aspects of their learning identities in their narratives of themselves as future teachers.

#### A Phemenographic Study of Beginning Teachers' Conceptions of Sustainability

Rita Hagevik, The University of North Carolina at Pembroke, rita.hagevik@uncp.edu

Patty Stinger-Barnes, University of Tennessee

Dorothy Blanks, University of Tennessee

**ABSTRACT:** In creating a society whose citizens have sustainable lifestyles, Education for Sustainable Development (ESD) plays a key role. The concept of sustainable development (SD) has developed independently from the input of educators so understanding how educators view SD is of great importance. In order to gain an understanding of and to investigate the experiences of others, we conducted a phenomenographic study. Twenty-four participants in a science methods course completed Draw-a-Sustainable Development and Draw-an-Environmental Steward Test before and after instruction on topics of food chains, populations, ecosystems, as well as societal issues related to sustainability. An Environmental Attitudes Questionnaire indicated that the participants were overall pro-environmental before and after the course. However, participant's conceptions of SD continued to be very narrow with a lack of understanding of the interconnectedness between the environment, energy, and technologies to the political, economic, and social concerns. Participants during interviews identified that they felt unprepared to teach about SD. Participants were unable to explain how stewardship was connected to sustainability or how the actions of some might affect others. In order to ensure a sustainable future, then our educational leaders will require more planned experiences related to SD and throughout their careers.

#### Service-learning in Support of Science Teacher Education

#### Meghan E. Marrero, Mercy College, mmarrero3@mercy.edu

**ABSTRACT:** Service-learning, an instructional method that combines classroom learning with community service, has been used in myriad fields to improve civic responsibility, enhance course content, and increase self-efficacy. For teachers, service-learning has been used to improve cultural competence and pedagogical skills (e.g., Anderson, Swick, & Yff, 2001; Barton, 2000; Kirtman, 2008; Lawrence & Butler, 2010). In undergraduate courses, scientifically-based service-learning, e.g., participating in environmental studies, has been shown to improve students' awareness of environmental issues, increase course assessment scores, and enhance personal environmental decision making (Gorman, 2010; Phillipson-Mower & Adams, 2010). This study engaged two science education students (one pre-service and one in-service teacher) in an intensive service-learning experience related to wetland restoration and examined their perspectives on the experience with respect to their teaching practice. The qualitative analysis of a variety of data sources, including interviews, blog posts and classroom artifacts formed a case study of the two teachers' experiences. Results indicate perceived increases in content knowledge and the inclusion of content and techniques from the experience into the teachers' own classrooms. The findings suggest that science-based service-learning may be one way to improve science teachers' pedagogical content knowledge.

#### **Strand 15: Policy**

*Science Education Reform Policy Issues* 2:30pm-4:00pm, Birmingham **Presider:** Gavin W. Fulmer, National Institute of Education (Singapore)

#### Assessing Multinational Interest in STEM - First Findings

Adam V. Maltese, Indiana University, amaltese@indiana.edu

**ABSTRACT:** Keeping America at the forefront of research and innovation is a common talking point at the highest levels of government. Recent research indicates that student interest in STEM coursework, informal experiences and career options plays a significant role in STEM pipeline persistence, above and beyond achievement and enrollment. However, it is still not clear how these interests develop and evolve over time, and what occurs at critical stages to influence persistence. At the same time, there seems to be mounting interest in comparing students across state boundaries and with other nations, 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 AMISTEM survey is based on the belief that a student's interests in STEM are developed from a combination of intrinsic factors and extrinsic experiences. The survey collected data from over 1000 students and faculty from the United States, Australia and China. In this paper we discuss the survey and initial comparative results, which depict interesting differences in the generation of STEM interest across countries.

Engineering in Science? A Study of Next Generation Science Standards and State-Level Science Standards Tamara J. Moore, Purdue University, tamara@purdue.edu

Kristina M. Tank, University of Minnesota

Aran W. Glancy, University of Minnesota

Jennifer Kersten, Richfield High School/University of Minnesota

**ABSTRACT:** Recent national documents pertaining to K-12 education have fostered a connection between engineering and science education, but engineering education at the K-12 level has yet to develop a strong tradition. As a result, we are left with a number of questions about the integration of these two areas, for example, How is engineering taught effectively in grades K-12? How does engineering education 'interact' with other STEM subjects such as science?, How has engineering been used as a context for exploring science, technology, and mathematics concepts? (NRC, 2009, p. 2). Understanding the current state of K-12 engineering education is useful in furthering the implementation of robust engineering and STEM standards and initiatives as well as beginning to answer the questions above. This paper uses the Framework for a Quality K-12 Engineering Education (Authors, 2013a) as a means of evaluating the existing science standards documents and the recently released Next Generation Science Standards (NGSS) in terms of the engineering that is present in the Next Generation Science Standards and in states' current academic science standards?

*Connecting Policy with Practice: Nigerian Case Study of Science Teacher Education, Demand, Supply and Quality* 

Peter A. Okebukola, Lagos State University, pokebukola@yahoo.com

Foluso Okebukola, Lagos State University

Olatunde Lawal Owolabi, Lagos State University

Sunday O. Banjoko, Lagos State University

Ayodele Ogunleye, University of Lagos

**ABSTRACT:** This is a report of a study which (a) reviewed the policy on science teacher education in Nigeria; (b) assessed the demand and supply of science teachers; and (c) assessed the quality of science teachers. Documentary analyses of the science education policy and analysis of science teacher demand and supply data were undertaken by three science educators. Science classroom observations using the standardized Science Teacher Assessment Inventory was used to gather data on quality from selected primary and secondary school teachers. Policy gaps were found in the area of training, benchmarking and standards setting and continued professional development. The supply and demand sides of science teachers also revealed significant gaps. A trend towards over-supply in some subjects and in some states were

highlighted. On the quality side, we observed weaknesses in primary and secondary science teachers in content knowledge of science. It is evident from the foregoing that noteworthy changes would need to be made to policy prescriptions and implementation to assure the delivery of good quality science education in Nigeria as well as other countries within and outside Africa with similar contexts.

### The Advanced Placement Test-Taking Explosion: What Is the Science and Math Blast Effect? Eugene Judson, Arizona State University, Eugene.Judson@asu.edu

**ABSTRACT:** Advanced Placement (AP) programs have grown 500 percent in two decades. The national fervor promoting AP test-taking can be traced to the standards-based movement of the 1990s. The call to action connecting national needs with classrooms is particularly acute in science, technology, engineering, and mathematics (STEM) fields. This study examined growth of science, computer science, and mathematics AP exams in the context all AP exams. Additionally, achievement levels were traced over 20-years. While AP programs have grown overall, science and math AP exams have grown at a less feverish pace. Additionally, there have been substantial increases in the percentage of students achieving the lowest score (i.e., a 1) on AP exams, with this proportion doubling in Biology in the last ten years.

Concurrent Session #9 4:15pm – 5:45pm

#### **Publications Advisory Committee Sponsored Session**

*Symposium – The Anatomy of a Good Article: Publishing in the Journal of Research in Science Teaching* 4:15pm-5:45pm, King's Garden 1

#### **Presenters:**

Angela Calabrese Barton, Michigan State University, acb@msu.edu Joseph Krajcik, Michigan State University Bob Geier, Michigan State University

**ABSTRACT:** The purpose of this session is to engage potential authors in dialog about what constitutes a high quality article that aligns with the scope and focus of JRST. The session will offer perspectives on the anatomy of a high quality article from multiple perspectives: Editors, published authors, and reviewers. The editorial team will first present their model for how manuscripts are reviewed, including the publication guidelines that reviewers of the Journal of Research in Science Teaching use when reviewing submitted manuscripts. Their presentation will be followed by comments from three panelists who represent the author and/or reviewer position. The panelists will reflect a range of expertise in research approaches. A substantial portion of time will be devoted to open discussion. This session welcomes those who are new to academia and are interested in submitting to and getting published in JRST or anyone who would like to become a reviewer for the journal.

### Strand 1: Science Learning, Understanding and Conceptual Change

Argumentation, Intuition, and Decision-making

4:15pm-5:45pm, Sterlings 1 **Presider:** Calvin Kalman, Concordia University

Performance Expectations for Engaging with Ecosystem Services Science when Making Everyday Decisions: A Delphi Study Linking Ecosystem Services to All Citizens

John R. Ruppert, Rutgers University, jruppert@spc.edu

Ravit Golan Duncan, Rutgers University

**ABSTRACT:** Scientific exploration of human-environment relationships has proceeded at an alarming rate in recent years. The field that studies Ecosystem Services (ES) or benefits that humans derive from the environment is one field that studies this relationship. ES formed by merging natural and social sciences and, as such, has disciplinary ideas that

are not as neatly packaged and articulated as century older sciences like ecology. This Delphi study defines ES for general audiences, identifies disciplinary core ideas (DCIs), everyday decisions that can be informed by the science, and ways in which citizens can engage with the science when making everyday decisions. The results presented emerge from four rounds of survey using a panel of individuals with expertise in ecosystem services and education on human-environment relationships. These surveys contained open-ended response followed by rating and comment on ideas. This study identified 16 DCIs and eight performances that articulate what engagement with ES science might look like when using it to inform everyday decisions. These performances can serve as a model for future expansion of national science standards into the social sciences by articulating a science that removes disciplinary walls that may isolate the sciences from the everyday lives of citizens. The performances presented here are hypotheses based on expert opinion; therefore, this study lays foundations for an expanded area of education research by adding a dimension to the NGSS framework: engagement with science for everyday decisions.

#### Argumentation Prompts Mediating Students' Performance and Epistemic Games on Conceptual Physics Problems

Carina M. Rebello, University of Missouri, cp5xc@mail.mizzou.edu

Lloyd H. Barrow, University of Missouri

N. Sanjay Rebello, Kansas State University

**ABSTRACT:** Studies have shown that embedding scientific argumentation in problems can enhance problem solving skills. Research has also indicated that students have difficulty constructing arguments without appropriate scaffolds. We investigated the use of argumentation scaffolds on undergraduates' argumentation quality, conceptual quality, and problem solving strategies invoked on conceptual problems in introductory physics. In this mixed method study, we compared undergraduates' performance in two guided conditions – constructing or evaluating arguments – and one control condition. Results indicate that guiding prompts improve argumentation and conceptual quality of undergraduates' solutions. Further, undergraduates in the guided conditions used more sophisticated problem solving strategies than in the control condition. We discuss the implications of these results on the use of argumentation prompts on problems in introductory physics.

Enhancing Students' Critical Thinking Skills through Argument Based Inquiry: Results from A Scale up Research Project in Turkey

Murat Gunel, TED University, murat.gunel@tedu.edu.tr Recai Akkus, Abant Izzet Baysal University Melike Ozer-Keskin, Gazi University

Nilay Keskin-Samanci, Gazi University

**ABSTRACT:** This research paper focuses on the impact of Argumentation Based Inquiry (ABI) approach on students' critical thinking skills. The mechanism for achieving endeavor is the Science Writing Heuristic approach, which is a heuristic to scaffold critical thinking and scientific argumentation as well as to improve science content knowledge. From different states in Turkey there are 15 science teachers who are teaching at 6th, 7th and 8th grade levels involve in this three-year-long research program. The data collected from the students include critical thinking test and from the teachers include video recordings of implementation. In this paper, the data collected through Cornell Critical Thinking Test (CCTT) implementation within 3 years of project implementation by considering the teachers' implementation levels and students' group is analyzed. The CCTT pre-post data analyses results yielded that through out the 3-year data analyses there are a significant impact of teachers' implementation level and students' group on CCTT scores. While students' in ABI group scored significantly higher than those in comparisons group, students' in higher ABI implementation level teachers' classrooms showed significantly better performance on CTTT.

*Naïve Genetic Determinism and Genetics/Genomics Literacy: Do Human Intuitions have an Impact?* Kostas Kampourakis, University of Geneva, Kostas.Kampourakis@unige.ch Bruno J. Strasser, University of Geneva

**ABSTRACT:** Our understanding of the role of genes in determining biological traits has undergone a profound transformation. The results of Genome Wide Association Studies and the discovery of multiple epigenetic mechanisms have revealed a complex picture where genes, environments, and behavior, need to be taken into account to explain

biological traits. However, research in science education suggests that students generally hold views of what can be described as "naïve genetic determinism", the idea of "genes for" traits, which is also found in textbooks and even held by biology teachers. Thus, it is important to enquire on the origin and prevalence of these conceptions. Conceptual development research suggests that human intuitions, such as design teleology and psychological essentialism, may have an impact on students' understanding of science. It seems that humans tend to think of organisms as if they were artifacts, intentionally designed (design teleology) with essences fixed (psychological essentialism) for an intended use. These intuitions may form important conceptual obstacles to understanding genetics. This paper reviews the available evidence and outlines the research questions that need to be answered in order to carry out successfully the transition in science education required by the current transformation of biological knowledge.

#### Strand 1: Science Learning, Understanding and Conceptual Change

### *Related Paper Set – Development of Student Understanding of Ecosystem Change across Contexts and Scales*

#### 4:15pm-5:45pm, Duquesne

**ABSTRACT:** An integrated understanding of the effects of human-caused disturbance on ecological systems is essential for informed citizenship. This integrated understanding requires students to be able to reason across scales of time, space and organization, seeking mechanisms at smaller scales and contexts at larger ones. In paper 1, this paper set starts with a review of the development of modern approaches to understanding ecological systems, identifying three how three core ideas – hierarchical systems, mechanism, and constraints on processes – characterize challenging but appropriate learning goals for environmental science literacy. The theory is supported by new data from experts and by careful analysis of the NGSS. The remaining papers present in-depth empirical findings of student understanding of ecosystems at three time scales: ecological time (paper 2), micro-evolutionary time (paper 3) and macro-evolutionary time (paper 4). Each explores student thinking and learning about phenomena at the appropriate scale, and shows how hierarchical system thinking, probing for mechanisms, and appreciation of constraints operates. The empirical work is grounded in constructivist theory, and together the papers represent a significant advance in our efforts to develop learning progressions for both community/ecosystem ecology and evolution (both micro- and macro-) within the overarching arena of biodiversity.

### Ecological Systems and Learning Progressions: Applications of Basic Principles across Multiple Scales of Organization

John C. Moore, Colorado State University, jcmoore@nrel.colostate.edu Laurel Hartley, University of Colorado Denver Jennifer H. Doherty, Michigan State University Cornelia Harris, Cary Institute of Ecosystem Studies Alan R. Berkowitz, Cary Institute of Ecosystem Studies Charles W. Anderson, Michigan State University

Learning Progression Framework and Assessments for Community Ecology Laurel Hartley, University of Colorado Denver, hartleylaurel@gmail.com Jennifer H. Doherty, Michigan State University 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

Developing Understanding of Evolution in Complex Contexts Jennifer H. Doherty, Michigan State University, dohert59@msu.edu Laurel Hartley, University of Colorado Denver Cornelia Harris, Cary Institute of Ecosystem Studies Charles W. Anderson, Michigan State University

*Unifying Life: Placing Urban Tree Diversity into an Evolutionary Context* Yael Wyner, City College of New York Jennifer Doherty, Michigan State University

#### Strand 2: Science Learning: Contexts, Characteristics and Interactions Engaging Students in Experimental Design, Measurement, Computational Thinking, Data Analysis, and Causal Thinking

4:15pm-5:45pm, Heinz **Presider:** Chanyah Dahsah, Michigan State University

#### Unpacking the Development of Measurement Practice

Eve Manz, University of Colorado Boulder, eve.manz@colorado.edu

**ABSTRACT:** Identifying and operationalizing variables is an integral aspect of experimentation practice, but one that has received less attention in the literature. Therefore, we know little about how students, particularly young students, might be initiated into measurement practice. This study begins to fill this gap using the context of a third grade classroom's plant growth experiment by presenting a detailed analysis of how these young students developed practices of observing, recording, and operationalizing plant success. Analysis characterized the "epistemic levels" at which students positioned plant characteristics, from noticings, to shared attributes, to operationalizations of plant success. It showed that students brought to instruction important resources for sharing and debating what they saw and what it meant, and that in a context characterized by teacher support and extended experience with the phenomenon, they began increasingly to apply these resources to construct and critique complex, conceptually justified, claims about plant success.

Long-Term Development of Agent-Based Computational Modeling in 5th Grade: Shifting from Programming to Modeling

Amy V. Farris, Vanderbilt University, amy.s.voss@Vanderbilt.Edu Amanda C. Dickes, Vanderbilt University Gokul Krishnan, Vanderbilt University Cherifa Ghassoul, Vanderbilt University Pratim Sengupta, Vanderbilt University

**ABSTRACT:** Development of expertise in modeling is central to the development of scientific expertise (NRC, 2008). Given the recent emphasis to integrate computational thinking in K12 science curricula (Repenning, 2013; Sengupta, et al., 2013), this paper reports results from the first long-term, microgenetic study of 5th grade children's co-development of computational thinking and scientific modeling in the context of learning kinematics. We present a case study of one student's shift from programming to modeling and a whole-class analysis of the development of facets of computational thinking in the context of modeling phenomena. Our analysis identifies the nature of children's progressive symbolization—how the process of progressively refining one's representation of some aspect of the world can contribute to a deeper understanding of a domain (Hall & Stevens, 1995; Lehrer & Pitchard, 2002; Lehrer & Schauble, 2002; Enyedy, 2005)—¬–as children gradually adopted agent-based programming and modeling as the representational "language" (Giere, 1998) in their science classroom over 28 weeks.

#### *Teaching and Learning the Nature of Scientific Evidence Demands Attention to the Notion of Causality* Susan Kirch, New York University, susan.kirch@nyu.edu

**ABSTRACT:** Causal language is pervasive in modern science yet it is not treated as an essential cognitive tool that science students learn. The purpose of this study was to (a) describe classroom norms for assigning causation during an instructional unit designed to promote analysis of reasoning, argument and explanation and (b) design teaching and learning tools for the understanding the nature of assigning causation. Losee's (2011) theories of causality inventory was

used as a discourse analytic tool to process classroom transcripts of approximately forty fourth grade students working in small group conversations. The theory of causality primarily reproduced and used by study participants was Mill's method of difference. Implications of these findings for teaching and learning science will be discussed.

### Supporting the Development of Student Reasoning Across an Evolving Scientific Explanation Ann M. Novak, Greenhills School/Curtin University, anovak@greenhillsschool.org

#### David F. Treagust, Curtin University

**ABSTRACT:** Many documents, including the New Framework for K-12 Science Education, stress the importance of students' constructing scientific explanations. The reasoning portion of the claim, evidence, and reasoning framework is viewed as the most challenging for students. In this study, students constructed one explanation over time, cycling through four iterations, revisiting concepts and including new science concepts to discuss new evidence. We ask: As students gain more experience in writing explanations, do they develop an integrated understanding of appropriate scientific principles? Does the practice of analyzing data/evidence and writing early versions of the explanation provide students with experience to more thoughtfully incorporate concepts when writing about new evidence? Results for both questions indicated statistically significant effects. As students gained more experience in writing explanations, they included richer discussion using appropriate scientific principles. Once students had initial experiences and then obtained new evidence that included new science ideas, they incorporated appropriate and connected science ideas much more than in earlier explanations. These results provided evidence that students were able to transfer their learning to new situations. These types of experiences can assist students to develop integrated understanding that can be used to explain phenomena, solve problems, make decisions, and learn new concepts.

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

# Related Paper Set – Representing Science: Visual Data Highlighting Understandings and Meanings of Science

#### 4:15pm-5:45pm, Commonwealth 2

**ABSTRACT:** In this paper set we use drawings as important representations of learners' understandings of science that provide relatively direct and explicit links to learners' cognitive and cultural knowledge. The four papers present research on the use of drawings as an insightful data source for these studies of science education. The papers span settings and age groups and yet center on the technique of using visual representations as a means of gaining insights into science teaching and learning. The first paper explores the ways teacher candidates enrolled in science methods courses represent their digestive and endocrine system. The second paper is a longitudinal study to chart the changes in primary science learners' understandings of their internal organ systems. The third paper captures what doing science looks like and what is salient and meaningful to high school biology students. The fourth paper provides a review of newspaper comics centered on theory development as science reaches a public audience. In addition to providing examples of rich data sets through drawings, these papers provide case studies of rigorous and comprehensive modes of analyzing visual data.

Science Teacher Candidates' Drawings of the Digestive and Endocrine Systems Patricia Patrick, Texas Tech Unviersity, trish.patrick@ttu.edu

A Longitudinal Study of a Class of English Primary Children from Five Years to Eleven Years on Their Developing Understanding of What was Inside Their Body Sue Dale Tunnicliffe, University of London, lady.tunnicliffe@me.com Michael J. Reiss, University of London

Drawing for the Public: Newspaper Comic Panels Portray U.S. Science Values and Attitudes as Part of the Socio-Cultural Setting for Science Learning Phyllis Katz, University of Maryland, pkatz15@gmail.com

Understandings the Meanings Secondary Biology Students Construct Around Science from Drawings Jeremy F. Price, Fairmont State University, Jeremy.price@fairmontstate.edu

#### Strand 2: Science Learning: Contexts, Characteristics and Interactions Socioscientific Issues and What Counts as Science

4:15pm-5:45pm, King's Garden 3 **Presider:** Jonathan Francis Osborne, Stanford University

Socioscientific Intertextuality in Secondary Science

Alandeom W. Oliveira, University at Albany, SUNY, aoliveira@albany.edu Troy D. Sadler, University of Missouri

Christina M. Nash, University of Missouri

**ABSTRACT:** This study examines socioscientific intertextuality – how writers juxtapose and connect across multiple texts for collaboratively making sense of socioscientific issues. Our intertextual analysis focuses on teacher and student writing during implementation of two biology cases written by teachers familiar with case-based pedagogy. Student written responses to socioscientific cases are viewed as having varied degrees of socioscientific intertextuality depending upon the extent of student social construction of a variety of intertextual links (e.g., use of similar lexicon across texts, consistent adoption of a particular type of reader-writer positioning across texts, existence of structural similarity between texts). It was found that, though both cases were designed to promote socioscientific intertextuality, only one case successfully achieved this goal. While the successful case prompted students to write socioscientific writing devoid of text-to-society connections (i.e., that lacked personal or societal intertextuality). It is argued that familiarity with the case-based pedagogy does not guarantee socioscientific levels of intertextuality in student engagement with pedagogical texts, and that consideration should be given to the linguistic expertise that teachers need to effectively write SSI cases and position adolescents socioscientifically.

The Impact of Socioscientific Issues on Moral Reasoning and Moral Sensitivity in High School Students Eunhang Lee, Ewha Womans University, eunhanglee@gmail.com

Dana L. Zeidler, University of South Florida

Younglan Chung, Ewha Womans University

**ABSTRACT:** This study investigated the effect of a Socioscientific Issues (SSI) unit of study on students' moral reasoning and moral sensitivity in Korea. We developed a 10-hour SSI program for high school students that was implemented during class time early in the academic school year. We employed a mixed-methods approach: 202 high school juniors completed the Defining Issues Test of moral reasoning (DIT; Rest, 1979) and a worksheet with various questions aimed at tapping moral sensitivity. The results of the DIT revealed no statistically significant effects with respect to progressing levels of moral reasoning as a result of the SSI unit of instruction. However, a qualitative analysis of the students' written data revealed four patterns of moral sensitivity. The students (1) recognized moral aspects of a situation, (2) were aware and felt empathy for how possible resolutions may affect other people, (3) anticipated possible consequences in society, such as side effects, and (4) examined different perspectives of a situation. Using these four patterns of moral sensitivity and analyzed their transcripts. This qualitative analysis showed that the students' moral sensitivity increased from the pre- to post-SSI instruction. These results suggest that the students' moral sensitivity improved and was used to buttress their reasoning on SSI as a result of the SSI instruction.

Storytelling in 1st Grade Science: Negotiating what Counts as Scientific Knowledge and Who Talks Science Danusa Munford, Universidade Federal de Minas Gerais, danusamun@gmail.br

Kely C.N. Souto, Universidade Federal de Minas Gerais

Vanessa Neves, Universidade Federal de Minas Gerais

Francisco A. Coutinho, Universidade Federal de Minas Gerais

**ABSTRACT:** In this study, we analyze storytelling events during science lessons in a 1st grade classroom in order to better understand how students and the teacher constructed what counted as scientific knowledge. We adopted theoretical-methodological perspectives from the field of narrative studies (for instance, the notion of narrative as performance, and

entitlement). During one school year, we conducted participant observation with records in video, as well as field notes. Informed by Interactional Ethnography we elaborated event maps and story lines. Then, we identified key storytelling events, which were transcribed word-by-word, including information about non-verbal language. Through our analyses it was possible to better characterize the diversity of accounts of experience present in the classroom. Moreover, we learned about how what gets told and who has the right to tell was discursively negotiated and constructed. Some participants had more access to narrative and communicative resources, influencing this process. The role of the teacher changed over time, involving greater participation on story formulations. This study can add to extensive research on science elementary school and to practice as it combines different constructs from narrative studies.

# Strand 4: Science Teaching--Middle and High School (Grades 5-12): Characteristics and Strategies *Investigating Beliefs and Epistemologies of Teachers and Students* 4:15pm-5:45pm, Fort Pitt

Relations between the Turkish High School Students' Physics-related Personal Epistemologies and their Selfregulated Learning Strategies Muhammet Mustafa Alpaslan, Texas A&M University, alpaslan27@tamu.edu Bugrahan Yalvac, Texas A&M Cathleen C. Loving, Texas A&M University Victor Willson, Texas A&M University **ABSTRACT:** In this paper, we have explored the level of the relations between Turkish high school students' person

**ABSTRACT:** In this paper, we have explored the level of the relations between Turkish high school students' personal epistemologies, achievement goals, learning strategies, and achievement. We sought to empirically test Muis' hypothesis (2007), which claims that students' personal epistemologies influence their self-regulated learning processes. Two-hundred-nine high school students 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 physics. Viewing physics as an accumulation of facts leads the students to have low motivation in learning physics, low meta-cognitive engagement in learning tasks, and low achievement in physics. Implications and future direction are discussed.

How Biology Teachers' Beliefs Influence the Tasks They Use

Christian Förtsch, University of Munich, christian.foertsch@bio.lmu.de

Sonja Werner, University of Munich

Melanie Jüttner, University of Munich

Birgit Jana Neuhaus, University of Munich

**ABSTRACT:** The professional competence of teachers can be divided into cognitive aspects and affective aspects. This part of the DFG-funded project LerNT focuses on cognitive aspects of biology teachers, described by the expectancy-value model, influencing the use of special written tasks in biology lessons. These tasks should be oriented towards 'German Education Standards'. Therefore a quantitative quasi-experimental video study in a pre-post design was conducted. 28 biology teachers of secondary schools in Germany were videotaped for three botany lessons (N = 82 videos) in grade six. Additionally, a questionnaire on affective aspects involving the use of competency-orientated tasks was filled out and three self-generated written tests per teacher (N = 84 tests) were collected. These tasks were analyzed using a coding manual developed around four competencies, as described in German Education Standards. The calculated structure equation model shows that on the one hand Expectation of Success (r = .49; p < .001) and on the other hand Costs (r = -.42; p < .01) influence the use of competency-based tasks in biology lessons. These results throw a spotlight on potential problems that arise, while implementing German Education Standards in biology lessons, and allow the comparison of German and US Education Standards.

### Creationism vs. Evolution: A Study of the Opinions of Georgia Biology Teachers

William H. Nye, Gwinnett County Public Schools, wnye@comcast.net

**ABSTRACT:** This study surveyed Georgia public high school biology teachers for opinions regarding the teaching of creationism and analyzed respondents' opinions regarding attitudinal and biographical variables, and compared current

opinions to 1983 Georgia science teachers. Of the educators responding, 92% stated they were familiar with the term creationism, 17% claim to teach creationism and evolution, 3.4% creationism without mention of evolution and 1.4% teach neither. Since the inclusion of evolution in Georgia standards, this study revealed more than 20% of respondents continue to include instruction on creationism; meanwhile, respondents claiming to teach evolution increased from 39% to 78% and those teaching neither decreased from 31% to 1.4% in the same time period. This paper argues that policy matters. Although teachers' personal beliefs are major contributors to classroom practices regarding the teaching of evolution and creationism, data indicate that state standards, in part, have influenced the teaching of evolution. This study reasons administrative policy providing guidance and strategies to science teachers directing the manner in which creationism is introduced during the teaching of evolution may limit the wide range of creation teaching practices occurring currently and increase student understanding of scientific practices through the development of emotional and deductive reasoning.

#### Strand 5: College Science Teaching and Learning (Grades 13-20) Improving Undergraduate Instruction

4:15pm-5:45pm, Birmingham **Presider:** Carrie J. Boyce, The University of Southern Mississippi

*Evaluating Institutional Change in Biological Sciences at a Research-Intensive University: The Beginning* Rebecca L. Matz, Michigan State University, matz@msu.edu

Sarah E. Jardeleza, Michigan State University

Joseph S. Krajcik, Michigan State University

**ABSTRACT:** This study focuses on an institutional effort at a large, public research-intensive university to improve teaching and learning in undergraduate biological sciences, called the Biology Initiative. The programmatic vision for the Biology Initiative is "to implement a core curriculum for life-science majors that provides the skills and content knowledge necessary for success in biological sciences." A case study methodology was employed to examine the primary research question: What factors promote reform in the biological sciences at this research-intensive university and why? Specifically, what were the major challenges in the first year of the Biology Initiative and how were they overcome? Both direct observations and documentation were sources of data. Three particular areas of challenge in implementation of the Biology Initiative emerged from the data: organization, communication, and building community. Interestingly, it appears that the communication and building community issues derived from the organizational challenges. Actions taken to address challenge areas are described, such as leadership declaration, organizational system creation, and increased communication between and with all stakeholders. Recommendations are made for other institutions considering improvements of the same scope as the Biology Initiative.

Undergraduate Teaching Assistant Impact on Student Academic Achievement and Persistence in General Chemistry

Stephanie B. Philipp, University of Louisville, stephanie.philipp@louisville.edu

Thomas R. Tretter, University of Louisville

Christine V. Rich, University of Louisville

**ABSTRACT:** This presentation will share the results from a study of entry-level undergraduate students in a program implemented to increase student retention in STEM majors. With a theoretical foundation of Lave and Wenger's Community of Practice and Wheeler, Martin and Suls' Proxy Model of Social Comparison, research questions asked about the impact of undergraduate teaching assistants (UTAs) on students' final exam grades and persistence of students to enroll in the next semester of general chemistry required for many STEM majors. A detailed description of the program implemented using UTAs will be given. Multilevel analysis indicated that having a UTA gave students with above average college GPA a statistically significant boost on their final exam score. Logistic regression analysis showed that students in UTA-led recitation sections were three times more likely to enroll in the next semester of general chemistry.

#### Using Department-Level Social Networks to Inform Instructional Change Initiatives Kathleen Quardokus, Western Michigan University, kathleen.m.quardokus@wmich.edu Charles R. Henderson, Western Michigan University

**ABSTRACT:** Many change initiatives aim to improve undergraduate instruction by focusing on individual instructors. Recently, it has been suggested that the academic department is the most productive unit of change. To work at the departmental level, it is important for a change agent to understand the social structure of the department. This paper will describe how change agents can identify this social structure through the use of social network analysis of self-reported teaching discussions. Through an example of five academic departments that are involved in a change initiative, we discuss how social network analysis can identify features of the overall structure, subgroups within a network and well-connected individuals. Information from these analyses can be used to fulfill the change agent tasks of learning about the current state of the department, recruiting individuals for participation and anticipating the spread of the innovation. Results indicate that future applications of social network analysis of departments will provide meaningful insight into instructional change initiatives.

Latency toward Public Speaking in Pre-engineering and Physics Students at a Two-year College Pamela A. Maher, University of Nevada Las Vegas, maherp@unlv.nevada.edu

Janelle M. Bailey, Temple University

Allan M. Tucka, College of Southern Nevada

**ABSTRACT:** This paper reports on an investigation of latency toward public speaking among pre-engineering and calculus-based physics students at a two-year college in the southwestern US. Latency is defined as a hesitation to engage in oral communication with an unknown audience. Thirty (N=30) students self-selected to participate in a grant-funded project. These students made presentations to patrons visiting a Planetarium on physics concepts using the machines of Leonardo da Vinci as examples. The project exposed these students to interactive public speaking to a lay audience. We conducted a content analysis of participant reflections before and after presentations to determine the students' reasons for public speaking latency. Results suggest that student latency stems from the fear of making mistakes or giving out misinformation and opportunities to engage in informal public speaking help overcome these obstacles. Data also reveal that participants demonstrated increased confidence in their ability to transmit knowledge to the general public after having guided informal speaking opportunities. The results of this study can inform the practice of training scientists and engineers and can prepare these future professionals for communication skills necessary to their careers.

### Strand 6: Science Learning in Informal Contexts

#### Related Paper Set – STEM Learning Ecosystems

#### 4:15pm-5:45pm, Rivers

**ABSTRACT:** This session focuses on ways of studying and supporting trajectories of STEM learning for youth within community learning ecosystems. How do the people and resources within a given ecosystem—including parents, teachers, and community members, as well as science resources, events and places—create ripe conditions and pathways for "falling for science?" (Turkle, 2008). To what extent are the elements of these systems connected and synergistic, and how do they work over time to draw youth more deeply into STEM? These questions are considered in four contexts: a diverse under-resourced neighborhood in Portland Oregon, the city of Pittsburgh, a set of island communities, and underserved areas of rural Maine. Research approaches include: 1) design studies of STEM learning pathways that connect learners' experiences across place and time; 2) longitudinal analysis of the development and support of 5th-8th graders' STEM interests; 3) analysis of place-based community learning centered on energy conservation, and 4) analysis of the connections between community STEM Guides and STEM engagement of 10-18 year olds in rural communities. We will discuss results that characterize the "people, places, and pursuits" of particular ecosystems and link these systems and youth interest to the activation of young people's STEM learning.

Designing for Activation: Building STEM Learning Pathways for Pittsburgh's Youth Kevin Crowley, University of Pittsburgh, crowleyk@pitt.edu Christian D. Schunn, University of Pittsburgh Meghan E. Bathgate, University of Pittsburgh Stacy Kehoe, University of Pittsburgh Marti Louw, University of Pittsburgh Peter S. Wardrip, University of Pittsburgh

SYNERGIES: Understanding and Connecting STEM Learning Ecosystems in the Community Lynn D. Dierking, Oregon State University, dierkinl@science.oregonstate.edu Nancy Staus, Oregon State University John H. Falk, Oregon State University Faik Karatsa, Oregon State University Jay Breslow, Oregon State University Tricia Harding, Oregon State University William R. Penuel, University of Colorado

#### Connecting Community with STEM

Ruth Kermish-Allen, The Island Institute, RAllen@islandinstitute.org Karen Peterman, Karen Peterman Consulting

STEM Guides: Building Coherent Infrastructure in Rural Communities Janice R. Mokros, Maine Mathematics and Science Alliance Sue Allen, Maine Mathematics and Science Alliance Tom Keller, Maine Mathematics and Science Alliance

#### **Strand 7: Pre-service Science Teacher Education**

*Discourse and Argumentation* 4:15pm-5:45pm, Brigade **Presider:** Saouma B. Boujaoude, American University in Beirut

#### Assessing Quality of Pre-service Physics Teachers' Written Arguments

Mehmet Aydeniz, The University of Tennessee, maydeniz@utk.edu Deniz Gurcay, Hacettepe University, Turkey Ebru Balta, Hacettepe University, Turkey

**ABSTRACT:** The purpose of this study was to assess the quality of scientific arguments developed by pre-service physics teachers. The participants were 171 pre-service physics teachers recruited from two universities: 86 from University A and 85 from University B. Participants were prompted to develop a written argument to either support or challenge government's decision to invest in nuclear power plants. Data consist of written arguments developed by the participants. Data were analyzed using the CERR framework. While almost all of the participants provided an evidence to justify their claims, they failed to effectively coordinate between evidence, claim and theory to develop an argument. Students struggled the most in the warrant/reasoning category of the CERR framework. In our discussion we problematize college science teaching and advocate for integration of instructional strategies such as argumentation that can effectively engage student in construction, evaluation and justification of knowledge.

Using Discourse to Teach Science as Argument: The Successes & Strengths of Preservice Elementary Teachers Elisebeth Boyer, Ohio State University, boyer.386@osu.edu

Carla Zembal-Saul, Penn State University

**ABSTRACT:** This study explores the initial practices of three preservice elementary teachers who were prepared to teach science in a way that is grounded in research and coupled with effective modeling. It documents how the participants adopted a Teaching Science as Argument Framework (TSAF) using discourse and discussion. There is no straight path to effective science teaching so each candidate made sense of the teacher and learning practices in their own way following their own personal trajectories of understanding and implementation. The three approaches to adoption
detailed in this study are 1) Detached Discursive Approach, 2) Connected Approach with a Focus on Student Thinking, and 3) the TSAF Approach. The first approach represents a preservice teacher who used the language of science but who did not connect the use of discourse to its supporting learning theories. The second approach represents someone who demonstrated a commitment to probing student misconceptions and preconceived notions but who struggled with classroom implementation. The third approach exemplifies a preservice teacher who did not seem to struggle with pedagogical implementation and who demonstrated a strong commitment to the central tenets of the TSAF.

### Pre-service Teacher Discourses: Vernacular Versus Formal Science Learning Discourses Mohammad A. Basir, Oakland University, basir@oakland.edu

**ABSTRACT:** The interpretation of how students learn science is shifting toward an apprenticeship model in which students learn science through engagement in science practices, however pre-service teachers enter teacher education programs with prior science experiences viewing learning science as rote learning of a body of knowledge. Building on the discursive theories of language, it is aimed to investigate the gap between pre-service teacher vernacular discourses and formal science learning discourses. The investigation is based on the comparison study of vernacular versus formal Science Learning Discourses (SLeDs). The NRC (2007) document was analyzed as a representative of formal SLeDs and weekly writing essays that 72 pre-service teachers wrote over a course of semester were analyzed as representative of vernacular SLeDs. The results of the study suggest that the pre-service teacher discourses are placed more emphasis on learning science as content rather than practices. Furthermore, the results suggest that overemphasis on science teaching versus science learning discourses may prevent teachers to position science learning discourses as a stand-alone academic subject. It is conjectured that providing opportunities for pre-service teachers to explicitly compare and contrast science teaching and science learning discourses may increase the effectiveness of science methods courses.

### Prospective Science Teachers' Inferences about Student Understanding

Vicente A. Talanquer, University of Arizona, vicente@u.arizona.edu

Debra J. Tomanek, University of Arizona

Molly Bolger, University of Arizona

**ABSTRACT:** The goal of this study was to analyze how prospective science teachers approached the analysis of student written responses to formative assessment probes. We sought to identify what elements of students' written work were noticed, what types of inferences of student understanding were built, and what these different elements told us about levels of sophistication in assessing student understanding. Our results are based on the analysis of the written evaluations of student work made by 32 prospective teachers enrolled in a science education course at our institution. The results of this study suggest that analyzing teachers' assessment of student understanding requires paying attention to both domaingeneral and domain-specific aspects of teacher reasoning. Domain-general factors characterize how a teacher frames the assessment of student understanding. Domain-specific aspects characterize how the teacher attends to relevant disciplinary ideas. They refer to the productivity, quality, scope, and accuracy of teachers' interpretations. Study participants focused more on the description than on the interpretation of student thinking, paying more attention to issues of correctness than trying to make sense of student ideas. Prospective teachers' abilities to generate appropriate inferences were influenced by teachers' content knowledge and pedagogical content knowledge.

### Strand 7: Pre-service Science Teacher Education

Preservice Science Teachers' Pedagogical Content Knowldege

4:15pm-5:45pm, King's Garden 4 **Presider:** Sevgi Aydin, Yuzuncu Yil University

# *Towards an Evidence-Based Model of Pre-service Science Teachers' Pedagogical Content Knowledge* Vanessa Kind, School of Education Durham University, UK, vanessa.kind@durham.ac.uk

**ABSTRACT:** In this qualitative, exploratory study 235 pre-service science teachers (PSTs) responded to three unstructured vignettes, each representing a classroom situation featuring a misconception in chemistry, physics or biology. The paper summary shows data relating to the chemistry vignette. Further data will be presented at conference. Responses were analysed for evidence of pedagogical content knowledge (PCK) and subject matter knowledge (SMK) components.

Data revealed strong evidence for knowledge of instructional strategies and representations and some understanding of students' difficulties. Evidence relating to a didactic orientation towards teaching was also apparent. SMK analysis showed PSTs held content knowledge of differing quality. Analysis of connections between SMK and PCK showed that weak PCK emerged where content knowledge was incorrect / partially correct. A model based on this evidence is proposed, which offers scope for representing PCK as developing, rather than static. The model offers a means of representing high quality PCK that impacts positively on students' learning, and accepts SMK as an influencing factor. The component Orientations towards teaching is excluded as evidence about the nature of this component proved inconclusive. The paper offers insights that contribute to our understanding of PCK as a theoretical construct and its value in guiding high quality teacher education.

# *Nature and Development of Interplay among Pre-service Teachers' PCK Components in Mentoring-enriched PCK-based Practicum*

Betul Demirdogen, Bulent Ecevit University, betuldemirdogen@gmail.com

Sevgi Aydin, Yuzuncu Yil University

Fatma Nur Akin, Middle East Technical University

Esen Uzuntiryaki, Middle East Technical University

**ABSTRACT:** This study examined how the interaction among pre-service teachers' (PTs) pedagogical content knowledge (PCK) components developed throughout the educative mentoring-enriched PCK-based practicum course. Case study provided comprehensive information related to PTs' development of interaction among PCK components in practicum course. Participants were three pre-service chemistry teachers, information rich cases and volunteers (two females and one male), enrolled to the mentoring enriched PCK based practicum course. Data were collected through the use of content representation (CoRe) and semi-structured interviews. Deductive analysis by the use of existing categories and constant-comparative methods for identification of common patterns were used to analyze data. PTs' PCK was relatively undeveloped in terms of both components and interplay among them at the beginning, especially in terms of curriculum and assessment. However, instructional strategy and learner were central in all PTs' PCK maps at the beginning. PTs moved from fragmented PCK to a more integrated and coherent one through the end of the semester. Although all three PTs enriched all PCK components and interplay among those, the development in the interplay among the PCK components was idiosyncratic. Implications for science teacher education and research are discussed.

Mentor Influence in the Development of a Pre-service Biology Teacher's Pedagogical Content Knowledge Ellen Barnett, University Of Missouri, eb4nd@mail.missouri.edu

Carol Robertson, Fulton High School

Patricia Friedrichsen, University of Missouri

**ABSTRACT:** Mentors play a critical role in preservice teachers' (PSTs') development. When PSTs work with supportive mentors who teach in reform-minded ways, it opens up the possibility that the PST will teach similarly. However, mentoring is typically focused on general pedagogical knowledge (PK), not science specific pedagogical content knowledge (PCK), and there is little research on specific mentoring strategies to support beginning science teachers. The purpose of this study was to describe how an exemplary secondary biology teacher supported the PCK development of a PST. Interviews, audiotaped planning sessions, observations and participant journals were analyzed using open and axial coding. The mentor used various strategies to help the mentee develop his PCK for DNA and protein synthesis. She helped develop his knowledge of students' understanding, instructional strategies, curriculum and assessment of this topic by purposefully drawing his attention to student difficulties, helping him implement appropriate representations and activities, encouraging reference to objectives and supporting his full participation in assessment. These findings fill a gap in the literature by suggesting how mentors might provide the subject specific mentoring recommended for beginning science teachers. Implications include the need for professional development for mentors.

## How Does Pre-Service Teacher PCK Knowledge Relate to Enactment? A Case Study of Teaching Chemical Equilibrium

Marissa S. Rollnick, Wits University, marissa.rollnick@wits.ac.za Elizabeth Mavhunga, University of Witwaterrand

**ABSTRACT:** Between science content and methodology lies the teacher's pedagogical content knowledge (PCK) which refers to their ability to transform content knowledge for teaching. This study investigated the extent to which PCK knowledge can be translated into practice. The study uses a theoretical framework for topic specific PCK, which has five components, Learners' Prior Knowledge, Curricular Saliency, What makes topic easy or difficult to understand, Representations and Conceptual Teaching Strategies. The pre-service teachers were part of an intervention designed to give direct instruction on the five components of PCK in chemical equilibrium. At the end of the intervention each preservice teacher produced a major assignment demonstrating their ability to capture and portray their PCK. Subsequently each teacher taught four lessons on chemical equilibrium during their practice teaching. The lessons were scored using a specially designed rubric. Scores from the rubric and further qualitative analysis shows that the teachers implemented much of what they learnt during the intervention. However the conceptual teaching strategies component remained a challenge for both of them.

### Strand 10: Curriculum, Evaluation, and Assessment

*Exploring Assessment Validation* 4:15pm-5:45pm, Sterlings 2 & 3 **Presider:** Meghan R. Federer, The Ohio State University

Students' Reasoning Processes on a Multiple-True-False Concept Inventory: Exploring the Importance of Substantive Validity Evidence in Test Validation

Elizabeth P. Beggrow, The Ohio State University, beggrow.7@osu.edu

Meghan R. Federer, The Ohio State University

Ross H. Nehm, Stony Brook University

Minsu Ha, Stony Brook University

**ABSTRACT:** Evidence-based educational reform has been an impetus behind much educational research, including the development and use of concept inventories (CIs) (Libarkin 2008). CIs vary not just in their content focus, but also in terms of their format, quality, evidential support for validity, and alignment with cognitive processes (NRC 2012). Research demonstrating the limitations of existing CIs motivated the development of a new type of CI--the multiple true-false (MTF) ACORNS (Authors 2013). This instrument combines the unique strengths of both multiple-choice and constructed response assessment formats and consequently overcomes many limitations of previously developed CIs. However, how students reason about such novel MTF formats has yet to be examined. Here we use cognitive interviews to investigate students' reasoning processes when confronted with MTF instrument items. Cognitive interviews revealed: (1) the majority of participants interpreted the MTF assessment formats as intended and (2) the cognitive models detected by the MTF instrument aligned with those detected by the cognitive interviews. However, students' interpretations of mixed model statements were surprising. Overall, this study provides examples of why examining student reasoning processes is important for ensuring that CI response patterns validly reflect cognitive processes.

### Using Think Alouds to Explore the Cognitive Validity of Ordered Multiple Choice Items Jan Christoph Hadenfeldt, Leibniz Institute (IPN) Kiel, hadenfeldt@ipn.uni-kiel.de Knut Neumann, Leibniz (IPN) Kiel

**ABSTRACT:** Ordered Multiple Choice (OMC) items have been proposed as a means to diagnose students' state of understanding along a possible learning progression. In OMC items, each of the possible response options corresponds to a specific level of an underlying learning progression. But in order to provide more diagnostic information than typical multiple choice items, students' response behavior must reflect their understanding of the construct measured. That is, evidence about the cognitive validity of OMC items is required. In this paper, we present the findings from a think-aloud-study with N = 11 students from grade 6 (n = 3), grade 9 (n = 4), and grade 12 (n = 4). We investigated the cognitive validity of 8 OMC items selected from a pool of 39 OMC items utilized in an earlier study with N = 1364 students. The items covered four aspects of students' understanding of the matter concept (2 items per dimension) as defined by the underlying learning progression. Our findings suggest that 9th and 12th grade students' choice of response option was

mainly based on cognitive processes related to their understanding of the matter concept, whereas 6th graders' choices were mainly based on other, non-matter-related cognitive processes.

Literature Review of Characteristics of Science Item Contexts Ting Wang, University of Washington, tingwang@uw.edu Min Li, University of Washington

**ABSTRACT:** Item context is defined as the item component of supplemental information that precedes or follows a question in an item, such as a description of a lab setup, a natural phenomenon, or a practical problem (Authors, 2012). The effect of real world contexts on student test performance has been the subject of considerable research for a long time (Little & Jones, 2010; Reisslein, Moreno, & Ozogul, 2010). Despite their widespread use in the science testing, the utility and practice of the contexts used in items have been called into question by some researchers (Boaler, 1993; Wiliam, 1997). This review paper is guided by the two research questions: (1) what are the critical characteristics of item contexts? And (2) what are the impacts of those characteristics on student performance on science assessment? We summarize, integrate and compare the research of three difference strands (i.e., contexts used in science teaching, assessment, and item generation) in terms of how they define item contexts and research findings of context characteristics in relation to student performance.

### Strand 10: Curriculum, Evaluation, and Assessment

### *Related-Paper Set – Implementing Genetics Curricula Informed by the NRC Framework* 4:15pm-5:45pm, Smithfield

**ABSTRACT:** This related paper set describes findings from our first-year implementation of innovative technologybased genetics materials and assessments, informed by the National Research Council (NRC) Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas (2012). The purpose of this session is to describe different aspects of our findings in relationship to implementation of genetics curriculum, including elementary and middle grade student learning of genetics, impact of our mentor-mentee model to unit implementation, comparisons between student learning in traditional versus innovative classrooms, and integration of content and practices and impact on student learning.

Learning about Genetics in Elementary Classrooms: A Comparison Study Dante Cisterna, Michigan State University, cisterna@msu.edu Michelle Williams, Michigan State University Amal Ibourk, Michigan State University Amy Frahm, Michigan State University

Developing a Mentor Model for Cross-grade Genetics Curricula Tamara J. Heck, Michigan State University, heckt@msu.edu Joi Merritt, Arizona State University Elizabeth X de los Santos, Michigan State University

Cross-grade Findings: Patterns of Students' Knowledge Integration Related to Genetics Joi Merritt, Arizona State University, jmerritt@msu.edu Amanda Opperman, Michigan State University Dante Cisterna, Michigan State University Amal Ibourk, Michigan State University Michelle Williams, Michigan State University

*Tools to Support Scientific Modeling and Explanations* Yves Beauvineau, Culturally Responsive Science Pedagogies Angela H. DeBarger, SRI International Erika D. Tate, Bluknowledge LLC Amanda Opperman, Michigan State University Joi Merritt, Arizona State University

### Strand 11: Cultural, Social, and Gender Issues

*Symposium – Impact: Mini-Symposium as a Powerful Synergy for Young Black Scholars in Science Education* 

4:15pm-5:45pm, Benedum **Presider:** Malcolm B. Butler, University of Central Florida **Discussants:** Mary Atwater, The University of Georgia Salina T. Gray, Stanford University Geraldine L. Cochran, Florida International University Ashraf A. Shady, Queens College, CUNY Vanashri J. Nargund-Joshi, New Jersey City University Tamecia R. Jones, Purdue University Line A. Saint-Hilaire, Queens College, CUNY Gillian U. Bayne, Lehman College CUNY

Natasha Johnson, University of Georgia

**ABSTRACT:** This NARST symposium will allow seven of the participants and the two co-Principal investigators of an NSF-funded project to share their experiences in the first phase of an NSF-funded project. It will allow the science education research community to hear the voices and read the ideas of a young group of science education scholars (doctoral students, beginning faculty members and coordinators) whose findings from their micro-research studies will add to the science education research community understandings of learning activities related to teaching and learning and enhance our understanding of conducting successful programs to assist young scholars to enhance their research development.

### Strand 12: Educational Technology

*Technology in Science Teacher Professional Development* 4:15pm-5:45pm, King's Garden 5 **Presider:** Jennifer Weible, Penn State University

A Personalized Digital Badging Space for Science Teacher Professional Development Christopher Gamrat, Penn State University, cwg118@psu.edu Heather Toomey Zimmerman, Penn State University

**ABSTRACT:** To provide a customized science learning opportunities, a digital badge system was designed to support science teachers as they personalized and implemented their own professional development plan. Teacher Learning Journeys (TLJ) creates a personalized professional development (PD) approach that relies on digital badging to provide an experience that supports the daily practices of today's science classrooms. This study analyzed the role of personalization in teachers' PD using a case study analysis (n=8 teachers) Researchers used thematic analysis on teachers' goal statements and activity reflection logs completed by each participant. Findings include emergent customization common among participants in regard to teaching practice, technology use, student support, and specific of their local setting/region. Using TLJ, the eight teachers found themselves in a decision-making role when selecting their learning goals and identifying personally applicable PD. Decision making provided the teachers with the ability to explore science content at the desired depth and breadth to provide PD customized for their expertise and experience. Implications of this study support support future design of just-in-time education technology, teacher professional development, and informal personalized learning.

Speak, Chat, or Write: Differential Interactions in Science Teacher Professional Development with Distance Education Tools

Lauren Madden, The College of New Jersey, maddenl@tcnj.edu M. Gail Jones, North Carolina State University Gina Childers, North Carolina State University

**ABSTRACT:** New tools for teaching science education with distance education afford students with a variety of modes of communication. This study examined students' interactions during a science education distance education course. All interactions that took place with Elluminate Chat, Elluminate Voice, and Moodle learning platforms were recorded, transcribed, and analyzed. Interactions were coded according to the target of the interaction, the content, and the type of interaction (comment or question). Results showed that the different modes of interaction provided distinctly different opportunities for communication and served different purposes with the instruction. Furthermore, there were individual differences in students' behaviors across the communication modes. The implications of the study for distance education of science teachers is discussed.

### *Exploring the TPACK of Taiwanese Secondary School Science Teachers Using a New Contextualized TPACK Model*

Syh-Jong Jang, Chung-Yuan Christian University, jang@cycu.edu.tw

**ABSTRACT:** Existing research on TPACK shows little about in-service secondary school science teachers' TPACK through a quantitative approach. The purposes of this study were to explore TPACK of secondary school science teachers using a new contextualized TPACK model. Associations between in-service teachers' TPACK and other factors were also examined. There were 1292 science teachers from secondary schools for factor analysis. An independent samples t-test was conducted when there were two groups (i.e., gender) to be compared for TPACK. ANOVA was conducted when there were more than two groups (i.e., science teaching experience) compared for TPACK. The results indicated that secondary science teachers' TPACK was statistically significant according to gender and teaching experience. With the consideration of other TPACK sub-components, male science teachers rated their TK significantly higher than did female teachers. Experienced science teachers tended to rate their CK and PCKCx significantly higher than did novice science teachers. However, science teachers with less teaching experience tended to rate their TK and TPCKCx significantly higher than did novice science teachers with more teaching experience. The study makes contributions science to teachers' difference on TPACK by gender and teaching experience. The research implications of this study are provided along with suggestions.

Teachers' Perceptions of Their Use of Technologies for Self-directed Learning and the Obstacles They Present Jennifer Jocz, National Institute of Education, Singapore, jennifer.tan@nie.edu.sg

Wenli Chen, National Institute of Education, Singapore

Doris Choy, National Institute of Education, Singapore

Horn Mun Cheah, National Institute of Education, Singapore

Seng Chee Tan, National Institute of Education, Nanyang Technological University

**ABSTRACT:** Research shows that self-directed learning (SDL) can improve students' academic ability and satisfaction. Information communications technology (ICT) can support SDL; however, obstacles may hinder their use. Since using ICT to support SDL is advantageous, it is imperative to investigate how these obstacles affect teachers' ICT use. This study aimed to investigate primary (grades 1-6), secondary (grades 7-10), and junior college (JC) (grades 11-12) teachers' perceptions of their ICT use for SDL and the challenges they face. A random sample of 1000 was taken from a survey completed by a large number of teachers of all disciplines in Singapore. Results indicate that student obstacles and teaching obstacles were related to lower use of ICT for SDL among primary and secondary teachers, respectively; however, direction by school leaders was associated with an increased use of ICT for SDL at all levels. Additionally, more sufficient access to technologies was associated with a decreased use of ICT for SDL among primary and secondary teachers. These findings suggest obstacles affect teachers' use of ICT for SDL differently depending on level. Since school leaders play an important role in providing direction, they should be aware of these differences to specifically address the needs of their teachers.

Strand 13: History, Philosophy, and Sociology of Science Subject Matter: Biology 4:15pm-5:45pm, King's Garden 2 Presider: Jason R. Wiles, Syracuse University

### *The Challenges of Scientific Knowledge on Socioscientific Decision Making* Mijung Kim, University of Victoria, mjkim@uvic.ca

**ABSTRACT:** To understand the complexity of students' decision making skills and its pedagogical implementation, much research has emphasized students' critical thinking and the relationship between scientific knowledge and decision making on socioscientific environmental issues. Research studies on STSE or SSI education have attempted to find out the relationships among scientific content knowledge, reasoning, and decision making on complex issues. Their findings have shown different claims in terms of the role of scientific knowledge in one's reasoning and decision making. Some researchers found there was a significant coalition between content knowledge and reasoning and others found that the influence of scientific knowledge was minimal on people's reasoning. Among the previous researches on SSI decision making, the role of scientific knowledge in one's decision making is still perplexing. This study continues the question of scientific knowledge in SSI decision making by looking into how adults (5th year university students) without science background make decisions on their local socioscientific and environmental issues. The findings suggest there were distrust and uncertainty around scientific knowledge in the public which increases the complexity of one's decision making and challenges science teaching in terms of the roles of scientific knowledge on social environmental issues.

### Utilizing a Phenomenology of Place in Science Education to Enable Youth in Democratic Reforms Rachel Luther, University of Southern Mississippi Gulf Coast, rachel.luther@gmail.com

**ABSTRACT:** Despite the increase in marine science curriculum in secondary schools in the United States, marine science is not generally required curricula and has been largely deemphasized or ignored in relation to earth science, biology, chemistry and physics. Even when incorporated into these subject areas, it represents a token approach to oceanography, and yet an understanding of the Marine Sciences is vitally essential to living as a competent US consumer. In this essay I argue for the integration of marine science more fully in secondary science through a phenomenology of place as a way to serve ocean literacy if that means people who engage can actively participate in making more informed choices and advocate for affected parties and the ocean. A marine science curricula in science education can reveal and protect the eroticism of the ocean through a phenomenology of place by allowing students to become aware of how intimately connected they are to the ocean. As educators use phenomenology of place in their science curriculum, they can help students develop and foster erotic relationships with the ocean, so that students are able to consider the value of the ocean in order to establish respect and conservation measures.

## The Effect of Learner-directed Scientific Investigations on Students' Questionings and their Nature of Science Views

Banu Avsar-Erumit, Indiana University, bavsar@indiana.edu

Khadija Fouad, Indiana University

Valarie Akerson, Indiana University

**ABSTRACT:** In teaching science, student-directed inquiry approach has become popular where students ask their own questions and seek ways to answer them. Therefore, the ability of asking questions that can be answered through investigations is one of the most important components of scientific inquiry. However, students do not always ask investigable and task-specific questions. This study focused on how going outside and investigating the density of earthworms in their natural setting was effective for improving students' subsequent questions about these creatures. Another focus was to examine how this affected students' nature of science views. The study was conducted in two sections of a scientific inquiry class in a Midwestern University. Data sources included the VNOS-B, student worksheet that included student-generated questions the post-reflection sheet. The questions written by the students were compiled and sorted as investigable and non-investigable, and specific and general. The questions were categorized by using the typology created by Chin (2002). The results showed that students asked more specific questions for the second investigation as compared to the first investigation. Students asked less descriptive questions and more cause-and-effect

and pattern-seeking questions after the first investigation. VNOS-B results showed a visible difference on some students' understandings of scientific creativity.

## *Exploring Relationships between Students' Conceptions of the Nature of Science, Evolution, and Global Climate Change*

Benjamin Carter, Syracuse University, elijahcarter@gmail.com

Jason R. Wiles, Syracuse University

**ABSTRACT:** It is overwhelmingly acknowledged by the scientific community that evolution and global climate change (GCC) are undeniably supported by physical evidence. And yet, both topics remain politically contentious in the United States. Students' conceptions of the nature of science (NOS) may be key factors in determining attitudes towards evolution and GCC. With this hypothesis in mind, we asked: Do changes in NOS understanding correlate with changes in attitudes towards evolution or GCC? Are correlations similar for evolution and GCC? What demographic factors influence these correlations? Are other factors from the literature important? We administered surveys to a large sample of students in a mixed-majors biology course at a medium-sized, private university in the northeastern US. Students were surveyed both at the beginning and end of the course. The surveys included previously validated tools to measure acceptance of evolution and NOS conceptions, questions on GCC opinions from national polls, and items related to demographic factors thought to influence acceptance of evolution or GCC. Correlation tests and ANOVA/ANCOVA were used to look for significant relationships and interaction effects in the data. The data support the hypothesis that NOS conceptions correlate with positive attitudes towards evolution and GCC.

### Wednesday, April 2, 2014

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

### **International Committee Sponsored Session**

Symposium – Linking Global Science Education Associations with NARST

8:30am-10:00am, King's Garden 3

Presider: Hsiao-Lin Tuan, NARST International Coordinator

### Discussants:

Lynn Bryan, National Association for Research in Science Teaching

Manuela Welzel-Breuer, European Science Education Research Association

Chi-Jui Lien, East-Asian Association for Science Education

Marissa Rollnick, Southern African Association for Research in Mathematics, Science & Technology Education Debbie Corrigan, The Australian Science Education Research Association

**ABSTRACT:** Global science education community has been developed quickly during the past twenty years. Many regions started to establish their own science education associations due to their history, culture, educational policy or education system, and students & teachers difference. These difference made each regional science education association developed different research interests or research agenda. In the present, there are five regional science education Association (ESERA), Australia Science Education Association (ASERA), East Asia Science Education Association (ESERA), Australia Science Education for Research in Mathematics, Science and Technology Association (SAARMSTE). This symposium will invite president or representative from the above associations to present the history of their associations, the features of their associations, the major policy influence their research agenda, and the current research dominated in their associations. Through their presentation, NARST members can find the future trend in the international science education research.

### Strand 1: Science Learning, Understanding and Conceptual Change

### Related-Paper Set – Methodological Tradeoffs in Learning Progressions Research

8:30am-10:00am, King's Garden 1

Presider: Ann E. Rivet, Columbia University

Discussant: James Pellegrino, University of Illinois at Chicago

**ABSTRACT:** The Framework for Science Education and the Next Generation Science Standards endorse a developmental perspective on learning, drawing on current research around learning progressions (LPs) in science. While holding much promise, there are thorny issues regarding the ways in which LPs are developed and studied, and the kinds of evidence and methodologies needed to empirically test these conjectural models of learning. Investigating these issues is an essential part of evaluating the viability and usefulness of LPs to inform standards, curriculum, and assessment. In this related paper set, we bring together a diverse group of experienced researchers to discuss their various approaches to LP research, along with the trade-offs, pitfalls, and limitations inherent to each approach. Some key challenges broached in this presentation and discussion will include: How do different approaches balance in-depth understanding of a small portion with a broad view of an entire progression? How do they account for different related dimensions to a progression? How do they account for the multiple roles demanded of assessment items? What is the role of rich description versus statistical generalizability with respect to progression validation? Rich group discussion will follow the presentations, with extensive audience participation encouraged.

Introduction and Discussion to Methodological Tradeoffs in Learning Progression Research Ann E. Rivet, Columbia University, rivet@tc.columbia.edu Ravit Golan Duncan, Rutgers University *Towards the Development of a Particle Model of Matter Progression* Joi Merritt, Arizona State University, jmerritt@msu.edu

Developing Validity Arguments for Learning Progression-Based Written Assessments Karen Draney, University of California, Berkeley, kdraney@berkeley.edu Jennifer Doherty, Michigan State University Charles W. Anderson, Michigan State University

*The Potential of Modern Statistical Approaches in Validating Learning Progressions* Knut Neumann, Leibniz Institute (IPN) Kiel

The Affordances and Challenges of Comparative Longitudinal Designs in Matter LP Research Carol Smith, University of Massachusetts

#### Strand 3: Science Teaching--Primary School (Grades preK-6): Characteristics and Strategies *Discourse Opportunities in Elementary Science Classrooms* 8:30am-10:00am, Fort Pitt

**Presider:** Mary E. Hobbs, Center for STEM Education

Teacher's Role of Questioning: Approaches That Promote Student Cognitive Complexities and Dialogical Interaction in Argumentation

Ying-Chih Chen, University of Minnesota, chen2719@umn.edu

Brian M. Hand, University of Iowa

**ABSTRACT:** The purpose of this study was to investigate the various questioning roles elementary teachers adopt to scaffold dialogical interaction, students' cognitive responses, and the use of evidence for constructing and critiquing ideas for argumentative practices over time. The multiple-case study was designed as a follow-up study after a four-year professional development program that emphasized an argument-based inquiry approach. Data sources included 22 videos focusing on whole-class discussion from three early elementary teachers' classes. This study conceptualized four critical roles of teacher questioning---dispenser, moderator, coach, and participant---in light of the ownership of ideas and activities. The findings revealed three salient changes: (a) teachers' m-RTOP scores increased as they persistently implemented an argument-based inquiry approach, (b) in argumentative environments, teachers use multiple roles in establishing patterns of questioning, framing classroom interaction, and scaffolding students' cognitive thinking, and (c) as teachers' patterns of questioning changed, the frequency of students' talk increased and the dialogical interaction between students and teachers became more evidence-based and connected. This study suggests that an essential component of teacher professional development should include the study of teacher roles of questioning for establishing argumentative discourse and that this development should consist of ongoing training with systematic support.

Argumentation Opportunities and Support Using Traditional and Electronic Science Notebooks: A Comparative Study

Courtney Behrle, North Carolina State University, cdbehrle@ncsu.edu

Angela Shelton, North Carolina State University

Lindsay Patterson, North Carolina State University

Eric N. Wiebe, North Carolina State University

**ABSTRACT:** Science notebooks are an established vehicle for supporting science writing in the elementary classroom, with a new generation of electronic science notebooks having the potential for enhanced support for inquiry and argumentation through writing. This mixed-methods comparative multi-case study looked at four fourth grade teachers each implementing both traditional and electronic science notebooks. Research team members used a classroom observation protocol designed for elementary classrooms engaged in inquiry investigations to record and classify teacher and students actions, while a rubric was used to score student argumentation. Overall, the electronic science notebook

instructional environment seemed to encourage a consistency of implementation across classrooms, more opportunities to engage in written argumentation, and a diverse range of quality of these responses. The traditional classrooms showed a greater diversity of instructional strategies. In the traditional classrooms, there were fewer opportunities for students to engage in written argumentation, but some teachers provided opportunities to engage in whole class argumentative discussion. This study demonstrated the utility of an electronic science notebook to provide support for elementary grades argumentation around inquiry investigations and the importance of professional development to effectively utilize them.

### Utilizing A Claims, Evidence, Reasoning Framework to Integrate K-5 Instruction Ingrid S. Weiland, University of Louisville, ingrid.weiland@louisville.edu

Kristin Cook, Bellarmine University

**ABSTRACT:** This study contributes to the knowledge base on integrated instruction by examining a Claims, Evidence, Reasoning (CER) framework to teach the Common Core Standards for ELA and Mathematics, the NGSS, and the state social studies standards. Most elementary school teachers are charged with teaching all content areas to their students and often state that lack of time is the largest barrier to teaching full science programs (Appleton, 2007; Authors, 2011). One way to alleviate time constraints is to integrate instruction. This action research study examined the following questions: a) In what ways can the Claims, Evidence, Reasoning framework support integrated instruction? and b) How do Bloom teachers perceive using the framework? Pre, mid, and post interviews were conducted, as well as analysis of artifact. Findings suggest that CER can provide a clear structure and focus for school-wide integrated instruction. Bloom teachers found that the CER framework was challenging to learn and implement, but that it fostered deeper discussions about content with their students.

*Examination of the Initial Practices of Three Fifth Grade Science Teachers Engaging Students in Critique* Matthew J. Benus, Indiana University Northwest, mbenus@indiana.edu Brian M. Hand, University of Iowa

**ABSTRACT:** The purpose of this study was to examine the initial practices three fifth grade science teachers used to engaging their students in critique. Each of the classrooms used argument-based inquiry (ABI). This study examines the dialogue in a science classroom to better understand how experienced teachers and beginning students of ABI engage in fundamental forms of critique around science topics. Few if any studies have examined the ways in which teachers develop critique to support student learning in the science classroom. The teachers in this study used the Science Writing Heuristic (SWH) approach to ABI with students who had no previous experience engagement in ABI. Full implementation of ABI demands that meaning from individuals, the learning community, and outside resources be constructed and critiqued. The results showed that the teachers principally engaged in emerging forms of critique that helped the students to construct knowledge in science. The findings also have informed theory and practice about science argumentation, the important beginning steps and environment that fosters a discourse space which includes critique and the teacher's ability to help students notice and examine students' own thinking around their own ideas and the ideas of others.

Strand 4: Science Teaching--Middle and High School (Grades 5-12): Characteristics and Strategies Investigating the Influence of Initiative, Self Efficacy and Emotions on Teaching 8:30am-10:00am, Duquesne Presider: Isha DeCoito, York University

# Novice Science Teachers' Recognition and Use of Resources to Learn from Practice David Stroupe, Michigan State University, dstroupe@msu.edu

**ABSTRACT:** I examined how five novice teachers navigated tensions about the role resources – physical and intellectual commodities in a context – should play to support ambitious practice or more conservative forms of science teaching. Using a situative framework, this study traced beginning teacher learning over the course of one school year. Analysis of discourse during classroom interactions, artifacts created by participants and students, and interviews with participants afforded insights into how and why novices learned from practice using resources. While all participants in this study recognized and used the same resources to shape instruction, including students' science ideas, how the novices

used resources over time provided them with different kinds of opportunities to learn from practice. This study provided insight into how teachers who readily enacted ambitious practice learned differently than teachers who frequently engaged in more conservative forms of science teaching.

### The Effects of Emotive Reasoning on Secondary School Students' Ability to Evaluate Evidence on Socioscientific Issues

Wardell Anthony Powell, University of South Florida, wardellpowell@aol.com

#### Dana L. Zeidler, University of South Florida

**ABSTRACT:** It is well documented in the literature that secondary school students do have difficulties evaluating evidence when asked to make informed decisions on contentious issues. The purpose of this investigation was to design, implement, and evaluate a semester long integrated SSI high school biology curriculum that was aimed at understanding the relationships between students' emotive reasoning on their abilities to evaluate evidence. Forty-five 9th grade students from two Biology Honors classes at a Tampa Bay Area High School participated in this study. Qualitative analysis of the data revealed that students used factors such as newly gained knowledge, experience on the topic, scientific knowledge, and emotions to evaluate evidence. Quantitative analysis of the data revealed statistically significant difference in students' interests in the general topic between the treatment and comparison groups (H (1) 4.2684, p = 0.039). Results also showed statistically significant difference in how students from the treatment and comparison groups rated their ability to evaluate evidence (H (1) 4.8835, p = 0.028). 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.

## Personal Self-Efficacy and Outcome Expectancy for Teaching Inquiry: Professional Development that Transforms Teachers' Instruction

Christine R. Lotter, University of South Carolina, lotter@mailbox.sc.edu

Stephen L. Thompson, University of South Carolina

Tammiee Dickenson, University of South Carolina

### Whitney Smiley, University of South Carolina

**ABSTRACT:** In order to effectively teach science as inquiry, teachers must have confidence in their own abilities to implement this approach. In this study, we used the Teaching Science as Inquiry (TSI; Smolleck & Yoder, 2008) instrument to examine changes in middle school science teachers' self-efficacy to teach science as inquiry after participating in a year-long professional development program. The TSI instrument was administered three times to 80 teacher participants: before and after a two-week summer institute and at the end of the academic year. Changes between time points of TSI administration were examined for personal self-efficacy and outcome expectation across five essential features of classroom inquiry. The results indicate the effectiveness of the professional development program at increasing participants' personal self-efficacy and outcome expectancy around inquiry-based science instruction. The professional development program which engaged teachers in inquiry instruction as students (content instruction) and provided time for teachers to enact inquiry with enrichment students and receive immediate feedback during group reflection sessions helped to increase the teachers' efficacy with inquiry instruction.

## The Impact of the Medium of Instruction on Students' Learning in Physics at the Senior Secondary Level in Hong Kong

Dennis Fung, The University of Hong Kong, clfung@hku.hk

Valerie Yip, The University of Hong Kong

**ABSTRACT:** This research is a 3-year longitudinal study which investigated the impact of the medium of instruction (Chinese and English) on the students' learning in science in Hong Kong secondary schools. The data collection included conceptual tests, examination results and in-depth interviews with teachers and students. The significance of the present study is to provide a better understand of the benefits in using Chinese as medium of instruction (CMI). While the traditional and conventional approaches of research concerning MOI were mainly based on quantitative results, for example students' examination scores, passing rates of schools in different subjects related to MOI, the focus of the present study put the emphasis on the qualitative results. Indeed, the results reflected the impact of MOI on the student learning motivation, quality of performance in group projects, individual and group presentation of works and

contribution of idea in discussion forum. The paper also argued that the mixed mode of instruction was more popular for Hong Kong secondary school students.

### Strand 4: Science Teaching--Middle and High School (Grades 5-12): Characteristics and Strategies *Pedagogical Content Knowledge for Middle/Secondary Teachers* 8:30am-10:00am, King's Garden 5

**Presider:** David F. Treagust, Curtin University

Influence of Physics Teachers' CK, PCK and PK on Students Outcome Eva Cauet, University Dusiburg-Essen, eva.cauet@uni-due.de Sven Liepertz, RWTH Aachen University Sophie Kirschner, University Giessen 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 including content knowledge (CK), pedagogical content knowledge (PCK) and pedagogical knowledge (PK), to student achievement has not been empirically elaborated in physics educational research. The presented study places special emphasis on the investigation if direct statistical connections between teachers' professional knowledge and student achievement exist. For this purpose, a sample of 20 teachers and their classes (537 students) were tested. Teachers CK, PCK and PK are measured by separate paper and pencil tests. Student performance is measured by a multiple choice test in a multi-matrix pre-post design and students' cognitive abilities are surveyed by the Cognitive Abilities Test (CAT). The main result of this study is a correlation between teachers' PK and students' performance in the post test and the corresponding missing correlation for teachers' CK and PCK which challenges our understanding of PCK. The impact of PK, although it is small, even remains when students' pre knowledge and cognitive abilities are controlled in a regression analysis.

Cross-Cultural Validation of a Survey Measure of Biology Teachers' PCK for Teaching Photosynthesis Soonhye Park, University of Iowa, soonhye-park@uiowa.edu

Jee Kyung Suh, University of Iowa

Kyungwoon Seo, University of Iowa

Aeran Choi, Ewha Womans University

**ABSTRACT:** This study examined the cross-cultural validity of the PCK Survey that has been developed and validated in the context of US (Author, 2013). The PCK Survey is a paper-pencil test consisting of 30 True-False and open-ended items to assess a teacher's PCK for teaching photosynthesis at grades 9 and 10. The PCK Survey was administered to about 2,000 science teachers in a State of US and the test scores collected from completed surveys indicated an acceptable level of reliability (i.e., Cronbach's  $\alpha = 0.836$ ). Both content-related evidence and construct-related evidence indicated that the survey items assess the full range of the sub-knowledge components of PCK. The same survey was translated into Korean and administered to 100 Korean teachers. To examine the cross-cultural comparability of the survey, reliability, item difficulty and item discrimination were compared between two groups of teachers. The reliability of the items were high enough (alpha > 0.7), which suggests that the survey items would yield similarly reliable PCK test scores in the two countries. Point-biserial values suggested that the survey items produced test scores that acceptably reflect differences in teachers' PCK in both countries. Limitations of the study and directions for future research are also discussed.

### Strand 6: Science Learning in Informal Contexts Novel Technologies to Engage the Public with Science 8:30am-10:00am, Rivers Presider: Catherine Eberbach, Rutgers University

## The Interaction of Scientific Literacy and Position towards Animal Experimentation in Authentic Online Public Discussions

Ayelet Baram-Tsabari, Technion, ayelet@technion.ac.il Esther Laslo, Technion

**ABSTRACT:** This study focuses on the expressions of scientific literacy in reader comments, using an online public discourse on the issue of animal experimentation (AE) in a leading Israeli news site as a data source. The analytical framework is based on the school science curriculum, in order to describe how the aims of school science are echoed in an authentic public engagement with science setting. For this reason, the formal Israeli biology curriculum's definition of scientific literacy is adopted, encompassing scientific knowledge, perceptions of the nature of science (NOS), scientific skills and structuring an informed position. Quota sampling of ten articles and 684 comments were selected. Comments supporting AE used more and higher level scientific concepts, while NOS and inquiry contents showed no significant quantitative differences between the two clear positions. However contrasting positions were supported by different NOS contents, when investigation contents backed supporting arguments while opposing AE showed more social contents. The findings challenged the traditional deficit model which views public disagreement with scientists as a consequence of ignorance, while scientific literacy found as not necessarily correlated with pro-science positions.

Utilizing Gigapixel Image Technology for Science Communication and Observational Skills Development in a Museum Setting

Camellia Sanford, Rockman et al, camellia@rockman.com

Marti Louw, University of Pittsburgh

**ABSTRACT:** Increasingly, scientists have been tasked with sharing their research with public audiences as a way of supporting the development of a scientifically literate populace. Yet studies have shown that many scientists struggle with the process of communicating their research activities and content to non-expert, public audiences (AAAS, 2008). Content novices also experience difficulty observing and interpreting scientific phenomena without additional scaffolding and mediation (Phillips & Rowe, 2009). The current study addresses this two-tiered problem by combining the strength of museums to mediate content for the public with the power of technology to translate scientists' ideas. Visitors' thoughts and conversations at a natural history museum exhibition using high-resolution Gigapixel image technology are examined for evidence of observational behaviors and content interpretation.

Science on Windows: Shifting the Context of Informal Learning Using Touchfoil Technologies with Environmental Data

Amie Patchen, Boston College, Amie.Patchen@bc.edu Shakib Ahmed, Boston College Connor Rooney, Waltham High School Lin Zhang, Boston College Jae Jin Han, Boston College Dennis Debay, Manhattanville College James Haley, Boston College Mike Barnett, Boston College

**ABSTRACT:** In recent years there has been an increase in science exhibits occurring in public spaces such as parks, train stations, ballgames, or other locations where large numbers of people pass by. Termed Public Science (Arcand & Watzke, 2011), these outreach projects attempt to engage individuals who are not actively pursuing a science experience (Crettaz von Roten, 2011; Norsted, 2010). To date, many of these projects have taken the form of static displays similar to what one might find in a museum setting. Our work seeks to build on these previous projects by adding an interactive and technological-rich element to the experience. Central to our work is the sharing of air quality data that is being collected at home by citizens and analyzed by youth and university-based students. The purpose of our work is to engage people in

thinking about data related to local science topics through an interactive display around the topic of air quality in public spaces such as bookstores, libraries, and restaurants. To this end, citizens are hosting air quality data eggs (sensors) and the data analysis and results from the air are being posted to a touch foil (an interactive thin film that transforms windows into iPads).

Mobile Devices Supporting Families' Scientific Talk Related to Trees Heather Toomey Zimmerman, Penn State University, heather@psu.edu Susan M. Land, Pennsylvania State University Lucy R. McClain, Penn State University Michael R. Mohney, Penn State University Gi Woong Choi, Penn State University Fariha H. Salman, Penn State University

**ABSTRACT:** This research examines the Tree Investigators project to support science learning with mobile devices during family public programs in an arboretum. Using a case study methodology, researchers analyzed video records of ten families (25 people) using mobile technologies with naturalists to understand how mobile devices supported science talk related to tree biodiversity. The conceptual framework brings together research on technological supports for science learning and research on strategies that encourage families to engage in conversations that support observation and explanation practices. Findings suggested that families engaged in high levels of perceptual talk (describing and identifying) while using mobile computers. Commonly, families articulated scientific observations when supported by prompts, visuals, and scaffolds delivered by the mobile computers. Families struggled to make explanations about the biological importance of what they saw in relation to ecological principles; however, families made connections to their everyday life within explanations they developed at the arboretum. Our research showed the importance of mobile supports that provided on-demand, localized sense- making resources for explanation building while limiting observational complexity.

#### **Strand 6: Science Learning in Informal Contexts** *Supporting Pre-service Teachers: The Role of Informal Science Environments* 8:30am-10:00am, Sterlings 1

Presider: John R. Ruppert, Rutgers University

Studying Contributions of a Place-based Museum Teaching Residency on Urban Science Teacher Candidates Maritza Macdonald, American Museum of Natural History, mmacdonald@amnh.org Preeti Gupta, American Museum of Natural History

Alix R. Cotumaccio, American Museum of Natural History

**ABSTRACT:** The context for this paper a natural history museum in engaged in the preparation of new science teachers. The program brings together two disparate fields of education practice and research, informal science education and research on Urban Teacher Residency pre-service models to create a Masters level program that prepares science teachers to teach in high needs schools. This is the second year of a three-year study with the following research questions: 1) how does a museum place-based residency develop science teaching identities and skills in teacher candidates; 2) are there strands of learning in museums transferable to in-school teaching; 3) what strategies, experiences, or assignments enrich the experiences of science teacher candidates, beyond the learning of content or how to plan museum investigations; and 4) how might contributions or insights from this work support urban science teacher preparation online and onsite ? This paper describes findings from the summer residency component as related to these questions. This study advances our understanding of how the context of informal science institutions can be critical contributors in supporting teacher preparation.

### *Summer Learning: Teacher and Student Co-Development*

Sumi Hagiwara, Montclair State University, hagiwaras@mail.montclair.edu

**ABSTRACT:** The bandwagon approach to STEM education raises concern over the universal approach to STEM without critical inquiry into program efficacy and the ways in which STEM education can impact how students learn and

teachers teach. In an effort to develop a STEM program that aims to prepare a 21st century learner, the following study examines an four-week, inclusive summer STEM program, the Science and Math Collaborative (SMC), for children in grades 1-6 that partners with a graduate science and math methods course. The SMC positions graduate elementary preservice students and children as partners in teaching and learning inquiry based science, technology, engineering and mathematics (STEM). Thematic and project-based learning guides the camp curriculum, and instructional practices are guided by inquiry to develop students critical thinking and problem solving skills through a STEM them. Graduate students participate in the camp as they explore how children learn science and mathematics, develop interactive science and math learning centers for the campers, and position themselves as co-learners with the students. Qualitative data will be presented as a case study of the SMC program based on outcomes from the instructors, campers and graduate students.

### Strand 7: Pre-service Science Teacher Education *Cultural Approaches to Preservice Teacher Education* 8:30am-10:00am, Smithfield

Preparation for Culturally Responsive Science Teaching: With and Without Field Placement in a High-Need School

Kevin Goff, College of William & Mary, kdgoff@email.wm.edu

Juanita Jo Matkins, College of William & Mary

Jacqueline Theresa Mcdonnough, Virginia Commonwealth University

**ABSTRACT:** Science teacher education programs have embraced the mission of preparing students for teaching in high-need schools, yet providing field placements in authentic high-need contexts is often difficult. This paper describes year 4 results in one university's ongoing effort to cultivate proficiency in culturally responsive science teaching via alternative strategies. For four years it has used supplemental field experiences in high-need schools, coupled with exercises to provoke cultural self-awareness and cross-cultural consciousness, to compensate for its lack of access to high-need settings for student teaching. In response to each iteration of data analysis, this program has expanded and revised these strategies, and in the past two years its preservice teachers have exhibited signs of real improvement over previous cohorts in the richness and realism of their ideas about teaching in high-need schools, and their readiness to adapt instruction and classroom process to student culture while engaging them in inquiry and "explore-before-explain" pedagogy. However, one participant revealed an unexpected turn: Although she alone could be placed in a high-need school for student teaching, she failed to exhibit the same growth as her classmates, arguably due to a mismatch between teacher culture at that school and the university program.

Using a Structured Observation Protocol to Awaken Cultural Responsiveness in STEM Preservice Teachers Julie C. Brown, University of Florida, brownjc@ufl.edu

Kent J. Crippen, University of Florida

**ABSTRACT:** We present the results of a study representing a first iteration in the design process of the Growing Awareness Inventory (GAIn), a structured observation protocol for building the awareness of preservice teachers (PSTs) for resources in mathematics and science classrooms that can be used for culturally responsive pedagogy (CRP). The GAIn is designed to develop awareness of: how students use language in classrooms; relationships between teacher questioning patterns and student participation; messages conveyed by the classroom environment; and ways to incorporate students' interests into lesson plans. The methodology took the form of a multiple case study design with fourteen mathematics PSTs as one case and five science PSTs as the other case. The participant's response to the GAIn and lesson plans served as data sources. Findings reveal that the GAIn scaffolded PSTs' awareness of their students, their own attitudes, and several elements of CRP. However, there were key areas of CRP that were neither explored with the GAIn nor identified by the participants as lesson plan resources. Consistent with design-based research, outcomes include a design framework for revision of the GAIn and a theory of action that situates it within a STEM teacher education course that includes a field placement.

Forging Identities as Urban or High Needs Teachers: Voices of Entry Year Science and Mathematics Preservice Teachers

Roger Pomplas, University of Cincinnati, pomplar1@mail.uc.edu Helen M. Meyer, University of Cincinnati

**ABSTRACT:** This research is part of a longitudinal study focused on the development of pre-service teachers' identities as teachers for urban and other high needs environments. This paper discusses the identities of three group of pre-service teachers: traditional undergraduates, recent graduates (3 years for BS) and career changers, at their entry into a secondary STEM teacher licensing program. Qualitative interviews were conducted with all participants and analyzed to look for identity status at entry based on science content background, teaching/learning background, experience in urban or other high needs community and images of being a teacher. Initial findings indicate that most participants were confident about their science content however career changers most strongly identified as being scientists. Undergraduates had stronger stated teacher identities , and few participants had an urban or high needs identity. This research contributes to the science education community as it begins to articulate how experiences prior to licensing shape teachers' identities.

### **Strand 7: Pre-service Science Teacher Education**

### Educating Highly-qualified Science Teachers: Challenges and Perspectives

8:30am-10:00am, Birmingham

**ABSTRACT:** Understanding what makes a highly-qualified science teacher requires careful research on teacher education programs. Existing research pertaining to secondary science preservice teachers (PSTs) is limited in the areas of: (a) master of subject matter knowledge; (b) evolving teacher self-efficacy; and (c) inquiry-based enacted curricular practices. We studied each issue over the course of an intensive, 14-month, graduate teacher certification program for practicing scientists and recent science graduates. First, we asked if there was a relationship between amount of content area undergraduate coursework and performance (GPA in core content courses) and found an expected, yet preliminary, connection between higher undergraduate GPA and fewer retained science misconceptions. Second, we surveyed preand post-program teaching self-efficacy beliefs in classroom management, instructional practices and student engagement; our analysis indicates a positive change over time on two of the three scales, and a reasonably large effect size. Finally, classroom inquiry-based instructional factors showed improvement as PSTs gained experience through student teaching and in their first year teaching science (fall and spring comparisons) over each 5-month period. We also present qualitative sub-studies of teacher self-efficacy and use of classroom discourse by PSTs as typical examples of issues faced by new teachers.

Professional Practice: Pre- to Post-Teacher Education Program Elizabeth B. Lewis, University of Nebraska-Lincoln, elewis3@unl.edu Aaron Musson, University of Nebraska-Lincoln Jia Lu, University of Nebraska-Lincoln

Observing Inquiry-based Instructional Practices Elizabeth B. Lewis, University of Nebraska-Lincoln, elewis3@unl.edu Aaron Musson, University of Nebraska-Lincoln Jia Lu, University of Nebraska-Lincoln

Following Teachers' Self-efficacy and Instructional Practices Aaron A. Musson, University of Nebraska-Lincoln, aaronmusson@gmail.com Elizabeth B. Lewis, University of Nebraska-Lincoln

Discourse in the Classroom: A Comparison of Two Preservice Teachers Jia Lu, University of Nebraska-Lincoln, lvjia1027@gmail.com Elizabeth B. Lewis, University of Nebraska-Lincoln

### Strand 7: Pre-service Science Teacher Education *Preservice Teachers' Conceptions and Enactment of Inquiry* 8:30am-10:00am, Brigade **Presider:** Jessica J. Thompson, University of Washington

### Facilitating Primary Pre-Service Teachers Understandings of Inquiry-Based Learning

Gillian Kidman, Oueensland University of Technology, g.kidman@qut.edu.au

Stephen Keast, Monash University

Rebecca Cooper, Monash University

**ABSTRACT:** This paper explores the understandings of primary school pre-service science teachers as they undertake an inquiry-based experience. A learning experience was created for the pre-service teachers that would enable them to participate in modeled inquiry experiences during their training, using curriculum and materials that were aligned with the requirements of the Australian Curriculum: Science, and had a focus on teacher content knowledge (knowledge of science subject matter (e.g. biology, physics), and knowledge of classroom inquiry). It was found that there existed inter-domain knowledge between 1) the science concept knowledge and the ICT knowledge, 2) the inquiry-based instruction and the ICT knowledge, and 3) the inquiry-based instruction knowledge as well as knowledge relating to inquiry-based pedagogy. Pre-service teachers made a conceptual shift of using ICT's for learning science rather than for doing science. Through the integration of science content (biology and physics) with ICT's (Slowmation Animation) via inquiry-based instruction, it was possible to model the learning of pre-service teachers by investigating inter-domain knowledge.

# Preservice Teachers' Conceptions and Enactments of Inquiry-Based Learning after a Physics Inquiry Course Paige K. Evans, University of Houston, pevans@uh.edu

**ABSTRACT:** Research suggests that preservice teachers who have experienced inquiry are more likely to practice the inquiry method in their own classrooms (McDermott, 2007; Windschitl, 2002). The purpose of this qualitative study was to examine the effects of a Physics By Inquiry course on preservice teachers' conceptions of inquiry-based learning and subsequent enactment of inquiry-based learning during their student teaching semester. Data for this qualitative research was collected via personal research journal, surveys, video tape recordings, field notes, participants' observation notes of inquiry classes, student assignments, observations, and interviews. Results show that participants who experienced the Physics by Inquiry Course had a greater understanding of inquiry-based learning and how to employ it in the classroom. Additionally, participants unearthed roadblocks encountered when altering mandated curriculum in their schools. Results highlight the potential benefit of including courses whereby content is taught as inquiry in pre-service science teacher preparation programs.

### Examining Pre-service teachers' Conceptions of Inquiry using Teaching Scenarios Frackson Mumba, University of Virginia, mumbafrackson@gmail.com

### Vivien M. Chabalengula, University of Virginia

**ABSTRACT:** This study examined pre-service science teachers' conceptions of inquiry using teaching scenarios. A sample comprised 12 pre-service high school science teachers at our national university. We adopted and administered an open-ended survey designed by Kang et al (2008). The survey consisted of ten short teaching scenarios representative of inquiry activities or teaching, in which teachers were asked to classify ten teaching scenarios as representative of inquiry activities or teaching, and provide reasons for their choice. Additionally, teachers were asked to write a narrative describing an ideal inquiry science lesson, describing the roles of the teacher and students, as well as lesson objectives, classroom environment and assessment. The results show that the pre-service science teachers had a narrow conception of inquiry that emphasizes the collection of facts. Based on the inquiry lesson narratives, the teachers conceived inquiry as putting more priority on involving learners in gathering evidence (EV at 83%) and engaging students in questions (EQ at 75%) that can make them explain the evidence (EX at 75%). Unfortunately, the pre-service teachers didn't strongly believe that learners should go further to communicate and justify explanations (EC at 42%) and connect their explanations to scientific knowledge (EK at 8%).

Developing a Paper-Pencil-Test to Evaluate Pre-service Science Teachers' Competencies in Scientific Inquiry Focused on Biology

Sabrina Mathesius, Freie Universität Berlin, sabrina.mathesius@fu-berlin.de Stefan Hartmann, Humboldt- Universität zu Berlin Annette Upmeier zu Belzen, Humboldt-Universität zu Berlin

Dirk Krüger, Freie Universität Berlin

**ABSTRACT:** Teachers' professional knowledge is a decisive aspect of successful teaching. It has to be a key part of pre-service teacher education so the teachers are required to acquire knowledge of these standards in order to teach, analyze and support their students successfully. Currently there is a lack of research regarding modeling and measuring these competencies in teacher education (Kuhn & Zlatkin-Troitschanskaia, 2011). To address this challenge this project focuses on the content knowledge in scientific inquiry. The developed paper-pencil-test with seven sub-dimensions for the two dimensions "conducting investigation" and "using models" includes 113 items in biology, chemistry and physics and answered in a pilot-study by 430 pre-service science teachers compared to 132 science students. Supporting the hypothesis the data (analyzed by using latent regression) showed a significant effect on the predictor (pre-service science teacher vs. science student) on the latent ability for the biology. Furthermore it is planned to investigate this scientific inquiry skills in a large-scale assessment in two countries and four universities to have look at the development during pre-science teacher education within selected inquiry methods in focus. Item examples, item fit and model fit as well as student abilities will be presented at the conference.

### Strand 10: Curriculum, Evaluation, and Assessment

## Applying Rasch Modeling to Assessment Development and Validation 8:30am-10:00am, Benedum

*Measuring the Conceptual Development of Student Understanding of Newton's Third Law* Irene Neumann, Ruhr-Universität Bochum, neumann@physik.rub.de Joanna Peters, Ruhr-Universität Bochum

Ling L. Liang, La Salle University

Gavin W. Fulmer, National Institute of Education (Singapore)

**ABSTRACT:** Understanding the concept of force is a central goal of physics education. For instance, the re-cently introduced Framework for K-12 Science Education in the U.S. emphasizes "Motion and Stability: Forces and Interactions" (NRC, 2012, 103) as one of four core ideas of the physical sciences. One important aspect of the force concept is understanding interacting forces, that is Newton's Third Law (N3). Building on previous research on a learning progression by Alonzo and Steedle (2009), who described the development of understanding forces and motion but did not include interacting forces, this paper introduces a multiple-choice instrument to measure stu-dent understanding of N3. The instrument was based on a learning progression differentiating six levels of understanding N3 by employing so-called Ordered-Multiple-Choice items (Briggs et al., 2006). We administered the test to 314 college students; 103 students were physics majors, the others had varying science and humanities majors. Beside the instrument showing good psy-chometric quality, we also found that the response options' difficulties increase with increasing LP level as assigned. Therefore, our instrument provides a LP-based measure of students' un-derstanding of Newton's Third Law.

Validation of a Genomics and Bioinformatics Assessment: Analysis of Student Responses to a Criterion Referenced Multiple-Choice Measurement Tool

Chad Campbell, The Ohio State University, campbell.742@osu.edu

Ross H. Nehm, Stony Brook University

Brian Morton, Barnard College, Columbia University

**ABSTRACT:** Analysis of genomics and bioinformatics education (GBE) research revealed that few published articles adhered to the quality control benchmarks for assessment set forth by the educational research community. Recent work, however, has been done to rectify this predicament and established a genomics and bioinformatics (GB) content domain and developed and administered a multiple-choice assessment tool from which appropriate validity and reliability evidence was gathered. This work continues that effort by: (1) modifying or replacing problematic items; (2)

administering the modified assessment to students at large State and small Liberal Arts institutions; (3) analyzing resultant data using Rasch methodologies; and (4) interviewing students at various levels of GB content exposure. The results indicated that: (1) the assessment was capable of discriminating between students at various levels of GB content exposure; (2) most of the items had appropriate performance and fit statistics; (3) student interviews indicated that for some items students were not using the appropriate substantive processes when providing correct responses. The implications of these results for the assessment's construct validity are discussed.

## Constructing an Innovative Measure Assessing Interdisciplinary Understanding (IU)—Using Rasch Model to Assess Students' Energy Understanding

Shannon Sung, University of Georgia, ilaria.huang@gmail.com

### Ji Shen, University of Miami

**ABSTRACT:** Awareness for interdisciplinary understanding (IU) in science is raising; however, standard science assessments are typically designed to assess disciplinary understanding. To fill in the gap, we attempted to construct assessments of students' IU in science using the topic of energy. Two research questions were explored: (a) how measures were constructed to assess undergraduate students' understanding of energy from an interdisciplinary perspective? and (b) how psychometric analyses of an instrument measuring interdisciplinary understanding of energy could be interpreted? The crosscutting concept of energy is a natural fit for demonstrating IU because it is foundational to many science disciplines. The innovative interdisciplinary instrument incorporating energy concepts was administered to three science classes, one interdisciplinary and two discipline-based (N = 490). The Rasch model in the item response theory (IRT) was applied to test model-data-fit and to obtain item difficulty and students' IUS levels. Findings suggest that the Rasch model fits the observed dataset well and the construct validity (item separation index) is high. It indicates that the items in the current instrument will result in similar difficulty orders when administered to other groups, but not sensitive enough to distinguish high and low performers. The revisions of items, applications, and implications are discussed.

### Assessing the Efficacy of the MUM as a Valid Measure for Understanding of Macroevolution for Undergraduate Non-Science Majors

William L. Romine, Missouri Valley College, romine.william@gmail.com

### Emily M. Walter, Western Michigan University

**ABSTRACT:** Efficacy of the Measure of Understanding of Macroevolution (MUM) as a measurement tool has been a point of contention among scholars needing a valid measure of this construct. We explore the structure and construct validity of the MUM using Rasch and multi-parameter item response theory (IRT) methodologies around an intervention designed to improve understanding and acceptance of macroevolutionary principles in non-science majors. 290 students completed the pre-test, and 270 completed the post-test. Rasch and multi-parameter IRT perspectives are utilized to quantify item- and test-level characteristics, and validity findings using these methodologies are compared. Contrary to previous work, we find that the MUM as a whole provides a valid, reliable, unidimensional scale for measuring knowledge of macroevolution in introductory non-science majors, and that its psychometric behavior does not exhibit large changes across time. While we find that all items provide productive measurement information, several depart substantially from ideal behavior, warranting a collective effort to improve these items. Suggestions for improving the measurement characteristics of the MUM at the item and test levels are put forward and discussed.

### Strand 10: Curriculum, Evaluation, and Assessment

### **Building Learning Progressions for Scientific Argumentation**

### 8:30am-10:00am, King's Garden 2

### Presider: J. Bryan Henderson

**ABSTRACT:** Learning progressions are empirically grounded and testable hypotheses about how students' facility with core scientific concepts and explanations become more sophisticated over time with appropriate instruction (Corcoran et al., 2009; National Research Council, 2007). The growth of learning progressions research in science education has given rise to a new series of studies exploring how student argumentation develops in science classrooms. Some of these studies focus on classroom data obtained in situ to map how students' facility with argumentation can grow in its sophistication. Other studies begin with a hypothesized progress map based on an unpacking of the logical structure of argumentation in

combination with findings from prior research on student argumentation. While the approaches differ in their starting points, they share a common thread in the need to iteratively refine their hypotheses with empirical data. This symposium brings together researchers utilizing one or both of these techniques in order to compare and contrast their approaches to the challenging task of empirically operationalizing the products and processes of student argumentation.

Assessing Middle School Students' Abilities to Critique Scientific Arguments Amanda M. Knight, Boston College, knightam@bc.edu Cecilia Brito Alves, Lawrence Hall of Science Matthew A. Cannady, Lawrence Hall of Science Katherine L. Mcneill, Boston College

P. David Pearson, University of California, Berkeley

# Argumentation at the Start of School: Characterizing the Entry Points into a Learning Progression for Argumentation

Amelia Wenk Gotwals, Michigan State University, gotwals@msu.edu Hayat Hokayem, Texas Christian University Tanya Wright, Michigan State University

*IRT Analysis of Items Probing a Unidimensional Learning Progression for Argumentation of Increasingly Complex Structure* 

J. Bryan Henderson, Stanford University, jbryanh@stanford.edu Jonathan Francis Osborne, School of Education, Stanford University Anna MacPherson, Stanford University Evan Szu, Stanford Michelle Friend, Stanford University Andrew Wild, Stanford University

An Epistemology-Based Learning Progression for Scientific Argumentation Embedded in System of Practice Brian J. Reiser, Northwestern University Leema K. Berland, University of Texas, Austin Lisa Kenyon, Wright State University Christina V. Schwarz, Michigan State University

#### Strand 10: Curriculum, Evaluation, and Assessment

*Teachers' Assessment Practices* 8:30am-10:00am, Heinz **Presider:** Bill Zoellick, Schoodic Education & Research Center Institute

#### *Emergence of Teacher Sub-communities and Focus on Science Subject Knowledge*

Bill Zoellick, Schoodic Education & Research Center Institute, bill@sercinstitute.org

**ABSTRACT:** Science teachers, like people in any other profession, are intentional about whom they turn to for information and advice. One important consideration is whether a colleague is likely to understand one's point of view and be trustworthy. That consideration leads teachers to turn to other teachers who are in their same school or district or who teach at the same grade level. But teachers also consider the kind of information that another teacher will be able to provide. This consideration can lead them to reach beyond their local contacts to seek other kinds of expertise. When they do reach beyond local contacts, what kind of expertise do they seek? When teachers are implementing a new program, the expertise is often related to the mechanics of program implementation. But seeking information that helps a teacher deepen his or her content knowledge is also important to supporting ambitious teaching. This study uses social network analysis to examine the structure of teacher communities within a large, rural science education improvement initiative. It

provides evidence that, given the opportunity to do so, teachers will organize themselves into a community focused on improving their science content knowledge.

Portraits of Assessment: The Intended and Enacted Assessments in Middle School Science Classrooms Matthew Kloser, University of Notre Dame, mkloser@nd.edu Hilda Borko, Stanford University Jose Felipe Martinez, University Of California, LA Brian Stecher, RAND Corporation Rebecca Luskin, University Of California, LA ABSTRACT: Recent research suggests that quality assessment is key to effective teaching practice and student

Abs reaction research suggests that quarty assessment is key to effective teaching practice and student learning. However, few studies have shown how assessment practice plays out across entire units in real classrooms. This study seeks to create windows into practice by providing in-situ, comparative qualitative portraits of more and less effective science assessment practices using data from the Quality Assessment in Science Notebook. Specifically, this study compares middle school science teachers' intended and enacted assessment practices and how dimensions of these practices more or less correlate with student achievement. As part of a larger quantitative study, science teachers collected ten days worth of instructional and assessment artifacts as well as student work and reflections on their practice. These artifacts were rated independently on nine dimensions of effective assessment practice drawn from the literature. Two pairs of Notebooks - one rated high and one rated low - were qualitatively compared and showed that despite their overall rating, Notebooks were most similar on dimensions of goal setting and aligning goals and were most different on dimensions of cognitive complexity, the presence of scientific justification on the assessments, and the amount and quality of feedback provided by teachers.

Beginning Science Teachers' Views and Enactments of Formative Assessment in South Africa and the U.S. Melissa A. Jurkiewicz, University Of Georgia, maj32381@uga.edu

Rene Toerien, University of Cape Town

**ABSTRACT:** There is a global movement towards formative assessment. However, conflicting assessment policies exist both on the global and local level. South Africa and the U.S. represent countries whose teachers must navigate conflicting policies, which simultaneously push for summative and formative assessments. Furthermore, in both nations, new teachers, who are particularly prone to attrition, comprise a large portion of the teaching workforce and need to enter teaching as well prepared as possible. There are limited studies examining beginning science teachers' views and enactments of formative assessment. The purpose of this study is to better understand how the global push for two separate, and often conflicting, assessment purposes influences beginning science teachers' enactments and views of formative assessment. In this qualitative, cross-national study, we conducted semi-structured interviews, observed classrooms, and collected lesson artifacts. Our participants included sixteen beginning secondary chemistry teachers from South Africa and the U.S. We identified the strategies the beginning teachers used while implementing formative assessment as summative assessment, formative assessment in relation to instruction, and formative assessment and the role of students. This study has several implications for science teacher preparation programs.

Strand 13: History, Philosophy, and Sociology of Science NOS & K-12
8:30am-10:00am, Commonwealth 2
Presider: J. Steve Oliver, The University of Georgia

*Reorganizing a Curricular Unit about Energy around a Historical Narrative* Shulamit Kapon, University of Haifa, shulamit.kapon@edu.haifa.ac.il Irit Aharon, University of Haifa

**ABSTRACT:** Researchers and policy makers agree that science education should expose students not only to the conceptual and methodological aspects of science but also to its epistemic and social aspects. The question of how to explicitly teach the nature of science has attracted considerable research interest in the last few decades. We present a

teaching experiment of 12 academic hours in two junior high classrooms (N=56 students) in which mandatory content and activities related to the instruction of energy according to the Israeli national curriculum were reorganized and integrated into an evolving discussion about a popular scientific text written by Albert Einstein on the equivalence of mass and energy (Einstein, 1946). It is suggested that carefully selected popular scientific texts written by prominent scientists can be used to frame and reorganize the instruction of the formal scientific content by creating an instructional synergy between the conceptual, epistemic and social aspects of science.

Baby Steps: Elementary Teachers' First Attempts to Learn about and Teach the NOS Bridget K. Mulvey, Kent State University, bmulvey@kent.edu

Lucy J. Kulbago, Kent State University

Randy L. Bell, Oregon State University

Jennifer Chiu, University Of Virginia

**ABSTRACT:** This study explored nature of science (NOS) views, instruction, and future instructional plans of all 61 PreK-5 teachers who completed a semester-long inquiry and explicit, process skills-based NOS professional development (PD). Data sources were: pre/post-instruction modified VNOS-C questionnaire responses; five video-recorded lessons; and future NOS plans. Pre/post-instruction NOS views were categorized into three levels. Participants' instruction was examined for explicit NOS comments. Those instances and future plans were examined for trends within and across grade levels. Pre-instruction participants largely expressed naive NOS views and had not taught NOS explicitly. Post-instruction, all participants increased their NOS views. Almost all succeeded in explicitly teaching NOS; many taught it regularly. All who taught NOS planned to teach NOS post-PD and many planned to increase NOS reflection. NOS instruction was more frequent in the second of two semesters of PD courses, possibly attributable to the addition of a beginner's level NOS instructional model. Teachers focused future plans on: (1) continued NOS instruction; (2) incorporating/expanding visual NOS aids; (3) clarifying what an experiment is/is not; and (4) integrating many non-experimental inquiries and discussing the many ways science can be done.

Impact of a Large Scale Professional Development Project on Middle School Students' Views of NOS Yalcin Yalaki, Hacettepe University, yyalaki@hacettepe.edu.tr Nihal Dogan, Abant Izzet Baysal University Serhat Irez, Marmara University Gultekin Cakmakci, Hacettepe University Gaye Bala, Hacettepe University Ferah Ozer, Abant Izzet Baysal University Gulcan Gunsever, Abant Izzet Baysal University **ABSTRACT:** Science teachers hold a key role in improving students' views of NOS. In-service teacher education

**Abs reactive** teacher is note a key for in improving students views of NOS. In-service teacher education programs (professional development) are important venues for helping teachers improve their understanding of NOS and their skills on how to teach it. Designing and implementing effective professional development programs is a challenge. This study is about a large-scale teacher professional development project aimed at improving science teachers' views of NOS and their skills to teach NOS. The 30 month project started in January of 2013. First phase of the project was completed during the spring 2013 semester. 22 middle school science teachers (teaching grades 5 through 8) with more than 3000 students from a small city in central Turkey volunteered to participate in the project. Of the 22 participating teachers, nine of them used at least three or more different activities in a classroom in the course of the semester and also applied VNOS-D instrument as pre and posttests to their students. Results showed that, with few exceptions, students' views of NOS did not improve significantly in the first four months of the project. These results show the difficulty of impacting classroom learning in large-scale interventions.

First Assessment of High School Students' Understandings about Scientific Inquiry in Chile, South America Claudia Vergara, University Alberto Hurtado, claudia.vergara12@gmail.com Norman G. Lederman, Illinois Institute of Technology Judith S. Lederman, Illinois Institute of Technology Juan Jimenez, Illinois Institute of Technology Hernan Cofre, Pontificia Universidad Católica de Valparaíso **ABSTRACT:** Scientific inquiry (SI) is a fundamental part of scientific literacy. Most of the published works addressing students understanding of SI show that students do not understand scientific inquiry. This study investigated high school students' understanding of scientific inquiry in Chile. A sample of 221 students was drawn from 9 classes in two private schools, each from different districts in Santiago, Chile. We used mostly an quantitative method approach looking for a pre-determined view of inquiry elicited by a new open-ended questionnaire: Views about of Scientific inquiry. The aspects with the highest percentage of naïve views were: there is no single scientific method; inquiry procedures can influence results; and, explanations are developed from a combination of data and what is already known. Students in highest grades (11th and 12th) showed more informed view of some inquiry aspects. The implications for teaching nature of scientific inquiry in school and in science teacher education are also discussed.

### **Strand 14: Environmental Education**

*Symposium – Sociocultural Research in Environmental Education: Approaches, Methods, and Contexts* 8:30am-10:00am, Sterlings 2 & 3

#### **Presenters:**

Erica N. Blatt, College of Staten Island, CUNY Deborah J. Tippins, University of Georgia Heather Rudolph, University of Georgia Stacey Britton, University of Mississippi Patricia Patrick, Texas Tech University Olivia Aguilar, Denison University

**ABSTRACT:** In this symposium, the presenters share how each has utilized a sociocultural approach in her work in the field of environmental education research, the context in which this approach has been used, and the research methods employed in conducting this research. During this session, the researchers will briefly describe the history of sociocultural learning theory and provide an overview of the types of research questions explored using this theory in the field of environmental education related to culture, history, identity, emotion, place, social interactions, etc. As we discuss our own research utilizing methods including interviews, participant observation, Photovoice, story-telling, theater, etc. in places as diverse as urban classrooms in the US and villages in Kenya, this symposium is intended to expand audience participants' ideas regarding possible applications for sociocultural research. 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 sociocultural research.

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

**Presidential Sponsored Session** 

Supporting the Implementaiton of the Next Generation Science Standards through Research 10:15am-11:45am, Commonwealth 2

### **Presiders:**

Bryan Lynn, Purdue University Sharon Lynch, George Washington University

#### **Presenters:**

Presenters:

Members of the NARST-NGSS Position Papers Writing Teams Members of the Committee on Developing Assessment of Science Proficiency in K-12

### Strand 1: Science Learning, Understanding and Conceptual Change

# *Related Paper Set – Learning Progressions that Connect Science Practices, Crosscutting Concepts, and Disciplinary Core Ideas*

10:15am-11:45am, King's Garden 2

Presider: Charles W. Anderson, Michigan State University

**ABSTRACT:** The papers in this session report learning progressions research focusing on (a) a key NGSS crosscutting concept: Energy and matter: flows, cycles, and conservation, (b) science practices associated with inquiry and explanation, and (c) disciplinary core ideas about processes that transform carbon-based materials at multiple scales, including cellular and organismal metabolism, ecosystem energetics and carbon cycling, carbon sequestration, and combustion of fossil fuels. We describe learning progression assessments and frameworks for students using the strategy of tracing matter and energy for both inquiry and application practices at multiple scales in space and time. Paper 1 focuses on the development of principle-based reasoning as a fundamental strategy for explaining common carbon-transforming processes. Paper 2 focuses on relationships between students' inquiry and explanation practices in interviews and in classroom contexts. Paper 3 focuses on the development of students' inquiry practices in large-scale contexts: global carbon cycling and climate change. Paper 4 focuses on students' reasoning about the sustainability of agricultural production systems, including how those systems rely on and affect carbon and nitrogen cycling.

Learning trajectories of Principle-Oriented Level 3 and Fact-Oriented Level 3 Science Learners Hannah K. Miller, Michigan State University, hkm@msu.edu Allison Freed, Michigan State University Jenny M. Dauer, University of Nebraska Jennifer Doherty, Michigan State University Charles W. Anderson, Michigan State University

Relationships between Students' Inquiry and Application Practices for Carbon-Transforming Processes Allison Freed, Michigan State University, allisonlwebster@gmail.com Jenny M. Dauer, University of Nebraska Hannah K. Miller, Michigan State University Charles W. Anderson, Michigan State University

Connecting Macroscopic-scale and Large-scale Inquiry Practices Jenny M. Dauer, University of Nebraska, dauerjen@msu.edu Allison Freed, Michigan State University Charles W. Anderson, Michigan State University

Students' Ideas about Sustainability for Agricultural Production Systems Elizabeth X. de los Santos, Michigan State University Joshua M. Rosenberg, Michigan State University

Strand 2: Science Learning: Contexts, Characteristics and Interactions Instructional Practices in Chemistry and Physics 10:15am-11:45am, King's Garden 3 Presider: Hanife Can Sen, Yuzuncu Yil University

Investigating the Shifts in Thai Teachers' Views of Learning and Practices while Adopting ABI Approach Nattida Promyod, University Of Iowa, nattida5@hotmail.com Brian M. Hand, University of Iowa

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**ABSTRACT:** The purpose of this study was to investigate the implementation of the ABI approach in Thai classrooms. The study was conducted with five physics teachers by examining how they shifted their practices and views of learning. The study specifically focused on the change and the relationship throughout the ABI implementation phase on teachers' questioning, problem solving, and the establishment of learning environment. Data collection involved classroom observations and teacher interviews. The constant comparative method was employed during the data analysis process. The findings revealed that the three teachers who expressed positive attitude and a willingness to practice this approach started to shift their teaching and views of learning. Although each teacher exhibited different starting point within the three observed criteria, they began to shift their practices first. Then, they reflected back on their beliefs. In contrast to these teachers, the other two teachers were impeded by several barriers and therefore failed to implement the approach. Therefore, positive attitude, willingness, and shift of practice are connected and necessary for change. The study emphasizes that to support the implementation of the ABI approach, especially in large class size, opportunities for teachers to be challenged in both classroom and cognitive spaces are crucial.

#### Promoting Students' Understanding in Electrochemistry through Case-based Instruction Aysegul Tarkin, Yuzuncu Yil University, aytarkin@gmail.com Esen Uzuntiryaki-Kondakci, Middle East Technical University

**ABSTRACT:** This study aimed at comparing the effectiveness of case-based instruction (CBI) over traditionally designed chemistry instruction on 11th grade students' understanding of the electrochemistry concepts. A quasi-experimental research design was used. 117 11th grade students from three high schools were participated in this study. Two classes of the same teacher from each school were included in the study. One classes of each teacher was randomly assigned as experimental and control group. Students in the experimental groups (n=59) were instructed by CBI while students in the control groups (n=58) were instructed by traditional instruction. In order to measure the students' understanding of electrochemistry concepts, the Electrochemistry Concept Test developed by the researchers was applied as both a pre-test and a post-test to the control and experimental groups. Data was analyzed by running two-way mixed design Analysis of Variance (ANOVA). Findings of the study indicated that the change in understanding of electrochemistry in experimental group was significantly different to change in the control groups. Although there was an increase in students' understanding of electrochemistry in both groups over time, there was a much stronger effect when students were taught by CBI.

## Characterizing the Effectiveness of Coherent Instructional Materials on Middle School Students' Understanding of Core Science Ideas

Sung-Youn Choi, University of Michigan, choi.sungyoun@gmail.com Shawn Stevens, University of Michigan Namsoo Shin, University of Michigan

Deborah C. Peek-Brown, University of Michigan

**ABSTRACT:** This longitudinal study compares how students at schools that used coherent instructional materials build integrated understanding of important scientific ideas with those at schools that use traditional materials. We followed middle school students' understanding of chemistry core ideas over three time points across two school years and three grade levels. A total of 2235 students from eight schools, including 607 students in the coherent group and 1628 students in the traditional participated in this study. Item response theory was used to measure the latent ability for each student. We characterized student ability levels by school and instructional materials using descriptive statistics, learning gain and Cohen's effect size. The results indicated that regardless of instructional materials used, students showed significant growth in performance, but revealed different patterns of progress. The coherent group exhibited significantly higher gains in ability level than the traditional group. Although the coherent instructional material group started significantly lower than the traditional group, all students reached similar ability levels at the last data point. These results provide evidence that coherent instructional materials understanding in science. We will characterize factors that affect development of integrated understanding to further compare these groups.

### Strand 4: Science Teaching--Middle and High School (Grades 5-12): Characteristics and Strategies The Effect of Different Instructional Approaches on Student Learning 10:15am-11:45am, King's Garden 4 Presider: Jeffrey Nordine, Trinity University

From Contrasting Cases to Contrasting Models: Supporting Generalization in Model Development Jonathan T. Shemwell, University of Maine, jonathan.shemwell@maine.edu

Daniel K. Capps, University of Maine

Daniel Gibson, University of Maine

**ABSTRACT:** An important question for science education is how to support students to develop and revise different types of models. A related question is what knowledge and skills teachers may need to support model construction. The present study addresses these questions as they pertain to models representing the deeper structure of phenomena (ie., generalized models). We present an approach to constructing generalized models based on learning through contrasting cases. In this approach, learners, who are teachers in a professional development activity, construct a generalized model out of two or more specific models for different phenomena which share a common essential structure. Qualitative evidence developed from observing the learning process shows how the teachers generalize with multiple models, for instance by identifying common elements and discarding unique elements within models and by reconceptualizing elements. The evidence also shows what teachers learn from this process about generalized models, and what they learn about student construction of models. Implications of these accounts of the processes and results of model development and learning to model are discussed for instruction and for teacher professional development.

Understanding the Teacher's Role in Orchestrating Technology Enhanced Inquiry Learning Environments Jennifer K. LeBlanc, Texas A&M University, leblanc16@tamu.edu

Baki Cavlazoglu, Texas A&M University

Cheryl Ann Peterson, Texas A&M University

Carol L. Stuessy, Texas A&M University

**ABSTRACT:** Inquiry activities and collaborative technology have increasingly been integrated in science classroom practices in effort to promote authentic scientific practices and 21st century skills. As inquiry practices and technology tools within learning environments intersect, it becomes important to understand the role of teachers in orchestrating these complex learning environments. Due to the complex and often invisible nature of teachers' orchestration practices, more research efforts need to focus on examining roles teachers enact in guiding and facilitating technology enhanced inquiry learning environments (Viilo et al., 2012). Using a convergent mixed methods approach, our research examines how one middle school science teacher orchestrated the PlantingScience learning environment. Teachers implementing PlantingScience engage students in authentic science practices through inquiry activities and collaboration with scientist mentors in an online platform. We describe the teacher's role in guiding the entire inquiry cycle and each individual phase of inquiry while incorporating collaborative technology tools. Our results emphasize the adaptive and complex nature involved in orchestrating a technology enhanced inquiry learning environment; indicating the teacher guides inquiry through using teacher-centered, shared and student-centered levels of direction depending on the phase of inquiry.

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

#### Aproaches to Chemistry Instruction

10:15am-11:45am, Benedum

Presider: Marilyne Stains, University of Nebraska Lincoln

College Chemistry Students' Use of Memorized Algorithms on the Particulate Nature of Matter James M. Nyachwaya, North Dakota State University, james.nyachwaya@ndsu.edu Gillian H Roehrig, University of Minnesota

**ABSTRACT:** This study sought to uncover college students' conceptual understanding of the particulate nature of matter (PNM) using an open ended drawing tool. Students were asked to first balance three equations of chemical reactions, and then draw particulate representations of those reactions. Our data showed a big gap between students'

ability to balance the three equations (symbolic level understanding) and drawing appropriate particulate representations of the reactions (particulate level understanding). As part of the study, interviews were conducted in order to find out if students understood chemistry concepts underlying the equations of reactions used in the study. Our findings indicate that while our participants (students) were successful in answering aspects of the questions asked such as classifying chemical reactions, many relied on memorized algorithms and processes while responding to interview questions. We report our findings (interview data) that show the specific algorithms and memorized processes that were apparent from the students' responses to questions during the interviews.

Computerized Lexical Analysis of Students' Written Interpretations of Chemical Representations Luanna B. Prevost, University of South Florida, prevost@usf.edu

Kevin Haudek, Michigan State University

Mark Urban-Lurain, Michigan State University

**ABSTRACT:** Constructed response assessments, such are writing, provide insight into student thinking and allow instructors to create learning experiences that foster conceptual change. We investigate how computerized lexical analysis tools can facilitate the use of written assessments in high-enrollment introductory science courses. Specifically, we examine student interpretations of visual representations in chemistry using a combination of lexical and statistical analyses. Using this approach, we identified key ideas in student writing. Student expressed correct ideas that demonstrated students' abilities to make connections between the structure of molecules and their function. Additionally, groups of responses expressing incorrect or incoherent explanations were also extracted from student writing. Our results support the use lexical analysis coupled with statistical analyses to gain insight into student interpretations of chemical structures, and have the potential to support rapid feedback on formative assessments in high-enrollment introductory courses.

Factors Contributing to Problem-Solving Performance in First-Semester Organic Chemistry Enrique Lopez, University of Colorado, Boulder, enrique.lopez@colorado.edu Richard J. Shavelson, Stanford University SK Partners, LLC Kiruthiga Nandagopal, Stanford University John Penn, West Virginia University ABSTRACT: Problem solving is a critical skill in science disciplines and science education. Researchers have dedicated considerable effort investigating problem solving performance and have highlighted several factors. Twoically, studies

considerable effort investigating problem-solving performance and have highlighted several factors. Typically, studies have focused on the influence of individual factors. Therefore, the purpose of this study was to inspect the influences of a group of key factors (knowledge structures, prior science knowledge, spatial ability, gender, and ethnicity) and their contributions to problem solving in organic chemistry. This study utilized multivariate regression analyses to check the relationships and contributions of key factors to problem solving. Results indicate that knowledge structures accounted for a significant proportion of variance in students' problem-solving performance, while controlling for prior factors. Implications for research and practice in chemistry are discussed.

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

Students' Understandings in Physics

10:15am-11:45am, King's Garden 5

**Presider:** Muhsin Menekse, University of Pittsburgh

Undergraduate Physics Student's Problem Solving Frame and Epistemological Beliefs Wendi Wampler, Linn Benton Community College, wamplew@linnbenton.edu Lvnn A. Bryan, Purdue University

**ABSTRACT:** Problem solving is an essential part of the human experience. Most introductory undergraduate physics courses aim to help students develop the skills and strategies necessary to solve complex, real world problems, yet extensive research has shown that many students not only leave these courses with serious gaps in their conceptual understanding, but also maintain a novice-like approach to solving problems (Van Heuvelen, 1991; Walsh, Howard & Bowe, 2007). This study investigated how students frame problem solving within the context of a large

scale implementation of the Matter and Interactions [M&I] curriculum, and how, if at all, those frames related to student epistemological beliefs. Using qualitative methods, I examined the problem solving frames of six student volunteers from the M&I course; and using quantitative methods, I examined their epistemological beliefs. The findings indicate that when students' knowledge about problem solving and their epistemological beliefs and expectations were aligned, a shift toward a more productive frame occurred. Each student in the study adopted a more expert-like, deliberate approach to problem solving after a semester of M&I. This study has important implications for the teaching and learning of problem solving in physics, which are elaborated in the full paper.

Changing Students' Approach to Learning Physics in Undergraduate Gateway Courses Calvin Kalman, Concordia University, Calvin,Kalman@concordia.ca

Marina Milner-Bolotin, University of British Columbia Bruce M. Shore, McGill University, Canada Gyoungho Lee, Seoul National University Gul U. Coban, Dokuz Eylul University, Turkey Xiang Huang, Marianopolis College, Canada Ahmed Ibrahim, McGill University, Canada Xihui Wang, McGill University, Canada Xihui Wang, McGill University Mandana Sobhanzadeh, Mount Royal University Wahidun Khanam, Concordia University, Canada

**ABSTRACT:** This study investigated if and how a combined set of specially developed activities; reflective writing, critique-writing activities, & reflective write-pair-share combined with the collaborative conceptual-conflict group exercises can help students change their approach to learning physics and their actual learning. Each of these activities was previously successfully tested as a stand-alone activity. We also developed new rubrics for evaluation of the impact of the activities. Data were collected at two different institutions. At each institution the same instructor taught students in two sections. At the first, a comprehensive university, classes were relatively large sections in a typical calculus-based course in mechanics. At the second, a community college, there were relatively small classes of a typical algebra-based introductory course in mechanics, electricity, and magnetism. The two institutions used different textbooks and had different formats. Measured outcome variables included student interviews and writing products. Students identified key concepts, related concepts to their own prior understanding of the same and other concepts, and used a paradigm- rather than template-based approach to solving new problems. These differences were more clearly apparent than in stand-alone studies of the learning activities

Students Coming to Understand Ionizing Radiation - A Radiation Literacy Challenge Andy Johnson, Black Hills State University, andy.johnson@bhsu.edu Rebecca Maidl, Black Hills State University

**ABSTRACT:** Most people tend to think of radiation as being matter-like "stuff" that is emitted from radioactive objects and causes other objects to become radioactive. This is a significant barrier to radiation literacy. The Inquiry into Radioactivity (IiR) course materials are designed to develop radiation literacy among nonscience majors and to help students understand ionizing radiation as high speed subatomic particles emitted from unstable atomic nuclei. In studying student thinking about radiation and radioactivity, we find over 90% initially subscribe to the "matter-like" view but after eleven weeks of study in IiR, nearly 70% of students adopted a particulate view. This was identified in post-assessement data by examining consistency of student responses with a particulate model. We believe that this transformation in thinking is comparable in difficulty to other major conceptual changes required in physics such as understanding acceleration or connecting force to acceleration. The Inquiry into Radioactivity project is supported by NSF DUE grant 0942699. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation or of Black Hills State University.

College Students' Views and Use of Evidence in the Context of Conceptual Physics Problems N. Sanjay Rebello, Kansas State University, srebello@phys.ksu.edu Carina M. Rebello, University of Missouri Lloyd H. Barrow, University of Missouri **ABSTRACT:** Researchers have begun to recognize the importance of argumentation in science learning. An important aspect to argumentation is the use of evidence to support an argument. Research indicates that students have difficulty providing relevant evidence to support their arguments. Most students tend to select only evidence that supports their claim. They tend to rely on personal beliefs rather than evidence, and often engage in over generalizations, or make unsubstantiated assertions. While prior studies have evaluated students' arguments in terms of soundness or acceptability of evidence there are limited studies that characterize the kinds of evidence that students use, especially in the context of physics problem solving. In this study we explore and characterize introductory physics students' ideas of evidence while solving conceptual physics problems. We find that most students tend to rely on equation and physical laws as their primary evidentiary resource during problem solving in physics.

### Strand 5: College Science Teaching and Learning (Grades 13-20) *Teaching and Learning in Biology*

10:15am-11:45am, Heinz **Presider:** Hannah Sevian, University of Massachusetts

A Model of Biology Experts' Mechanistic Explanations: Themes across Multiple Disciplines Caleb Trujillo, Purdue University, ctrujil@purdue.edu Trevor Anderson, Purdue University Nancy J. Pelaez, Purdue University

**ABSTRACT:** Constructing explanations is essential for both science and learning. This study addresses the question, "What are the essential aspects of biology experts' explanations of cellular and molecular mechanisms within their domain?" To address this question we first built on previous work and our own thought experiments to derive an initial model about mechanistic explanations. Secondly, we tested the validity of the initial model by asking seven biologists from various sub-disciplines, to explain a cellular mechanism of their choice. Data was collected from interviews, artifacts and drawings and subjected to thematic analysis. We found that biologists: use our initial mechanistic model of molecular explanations by focusing on entities, activities, and organization. But in addition, they highly contextualize and constrain their explanations according to biological and societal significance; integrate explanations with the methods, instruments, and measurements they use to investigate; and use narrative stories along with analogies to explain their systems. These themes informed a modified model of expert-like explanations of cellular mechanisms. Our model will provide a foundation for future work in life science education research, as well as other science domains, and offers a way to teach explicitly about components of biological mechanisms.

Development of a Model for Current Use of Evolutionary Trees in Scientific Research

Yi Kong, Purdue University, iamkongyi@gmail.com

Nancy J. Pelaez, Purdue University

Trevor Anderson, Purdue University

**ABSTRACT:** Evolutionary trees, which are commonly used in textbook and classroom instruction, are powerful tools in modern biology. Research shows that students have difficulties understanding and interpreting evolutionary trees. To help students form correct understanding of trees, it might be helpful to teach them how scientists use and interpret trees. Since real examples of the use of trees in scientific research requires graduate level knowledge, those examples are not accessible for college students, K-12 students, or classroom teachers. Relatively little data support how trees are applied in modern scientific research. The purpose of this study is to examine how scientists use trees when they communicate their research findings. Using content analysis to examine current research articles in Science magazine and a "model of modeling" framework, this study developed and tested a model for how life scientists actually use evolutionary trees to communicate their research findings. The model generated can be used to develop and evaluate future instruction and assessments of students' abilities to use evolutionary trees.

An Exploration of Student Learning and Attitudes across Three Laboratory Platforms in a University Biology Course

Amber J. Reece, University of Central Florida, amber.reece@ucf.edu Malcolm B. Butler, University of Central Florida Kenneth Fedorka, University of Central Florida

**ABSTRACT:** Two virtual laboratory platforms were compared to the traditional, physical laboratory on student cognitive achievement and attitudes on learning, likability, usability, use of metacognition, and collaboration metrics in a University's majors-level introductory biology course. The impetus behind this research is the continuing increase in students choosing to major in STEM degrees and the resulting swell in enrollment in introductory biology courses. Students in a majors-level introductory biology course were randomly assigned to one of the three learning platforms (physical lab, "Smart" labs, and "Virtual Life" labs) for two lab exercises. They completed a pre/ post-test, post-lab quiz, and questionnaire as part of the project. Student achievement was comparable across the three learning platforms, and differences were found in student attitudes to their randomly-assigned group. These results are consistent with other studies comparing online and physical labs.

### How Mastery and Learning Assessment Goals Significantly Increased Learning and Achievement in Introductory College Biology

### Obed Norman, Project STEM PEOPLE, onorman6@gmail.com

**ABSTRACT:** This study reports on how the incorporation of mastery and effort goals into the course assessment resulted in a significant improvement of student performance in a Biology 101 class at a Historically Black University. The most important analysis of the study was comparing the achievement of the student in the study with the students in the other Biology 101 sections. This was done using the results of the comprehensive midterm and final examination. These examinations are set and graded by the Departmental Course Coordinator for Biology 10. The ultimate success of the strategy lay in the fact that the students in the study outperformed their peers in the Biology 101 cohorts in both the Department-wide Standardized midterm and final. On the Spring 2013 midterm the study cohort had an average of 59% which was just slightly above the average for all cohorts combined. On the final the study cohort increased their performance quite dramatically by averaging 72% on the Departmental Final and outscoring their peers on average by close to 20 percentage points. The superior performance of the study cohort is clear evidence that the strategy has great potential and further study, refinement and development of .the strategy is warranted.

#### **Strand 6: Science Learning in Informal Contexts Designing Afterschool Programs: What Works and How do we Know?** 10:15am-11:45am, Rivers

Presider: Alix R. Cotumaccio, American Museum of Natural History

# The Journey of a Science Teacher: Preparing Female Students in the Training Future Scientists after School Program

Rona M. Robinson-Hill, University of Missouri- St. Louis, rona.robinson-hill@slps.org

**ABSTRACT:** What affect does female participation in the Training Future Scientist (TFS) program based on Vygotsky's sociocultural theory and Maslow's Hierarchies of Needs have on female adolescents' achievement levels in science and their attitude toward science and interest in science-based careers? This action research project used mixed methods research design, targeted urban adolescent females who were members of Boys & Girls Club in an urban Midwestern metropolis after-school program. The data collection measures were three qualitative instruments and two quantitative instruments. The goal was to describe the impact the Training Future Scientist (TFS) after-school program has on the girls' scientific content knowledge, attitude toward choosing a science career, and self-perception in science. Through the TFS after-school program participants had access to a secondary science teacher-researcher, peer leaders that were in the 9th - 12th grade, and Science, Technology, Engineering and Math role models from a large Midwestern University Medical School that were graduate and medical students and fellows as volunteers. The program utilized the Buckle-down Curriculum as guided, peer-led cooperative learning groups, hands-on labs and demonstrations facilitated by

the researcher, trained peer leaders and/or role models that used constructivist science pedagogy to improve test-taking strategies.

Assessing Changes in Investigative Skills as an Impact of Informal Science Afterschool Programming Tirupalavanam G. Ganesh, Arizona State University, tganesh@asu.edu Terence J. G. Tracey, Arizona State University

Andrew Webber, Arizona State University

**ABSTRACT:** Informal-science programs offer the potential to enhance student engagement in science, technology, engineering, and mathematics (STEM) fields. There is a need for evidence that after-school programs impact students' interest, knowledge, and engagement in the STEM subjects. Engagement/interest and attitude/behavior tend to be the primary focus of assessment in these programs. By focusing only on STEM interests, the larger pool of interests is ignored. What matters is that STEM interests and competence perceptions should increase as a result of informal learning experiences but also that they should surpass other interests and thus become prominent. Single band assessments carry error that attenuates results. It is important to control for this attenuation, which is done best by including a broader interest assessment. The focus of this study was on changes in broad based interests and competence in STEM areas. The Inventory of Children's Activities-Revised survey was used which is based on Holland's (1997) six interest types: Realistic, Investigative, Artistic, Social, Enterprising, and Conventional (RIASEC). Using Hierarchical Liner Modeling we found that participants demonstrated gains in Investigative interests and competence pre to post perception over other RIASEC interest types.

# Can Afterschool Programs Help Urban Elementary and Middle School Students learn STEM Concepts and Skills?

Nancy Moreno, Baylor College of Medicine, nmoreno@bcm.edu Barbara Tharp, Baylor College of Medicine Gregory Vogt, Baylor College of Medicine Alana Newell, Baylor College of Medicine Michael Vu, Baylor College of Medicine

**ABSTRACT:** Afterschool programs can provide the academic and social supports that many students need to succeed in school, but there is little consensus as to best practices for these informal approaches. This pair of studies implemented STEM-related afterschool activities, in order to investigate effective program designs, and ways to engage students in STEM content outside of the regular school day. Study One implemented an infectious disease and microbiology curriculum in six elementary schools over the course of a school year. Outcomes were measured by a multiple-choice pre-and post-assessment, as well as qualitative evaluations by participating teachers. Study Two involved nine schools using engineering-focused activities, and evaluated student content knowledge gains via a multiple-choice pre- and post-assessment, as well as a measure of student attitudes towards science, and utilized a set of non-participating students as a comparison group. Implementation students in both studies demonstrated strong content knowledge gains, and teacher evaluations were very positive. The results suggest that afterschool programs with engaging curricula and appropriate guidance for teachers are capable of building students' STEM-related knowledge and skills outside of a regular classroom settings. Outcomes also contributed to a set of recommendations for the design and implementation of STEM afterschool programs.

One Activity at a Time: The Role of Instructional Materials in Afterschool Science Patrik Lundh, SRI International, patrik.lundh@sri.com Ann House, SRI International

Carlin Llorente, SRI International Cynthia M. D'Angelo, SRI International

Christopher J. Harris, SRI International

Tiffany Leones, SRI International

**ABSTRACT:** This paper describes the findings of and insights developed from a study of the use of instructional materials for afterschool science in publicly funded afterschool programs. The study involved a survey of 406 afterschool

sites and two sets of case studies; one involving site visits and interviews with staff about their science offerings at nine afterschool sites, and one involving case study interviews with afterschool site staff at an additional 13 sites regarding the instructional materials they use to support their afterschool science offerings. We summarize the types and features of science instructional materials that afterschool staff use, how such materials are selected, and the role of instructional materials in their preparation for leading afterschool science activities. We found that sites primary rely on "enrichment materials," which we define as stand-alone activities found on the Internet, in activity books, or other media. The constraints of time, staff capacity, cost, and limited goals for science explained these approaches. They also explained another important finding, which was that in cases where sites had access to and used science curricula developed for afterschool settings, staff followed similar approaches, and used such curricula as sources for single activities rather than implementing them sequentially.

### **Strand 7: Pre-service Science Teacher Education**

# Symposium – Citizen Science in the Education of Teachers: Developing a Sense of Place, Agency and Mindfulness

10:15am-11:45am, Sterlings 1

#### **Presenters:**

Lynda L. Jenkins, The Galloway School, lynda.jenkins07@gmail.com

Stacey Britton, University of Mississippi

Elizabeth Pate, University of Texas

Deborah J. Tippins, The University of Georgia

**ABSTRACT:** In recent years, citizen science has emerged as a promising ecojustice pedagogy within science teacher education. "Citizen Science in the Education of Teachers" is a symposium designed to start a conversation around research that highlights the development of sense of place, agency, and mindfulness across a diverse spectrum of citizen science projects.

Strand 7: Pre-service Science Teacher Education Improving Preservice Science Teacher Preparation 10:15am-11:45am, Brigade

Presider: Elizabeth B. Lewis, University of Nebraska

Training Pre-service Elementary Teachers to Effectively Teach Science to English Language Learners: The Impact on Student Learning

Edward G. Lyon, Arizona State University, eglyon@asu.edu

Jerome M. Shaw, University of California - Santa Cruz

Preetha K. Menon, UC Santa Cruz

Trish L. Stoddart, Unuversity of California, Santa Cruz

**ABSTRACT:** We report on student learning data collected through an NSF-funded project. Two groups of elementary pre-service teachers participated in the project. The treatment group completed a science methods course that infused literacy development with inquiry-based science and had cooperating teachers who participated in project-focused professional development (PD). The control group completed an unmodified course and their cooperating teachers received no PD. We observed 18 (12 treatment, 6 control) of the graduating participants teaching a common science unit in their first year of teaching and administered a pre-post science assessment that included multiple-choice and constructed-response items. The assessment measured students' understanding of science concepts and vocabulary (aligned with the unit content), as well as their science writing. We found that students (N=250) of treatment teachers demonstrated higher gains in their Science Writing than students (N=156) of control teachers (t=1.998, p=.047). We also found that Beginning/Early Intermediate ELLs outgained Early Advanced/Advanced ELLs and English Only students, although there was no interaction with the control/treatment condition. The findings hold promising evidence for training even new teachers to uptake practices that improve ELLs' science learning.

### Risk Taking in Joint Spaces and its Impact on Preservice - Mentor Teacher Hierarchies Martha M. Canipe, University of Arizona, mcanipe@email.arizona.edu

Kristin L. Gunckel, University of Arizona

**ABSTRACT:** Hybrid spaces have been recommended in teacher education as a way to provide preservice teachers with access to many sources of knowledge (Zeichner, 2010). These hybrid spaces have the potential to disrupt the traditional hierarchies that exist between mentor teachers and preservice teachers and thus may be risky environments for their participants. By examining the interactions that occurred between mentor teachers and preservice teachers during a joint science teaching learning event, we explore the potential risks that the participants encountered to their identities as teachers and learners. Through this exploration we identified how the participants worked to reduce this risk and the results for either maintaining or disrupting the hierarchy within the groups. The willingness of either the mentor teachers or the preservice teachers to engage in ways that pose a risk to their identities had the potential to disrupt the hierarchy in the group. Hierarchies were disrupted in groups where potential risk was alleviated by other group members either through alignment or valuing the contributions that were made.

### *Examining Pre-Service Secondary Science Teachers' Lesson Planning for Whole-Class Discussions* Danielle K. Ross, University of Pittsburgh, dkr13@pitt.edu

### Jennifer L. Cartier, University of Pittsburgh

**ABSTRACT:** This study offers insight into how teacher educators might design learning contexts to support pre-service secondary science teachers' (PSTs) planning for more authentic science practices aligned with the Next Generation Science Standards. Drawing upon Smith and Stein's (2011) Five Practices instructional model for orchestrating productive discussions, we developed role-play scenarios in which PSTs learn to notice and support student thinking throughout a classroom discussion. By providing repeated, scaffolded opportunities to engage in designing and planning lessons that support these discussions, the PSTs notice particular aspects of planning practices necessary for this robust teaching. These repeated learning opportunities allow the PSTs to approximate various aspects of each practice in an effort to support the development of their pedagogical design capacity (PDC) for planning whole-class discussions. This pilot study examines the PSTs' uptake and use of the Five Practices model for orchestrating discussions as they plan for whole-class discussions as part of their coursework.

# *Recruitment of Early STEM Majors into Possible Secondary Science Teaching Careers: The Role of Science Education Summer Internships*

### Lisa A. Borgerding, Kent State University, ldonnell@kent.edu

**ABSTRACT:** Due to teacher retirements and increasing preretirement teacher attrition, the demand for qualified science teachers often outpaces supply, especially in schools with high teacher turnover. Science educators may view teacher recruitment as a preservice teacher education experience in and of itself. The present project employed a four-week summer internship program designed to recruit non-education STEM majors into the field of secondary science education. The present study investigates how STEM majors who are not already considering teaching careers experience an intense summer science teaching service learning internship and how their views of teaching, learning, and their own possible career trajectories change throughout this experience. Utilizing a multicase study qualitative research approach, data sources included a pre-internship interview, collected documents, daily reflections during the internship, and a post-internship interview for five potential science teachers. The main findings indicate that all five potential teachers gained in their confidence as potential teachers but only particular interns came to consider secondary science teaching as an actual possible career. These findings are contextualized in light of how the potential teachers' ideas about science teaching and learning, high school students, and their own identities changed throughout the experience.

### Strand 8: In-service Science Teacher Education

Symposium – Research Experiences for Teachers: Proposed Relationships Between Elements of the Experience and Positive Outcomes

10:15am-11:45am, Sterlings 2 & 3 **Presider:** Bryan M. Rebar, University of Oregon **Presenters:** Lisa C. Benson, Clemson University

Sanlyn Buxner, University Of Arizona Jeffrey S. Carver, West Virginia University Allan Feldman, University of South Florida John Keller, California Polytechnic State University Renee S. Schwartz, Western Michigan University Sherry A. Southerland, Florida State University

**ABSTRACT:** Programs offering teacher researcher experiences (TREs) provide a promising approach to improving science teacher preparation and professional development, yet little is known about the relationship between the way in which these experiences are structured and supported and the outcomes they produce. Consequently, there is great variety in the way that TRE programs are implemented. Six independent studies of participants in different programs are represented in this symposium for the purpose of providing a forum to discuss the relationship between the program structures that most strongly associate with positive teacher outcomes. Collectively, the findings of these independent studies suggest the value of TREs in preparing teachers to engage their students in scientific and engineering practices as described by the Next Generation Science Standards when specific education research-supported structures are in place: (1) the inclusion of participants in tightly connected research groups; (2) high degrees of utility and autonomy in the research process; (3) involvement in meaningful research; (4) supplementary support for considering the scientific research enterprise, related educational research, and application of the experience to teaching. Overall, comparison of these studies suggests a generalized model for the relationships between components of TREs and anticipated positive outcomes.

### Strand 10: Curriculum, Evaluation, and Assessment

**Defining and Assessing Scientific Literacy** 

10:15am-11:45am, Smithfield **Presider:** Robert H. Evans, University of Copenhagen

A Conceptual Framework for Environmental Science Literacy: The Case of Qatar Rola Khishfe, American University of Beirut, rk19@aub.edu.lb

**ABSTRACT:** The purpose of this study was twofold: (a) develop a conceptual framework for environmental science literacy; and consequently (b) examine the potential of science standards/curricula to prepare environmentally literate citizens. The framework comprised four pillars: science content knowledge, scientific inquiry, nature of science (NOS), and socioscientific issues (SSI). A conceptual understanding of these pillars as interconnected was presented and justified. Then the developed framework was used to examine the potential of Qatari science standards to prepare environmentally literate citizens. Results showed that the secondary Qatari science standards generally take up the pillars of science content and scientific inquiry in an explicit manner. The NOS pillar is rarely addressed, while the SSI pillar is not addressed in the objectives and activities in a way that aligns with the heavy emphasis given in the overall aims. Moreover, the connections among pillars are mostly manifested within the activities and between the science content and scientific inquiry. The objectives and activities targeting the environment were less frequent among the four pillars across the Qatari standards. Implications from this study relate to the need for the distribution of the four pillars across the standards as well as the presentation of the different pillars as interconnected.

Budding Science and Literacy: A Classroom Video Study of the Challenges and Support in an Integrated Inquiry and Literacy Teaching Model

Marianne Odegaard, University Of Oslo, marianne.odegaard@naturfagsenteret.no Berit S. Haug, Norwegian Centre for Science Education Sonja M. Mork, University Of Oslo

Gard Ove Sorvik, University Of Oslo

**ABSTRACT:** In the Budding Science and Literacy project we explore how working with an inquiry approach, together with literacy activities in science classrooms, influence each other. Our esearch focus is: to explore how an integrated science and literacy approach may challenge and support the teaching and learning of science at the classroom level. Six experienced teachers and their students were recruited from a professional development course to the current classroom study. The teachers were to try out the Budding Science teaching model. This paper presents an overall video analysis of our material showing patterns of inquiry and literacy activities. The literacy activities vary across all the categories of inquiry, but oral activities are most frequent. Analyses of inquiry features show that especially the data phase of inquiry is important for the dynamics of the other classroom activities. We see that data is collected and handled using a whole range of multiple learning modalities, also by reading or writing. Most important students show more engagement when they discuss results from their own data. The paper suggests that handling data is a valuable force for linking literacy to science content, and for creating valuable learning situations when students discuss their inquiries.

### Advances in Socioscientific Issues: Theory, Research and Practice

### Dana L. Zeidler, University of South Florida, Zeidler@usf.edu

**ABSTRACT:** Socioscientific Issues (SSI) has proven to be a viable educational framework in recent years, having been informed by theory and scholarship from philosophical, developmental and sociological traditions that mark it off as distinct. SSI is a flexible framework that draws on bodies of scholarship that include, but are not limited to cognitive and moral development, emotive reasoning, character education, socio-moral discourse and the nature of science, that situate it in a sociocultural perspective. The purpose of this paper is to provide an overview of current themes identified in research literature that have progressed the SSI framework and include: I. Socioscientific Issues as Engagement of Curriculum Practice and Teachers' Pedagogical Beliefs – presents research that impacts the pedagogical application of classroom practice; II. Socioscientific Issues as Epistemological Development and Reasoning – reviews research on epistemological beliefs and the development of conceptual and psychological knowledge structures, including aspects of reflective judgment, discourse and argumentation; III. Socioscientific Issues as Context for the Nature of Science – examines research on how SSI affords a contextualized setting of NOS; and, IV. Socioscientific Issues as Character Development and Citizenship Responsibility – considers how SSI serves to promote the development of morality.

Exploring Measures of Fidelity of Implementation and Student Learning in 9th Grade Physics

Deborah L. Hanuscin, University of Missouri, hanuscind@missouri.edu

Christi Bergin, University of Missouri

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Nilay Muslu, University of Missouri

### Jaimie Foulk, University of Missouri

**ABSTRACT:** Good curriculum materials may improve science education; however, the effectiveness of a curriculum in promoting student learning depends on how it is implemented. Measuring fidelity of curriculum implementation is challenging. In this paper we compare two quite different approaches to measuring implementation – a structured narrative of a single lesson and an inventory of the percentage of content in the total curriculum that was covered and in what form – and their relationship to student learning. As part of an NSF-funded Math and Science Partnership, 10 teachers in a Midwestern state implemented a year-long curriculum in freshman physics. We conducted a mixed methods exploratory study of their fidelity of implementation and their 281 students' gains on standardized physics tests. It is often assumed that high implementation fidelity is ideal; however, our experience with the teachers suggested that high fidelity may result from teacher insecurity, and be linked to lower student achievement. Results confirmed that moderate fidelity may characterize teachers whose students have the highest achievement.
### Strand 11: Cultural, Social, and Gender Issues

Impact of Gender and Equity on Middle School Students

10:15am-11:45am, King's Garden 1

How Instruction, Gender, and Race Affect Students' Spatial-Scientific Learning Jennifer A. Wilhelm, University of Kentucky, jennifer.wilhelm@uky.edu Michael Toland, University of Kentucky Christa Jackson, University of Kentucky Merryn Cole, University of Kentucky Ronald Wilhelm, University of Kentucky

**ABSTRACT:** Differences were examined between groups of sixth grade students' spatial-scientific development pre/post implementation of an Earth/Space unit. Treatment teachers employed a curriculum called Realistic Explorations in Astronomical Learning, while control teachers implemented their regular Earth/Space units. A multi-level hierarchical linear model was used to evaluate student performance on the Lunar Phases Concept Inventory and four spatial domains, while controlling for two variables (gender and ethnicity) at the student level and one variable (teaching experience) at the teacher level. Overall LPCI results showed pre-test scores predicted post-test scores, boys performed better than girls, and Whites performed better than non-Whites. We also compared experimental and control groups by LPCI spatial domain outcomes. Domain findings revealed that experimental girls achieved higher Periodic Patterns (PP) domain post-scores than girls in the control group. In addition, a gender gap was observed (in favor of boys) within the control group for PP domain post-scores, while no gender gap was shown within the experimental group. This study displayed how we need to pay particular attention to the needs of males and females as well as with students of different ethnicities and races as they learn science that requires the development of spatial-scientific thinking.

# "But the Science We Do Here Matters"": Youth Sharing Visions of Civic Engagement with Science Daniel Birmingham, Loyola University Chicago, dbirmingham@luc.edu

### Angela Calabrese-Barton, Michigan State University

**ABSTRACT:** Civic action using scientific expertise is at the forefront of global concerns. However, despite relevance to issues such as climate change, research suggests that scientific understanding bears little impact on the decisions people make on civic engagement (Allum, Sturgis, Tabourazi & Brunton-Smith, 2008; Sadler, 2004). Furthermore, despite attention to the role of science literacy for democratic participation in science education reform initiatives, civic action using scientific expertise continues to play minimal roles in science education. In this paper, we are interested in how youth talk about and do science that "matters." Our investigation is based on extensive multi-media cases authored by four middle school girls from non-dominate communities. The cases, which included their personal stories of their experiences doing science, images of themselves doing science, and artifacts of their science "mattered" in their lives. We argue that the stories that the girls told about their cases, and the materials they included in their cases, reveal visions of youth being civically engaged with science in and for their community that hold pedagogical implications for reforming science teaching in classroom contexts.

### "I Can Do Science!": Wrestling with Stereotypes and Science Identity

### Myunghwan Shin, Michigan State University, shinmyu4@msu.edu

### Angela Calabrese-Barton, Michigan State University

**ABSTRACT:** This study explores how urban middle-school students interpret and respond to science-related stereotypes of their social identity group and how their interpretations and reactions to the stereotypes influence their formation of science identity. Linking the concept of stereotype threat with social practice theory, we aim to investigate complex and dynamic interplays between societal stereotypes and science identity development, positioning students with agency in their world. Using a critical ethnography, we collected qualitative data including interviews, participant observations, student artifacts, and informal conversations. Our findings suggest that students are not merely passive recipients of stereotype threats; instead, they actively utilize science activities as tools for challenging negative stereotypes. Implications for designing a science curriculum for the underrepresented group of students are discussed.

# Playing with Fire? The Hidden Curriculum in Genetics and its Impact on Adolescent Conceptions of Race Brian M. Donovan, Stanford University, briand79@stanford.edu

**ABSTRACT:** Race is a longstanding topic of biology textbooks. Yet, there appears to be no research investigating whether the treatment of race in modern biology textbooks impacts how students conceptualize race. In the present study, a randomized double-blind field experiment is used to investigate the impact of textbook-based genetics learning on adolescent conceptions of race. The study was carried out in an eighth grade classroom in a California Bay Area School. Students recruited for the study (n=43) read either a racialized or a non-racialized textbook passage on human genetic diseases. After a short distracting task they completed two different race conception instruments. Controlling for race, gender, age, prior race-conceptions, prior-genetics knowledge, and reading comprehension, statistically significant effects were observed on both race conception instruments by treatment. Students in the racialized condition exhibited stronger genetic conceptions of race than students in the non-racialized condition. Additionally, the analysis indicated that an understanding of Mendelian heredity moderated the observed treatment effects. The findings of the present study suggest that learning in school biology has the potential to inadvertently reinforce conceptions of race tied to racial prejudice. Implications for teaching and research are discussed.

### Strand 11: Cultural, Social, and Gender Issues Language and Science Engagement

10:15am-11:45am, Birmingham **Presider:** Felicia Moore Mensah, Columbia University

### Exploring the Relationship between Gender and Constructed-Response Explanation Performance

Meghan R. Federer, The Ohio State University, federer.21@osu.edu

Ross H. Nehm, Stony Brook University

Dennis K. Pearl, The Ohio State University

**ABSTRACT:** In this study, I examined the relationships among Personal Science Teaching Efficacy (PSTE) beliefs, observed science teaching practices, and the beliefs about these practices within a nationwide diverse sample of inservice elementary teachers. Data were collected from thirty-eight teachers using the Reformed Teacher Observation Protocol (RTOP), semi-structured interviews, and the Science Teaching Efficacy Beliefs Instrument (STEBI-A). Coded qualitative data and quantitative survey data were analyzed in order to compare the beliefs and practices regarding science teaching within and across PSTE levels. In addition, case profiles of eight teachers with varying levels of PSTE and RTOP scores were examined in closer detail. Results revealed that many positive behaviors commonly associated with greater science teaching self-efficacy, especially giving students more control over their own science learning, did manifest themselves in participants' beliefs about science teaching. However, many of these beliefs did not align with actual observed classroom practices. Interviews and observations of case profile teachers revealed how self-efficacy levels manifested themselves in different teachers. While there do appear to be some overall advantages to increasing elementary teachers' science teaching self-efficacy, the situation is much more complex than it is sometimes portrayed in the literature.

### Cross-Case Analyses of Four Inclusive STEM High Schools: School Mission and Student Supports Sharon J. Lynch, The George Washington University, slynch@gwu.edu

Kathleen M. Ross, The George Washington University

**ABSTRACT:** This paper reports on a cross-case analysis of four inclusive STEM high schools (ISHSs) with strong track records of success for students under-represented in STEM fields (including ethnic diversity, students from low SES families, students who are first generation in their families to attend college, and equal numbers of males and females). These schools have missions to recruit a diverse and representative student population and prepare these students for college and for STEM majors, jobs and careers. Although these ISHSs are located in different states and do not communicate with one another, by focusing on cross case analyses of two critical components, "inclusive STEM mission" and "supports for students under-represented in STEM", we see remarkable similarities the challenges faced by students and their families. More important, this paper reports on the school cultures and programs specially designed to support students, enabling them to prepare for and be successful in college STEM majors. These opportunity structures help

students develop the skills and knowledge, confidence and social capital. ISHSs are a new development in science education, and can inform the field of these grass-roots, but thoughtfully designed efforts to provide an entire school culture that supports success and inspiration in STEM fields.

Do Linguistic Features of Science Test Items Prevent English Language Learners from Demonstrating Science Knowledge?

Tracy E. Noble, TERC Rachel Kachchaf, TERC Ann S. Rosebery, TERC Beth Warren, TERC Catherine O'Connor, Boston University Yang Wang, Wisconsin Center for Education Research

**ABSTRACT:** It is important to understand those factors other than science knowledge and skills that may influence English language learners' (ELLs) science test performance. In this paper, we explore the effects of specific linguistic features of science test items on ELLs' performance on those items. This study examines ELLs' performance on 162 Grade 5 large-scale multiple-choice science test items and the correlation between this performance and two specific linguistic features of science test items. We also interviewed 52 Grade 5 ELLs to examine their interaction with these two features. Results indicate that both of these features were significantly correlated with lower ELL test performance compared to non-ELLs, indicating that the presence of these features may hinder ELLs' performance on test items, and often resulted in students answering incorrectly, even when they demonstrated knowledge of the content. Further, we found that these features were most frequently occurring in Life Science items, suggesting that ELLs' content knowledge may be underestimated for this science strand.

*Finding Personally and Culturally Mediated Science: Making Locally Generated Knowledge Global* Bhaskar Upadhyay, University of Minnesota, bhaskar@umn.edu Kara Coffino, University of Minesota

**ABSTRACT:** This qualitative study relates to briding between local knowledge based on local contexts and practices and science knowledge. In this paper I present how theory and practices go together where students not only help make science learning engaging but also attempt to make local knowledge a more globally acceptable knowledge. I further show that students, when given appropriate opportunities to share their knowledge, are more sophisticated in connecting the value of engineering and technological designs based on the needs of local contexts. This paper will draw attention of science educators as to how science teaching and learning could be transdisciplinary and the cost of doing engineering activities in poor schools serving marginalized students may be done at very low cost by capturing students' local knowledge.

### **Strand 12: Educational Technology**

**Cloud Applications in Science Education** 

10:15am-11:45am, Fort Pitt **Presider:** Tamara Holmlund Nelson, Washington State University

### *Facilitating Outdoor, Authentic, and Interactive Learning in an Environmental Education Program via Cloud Application*

Miri Barak, Technion, Israel Institute of Technology, bmiriam@technion.ac.il

**ABSTRACT:** This paper introduces a cloud application named: 'Wandering' designed to facilitate outdoor, authentic, and interactive learning through the creation of location-based interactive learning objects (LILOs). Our study was conducted among grade nine students (N=102) who participated in an innovative environmental education program. The students were asked to create a LILO by locating the place on a digital map, providing a short description of it, and writing what is most interesting about it. Then, they were asked to write a short activity, encourage their peers to act upon it and assess the LILO. By the end of the academic year, 216 LILOs were created, in a few kilometers space in a small

community town. Findings indicated that students who created a large number of LILOs, provided scientifically valid information, made logical links to important environmental issues, and developed attractive activities. Interestingly, most LILOs were related to the effect of pollution caused by humans on humans; only two considered the effect on plants and animals. Findings suggest that Wandering may serve as a platform for enhancing skills needed for life in the 21st century, such as: Engagement with others, Personalization, Independent learning, and Change adaption.

# Harnessing Cloud applications for Promoting Progressive Education Principles in Science and Technology Ariella A. Levenberg, Technion, ariellal@tx.technion.ac.il

### Miri Barak, Technion

**ABSTRACT:** Recent studies in science education criticize the use of web-based technologies, indicating that in some cases they are applied in a simplistic techno-centric way. This might be due to teachers' lack of understanding of technologies role in education and their connection to pedagogy and content knowledge. The goal of this study was to evaluate a pedagogical framework that harnesses cloud applications for promoting progressive education among science teachers. The research was conducted among 52 science teacher trainees, applying the Grounded Theory approach for the collection, analysis, and interpretation of data. The research tools included semi-structured interviews and reflective questions that were administered throughout the course in order to examine participants' learning views and experience. Findings indicated that most of the science teacher trainees expressed positive experiences related to learning via cloud pedagogy, typifying it as promoting collaborative learning, technology-enabled instruction, and transfer of competences. Findings also indicated that cloud pedagogy enhances collaborative writing and flexible thinking, two important strategies for attaining a shared goal. This study is in line with NARST 2014 theme as it can trigger a debate related to competencies needed for science education in the 21st century and ways for attaining and enhancing them.

### **Strand 12: Educational Technology**

*Modeling and Models in Science Education* 10:15am-11:45am, Duquesne **Presider:** Noemi Waight, University at Buffalo

High School Student Accomplishment of Cellular Biology Content Using 3-D Computer Based Modules

J. Steve Oliver, University of Georgia, soliver@uga.edu Georgia W. Hodges, University of Georgia Kyung-A Kwon, University of Georgia Sara P. Raven, Kent State University Wendell F. Rogers, Jr., University of Georgia Melissa A. Jurkiewicz, University of Georgia Allan S. Cohen, University of Georgia YoonSun Jang, University of Georgia James N. Moore, University of Georgia Thomas P. Robertson, University of Georgia

**ABSTRACT:** Research into use of realistic interactive computer-based learning environments is reported here. This study examined how student learning of cellular biology concepts in a first course of high school biology was supported by modules featuring interactive 3-D computer-based environments. A quasi-experimental design was implemented through which the same six teachers, and approximately 400 students per year, were participants. In year one, the researchers examined how a unit of introductory biology concerning cell structure and function was taught and learned. Pre- and post- tests of the cellular biology content were given to examine student knowledge growth across the cell unit. In the second year, the same teachers with different students were again the participants. Again the same pre- and post-tests were used to assess knowledge change. The data analysis revealed that two latent classes of students emerged after repeated measures ANOVA. In year one, no students were classified as belonging to the high achieving class upon the completion of the cell unit, regardless of their classification at the beginning of the unit. However in year two when the modules were used, 66% of the initially low achieving and 84% of the initially high achieving students were classified as high achieving.

Mapping Students' Understanding of Big Ideas of High School Chemistry Concepts in the Context of Computer Modeling-based Teaching and Learning

Noemi Waight, University at Buffalo, nwaight@buffalo.edu Xiufeng Liu, State University Of New York At Buffalo (SUNY)

Melinda Whitford, SUNY - Buffalo

ABSTRACT: This study reports on a mixed study on the fine-grained analysis of students' levels of understandings of three big ideas of chemistry phenomena-matter, energy and models-in the context of computer-based models and model-based assessments. Assessment results and follow up interviews revealed that students reflected consistent level 2 understandings of the above big ideas. Correlation coefficients for all three assessments revealed statistically significant positive correlations indicating that students' explanations during follow up interviews were consistent with their assessment outcomes. However, examination in detail revealed that alignment of explanations related to the energy and matter construct were more robust when compared with understandings of models. Indeed, explanations that specifically referenced the models reflected literal interpretations of the function of models. This finding was significant since students' understandings of big ideas in this context were in fact, undergirded by their exposure to multiple representations of computer-based models. So even when students had acquired basic background information and accessed knowledge components visible in the models, reconciling model representations remained illusive. The collective implications of the above are significant for novice learners. Demarcating their nuanced fine-grained understandings is essential before we attempt to attach expectations defined by expert capabilities and skills. 0 0 1 222 1266 University at Buffalo 10 2 1486 14.0 Normal 0 false false false EN-US JA X-NONE /\* Style Definitions \*/ table.MsoNormalTable {mso-style-name:"Table Normal"; mso-tstyle-rowband-size:0; mso-tstyle-colband-size:0; msostyle-noshow:yes; mso-style-priority:99; mso-style-parent:""; mso-padding-alt:0in 5.4pt 0in 5.4pt; mso-para-margin:0in; mso-para-margin-bottom:.0001pt; mso-pagination:widow-orphan; font-size:12.0pt; font-family:Cambria; mso-ascii-fontfamily:Cambria; mso-ascii-theme-font:minor-latin; mso-hansi-font-family:Cambria; mso-hansi-theme-font:minor-latin; }

Technology Enhanced, Modeling-oriented Assessment (TMOA) in Science Education: A Conceptual Framework

Young Ae Kim, Department of Mathematics & Science Education, University of Georgia, joyyakim@uga.edu Bahadir Namdar, University of Georgia

### Ji Shen, University of Miami

ABSTRACT: Much research has revealed that including dynamic, interactive modeling technology in science instruction is effective in producing positive student learning outcomes (NRC, 2012). Furthermore, modeling-oriented assessment (MOA) starts to flourish (Author 2 & 3, 2013) and technology starts to be utilized in MOA (Quellmalz et al. 2012). In this paper, we examine the roles of technology in constructing science assessment in modeling-based instruction. We review relevant literature and offer a conceptual framework that includes five essential aspects: (1) Embedded dynamic visualizations for integrating knowledge and overcoming language barriers; (2) Virtual experiments and interactive simulations for expanding topics of assessment and accomplishing the assessment of deep understanding and scientific practices; (3) Collaboration tools for providing a practical way to assess collaborative modeling; (4) Automated feedback algorithms allows students to carry out reflective modeling and critical thinking; and (5) Database and learning management system makes it possible for including modeling in large-scale, summative assessment. This proposal serves as a starting point to think about the current state of the intersection between technology and assessment. Given a few number of empirical studies we found, we call for more empirical investigation in the area of TMOA.

### Concurrent Session #12 1:00pm – 2:30pm

### Presidential and Engineering Education RIG Co-Sponsored Session

The Engineering Elephant in the Science Classroom: Awakening Dialogues between Science and

Engineering Educators

1:00pm-2:30pm, Brigade

**Presiders:** Bryan Lynn, Purdue University

Senay Purzer, Purdue University

### **Presenters:**

Dale Baker, Arizona State University Erin Peters-Burton, George Mason University David Crismond, City University New York Richard Duschl, National Science Foundation Tamara Moore, Purdue University Chris Schnittka, Auburn University

**ABSTRACT:** Over the next few years, a number of new curricula, assessments, as well as pedagogical approaches will be developed to address engineering practices emphasized in the *Next Generation Science Standards*. Yet, the two major research communities that will likely lead these efforts at times appear disconnected and perhaps even alienated from one another. In this session, we will examine the ways in which educational researchers with an engineering background approach K-12 science education research as compared to science education researchers. More specifically, we intend for this session to awaken productive discussions around "the elephants in the room" and highlight the synergies, challenges, and opportunities in these two research communities' motivations to conduct research, theoretical frameworks they employ, and methodological approaches they use.

### Strand 1: Science Learning, Understanding and Conceptual Change *Exploring Scientific Reasoning* 1:00pm-2:30pm, Commonwealth 2 **Presider:** Abdi M. Warfa, Metropolitan State University

Obstacles and Supports for Effective Reasoning with Evidence in Authentic Science Investigations Thanh K. Le, University of Maine, thanh.le@maine.edu Jonathan Shemwell, University of Maine Daniel K. Capps, University of Maine Sarah Kirn, Gulf of Maine Research Institute Christine Voyer, Gulf of Maine Research Institute

**ABSTRACT:** Supporting students in learning to reason is a major priority in science education. This includes learning to falsify plausible alternative explanations. We investigated middle school students' falsification reasoning in written scientific arguments for species identification within a field-based science education program. We also observed students' reasoning in the classroom as they engaged in a simulated version of the experience. Falsification reasoning was more frequent when higher levels of knowledge support were provided on species identification cards. Audio-recordings of student groups during the simulated investigation showed how reflective thinking was undermined by task orientation when falsification reasoning was absent. Implications for instructional design to better support falsification reasoning and more reflective processing are discussed.

Using Multiple Representations to Learn the Human Breathing Mechanism: Students' Explanations Mihye Won, Curtin University, mihye.won@curtin.edu.au Heojeong Yoon, Global Institute for STS Education

David F. Treagust, Curtin University

**ABSTRACT:** The purpose of this study is to understand how multiple representations influence student's learning of science concepts, in this case the human breathing mechanism. The study was conducted with Grade 11 students in a Biology class where the lessons were videotaped and analyzed to illustrate how multiple representations were used in class. Semi-structured interviews and a two-tier diagnostic test were administered. The data were analyzed using the theoretical framework of Ainsworth (2006) with regards to how the different representations were utilized and contributed to students' learning. In this study, we identified three distinct ways in which students used the representations: a coherent, scientific explanation guided by critical understanding of the nature of representations; mostly correct explanations but an incomplete understanding of those representations; and a search for one-to-one correspondence between representations resulting in incorrect explanations. In this paper, we illustrate these three distinct ways by three individual students' diagrams and interview transcripts to show how their understanding of the nature of multiple representations are made for attending to the issues when teaching with multiple representations.

### Teaching the Control of Variables Strategy: A Research-synthesis

Martin Schwichow, Leibniz Institute, schwichow@ipn.uni-kiel.de

Hendrik Haertig, IPN - Leibniz-Institut

Tim Hoeffler, IPN - Leibniz Institute

**ABSTRACT:** Designing controlled experiments and drawing valid inferences from such experiments is a crucial requirement for learning from inquiry. However, students do not show an adequate understanding of the control of variables strategy [CVS] without instruction. The presented meta-analysis identifies features of effective instruction from 67 intervention studies. Direct instruction in combination with cognitive conflicts seems to have a positive impact on student achievement concerning the CVS. Discovery learning is found to be less effective. Therefore, the CVS should be taught by direct instruction particularly when learning through inquiry is the focus of the curriculum. If students should learn from their own investigations, then the crucial inquiry skills should be taught as effectively as possible. The missing evidence of an age-dependency of student achievement offers the possibility to integrate the CVS into science curricula from K to 12. Besides the intervention aspects, a significant impact of the features of the tests on the intervention outcome was found. For example, multiple choice tests lead to higher intervention effects than open response formats. Therefore, standards for measuring student achievement in school relevant intervention studies are discussed. Further research could investigate the interaction of test and instruction aspects.

Knowledge Building in Undergraduate Molecular Genetics: Exploring Student Knowledge Integration and Mechanistic Reasoning

Katelyn Southard, University of Arizona, ksouthard@email.arizona.edu

Tyler Wince, University of Arizona

Molly Bolger, University of Arizona

**ABSTRACT:** The study of molecular genetics is focused on understanding complex, multi-leveled phenomena. While experts utilize domain-specific forms of reasoning to flexibly construct mechanistic explanations for these phenomena, undergraduate biology students must develop these forms of reasoning as they learn new ideas in this domain. We propose a framework that may be used to study the process of knowledge integration among undergraduate biology majors. Subjects in this study included students from both introductory and upper division molecular genetics courses. We utilized a mixed methods approach. Statistical analysis of student responses to content knowledge assessments and student produced concept maps was conducted. Qualitative analysis of recorded student interviews was used to examine domain-specific reasoning strategies that were associated with distinct levels of knowledge integration about targeted biological mechanisms. Through combined analysis of these three measures, we uncovered significant differences between introductory and upper division students in terms of basic conceptual understanding and interconnectivity of ideas, and developed a cognitive characterization of four levels of knowledge integration in molecular genetics. Findings suggest

that organization of ideas into appropriate and functionally based modules, using domain-specific mechanistic reasoning strategies, is critical for the development of expert-like understanding among undergraduate molecular genetics students.

Visual Cueing and Feedback Influencing Undergraduate Students' Reasoning Resources on Conceptual Physics Problems

Jeffrey W. Murray, Kansas State University, jwmurray@ksu.edu Amy Rouinfar, Kansas State University Elise Agra, Kansas State University Adam M. Larson, University of Findlay Lester C. Loschky, Kansas State University N. Sanjay Rebello, Kansas State University

**ABSTRACT:** Research has demonstrated that attentional cues overlaid on diagrams and animations can help students attend to the pertinent areas of a diagram and to facilitate problem solving. In this study we investigate the influence of visual cues and correctness feedback on students' ability to activate and coordinate the cognitive resources that they currently possess. The participants (N=90) were enrolled in an algebra-based physics course and were individually interviewed. During each interview students solved four problem sets each containing an initial problem, six isomorphic training problems, and a transfer problem. The cued conditions were given visual cues on the training problems, and the feedback conditions were told whether their responses (answer and explanation) were correct or incorrect, but the interviewer did not distinguish whether the source of their incorrectness was because of their explanation, or their answer. We found that the combination of both correctness feedback and visual cueing, were the most effective means to assist participants in not only the activation of the proper reasoning resources to successfully solve the problems, but also in the coordination of those resources.

Strand 2: Science Learning: Contexts, Characteristics and Interactions *Argumentation, Discourse, and Reading as Inquiry* 1:00pm-2:30pm, Rivers **Presider:** Tamara L. Clegg, University of Maryland

#### Student Navigation of Novel Science Practices and Discourse

Monica C. Mobley, The University of Tennessee, mclutch@gmail.com

Mehmet Aydeniz, The University of Tennessee

**ABSTRACT:** Student immersion into authentic scientific practices is central in science education reform and figures prominently in recently released Next Generation Science Standards as well as the Common Core State Standards (CCSS, 2010). With PARCC testing set to begin in 2014, school districts are increasingly pressured to meet NGSS and CCSS learning goals. Many states are already moving to implement NGSS and CCSS through mandatory curriculum inclusion. Meeting these standards as written for science courses requires students to participate in rigorous scientific argumentation with emphasis upon identification of claims, counterclaims, and evidence. While NGSS emphasize both modeling and argumentation, CCSS standards for science literacy are centered in argumentation. This study investigated students in two college-preparatory Chemistry classes as they navigated participation in a modeling and argumentation activity for the first time. Findings of the case study suggest that framing and context as well as teacher facilitation are critical components for productive scientific discourse to occur.

Scientific Argumentation for All? The Relationship between Teacher Beliefs about Argumentation and Student Socioeconomic Status

Rebecca Katsh-Singer, Boston College, katsh@bc.edu

Katherine L. Mcneill, Boston College

Suzanna Loper, University of California - Berkeley

**ABSTRACT:** Ensuring all students have opportunities to engage in scientific argumentation is a key goal of the Framework for K-12 Science Education. While research has shown that teachers' beliefs about argumentation can impact their classroom instruction, and that students in low SES schools are less likely to experience challenging science

learning, there is little research focused on the relationships between teachers' argumentation beliefs and student SES. As such, in this study we explored the scientific argumentation beliefs of teachers in low, mid, and high SES schools. Participants were 34 middle school teachers piloting a curriculum that included a focus on scientific argumentation. Our data sources included a survey that all teachers completed and an interview in which 20 of the 34 teachers participated. While our analyses suggest that teachers in all types of schools believe argumentation is important for their students, we also observed some differences between the teachers in high, mid, and low SES schools related to teachers' beliefs about student capability to engage in argumentation and their beliefs about the impact of state standards and tests on their argumentation. These findings point to the types of supports teachers may need to engage all their students in argumentation.

### *ELL Student Engagement in Argumentation Practice—Science Agency and Identity* Suna Ryu, UC Berkeley, sunaryu@ucla.edu

**ABSTRACT:** Researchers have increasingly advocated for the critical role of student engagement in scientific argumentation. Such focus on participation in argumentation, however, may create more challenges for ELLstudents because scientific argumentation may increase existing cultural gaps. From sociocultural approach to Discourse, engagement in scientific argumentation has a close relationship with their science agency and identity. In this study, the construct of epistemic agency and identity provides a way other than just academic language skills to account for how and why ELL students are (un)successful when participating in scientific argumentation. A year-long, qualitative case study design was used. Classroom video data, field notes, interviews, and two students' artifacts were collected. Critical discourse analysis and constant comparative approach were used to uncover the relationships between agency and engagement in scientific argumentation. Findings suggest that the authoring of epistemic agency and identity seemed to have significant influence on engagement in scientific argumentation. Social dynamics and cultural resources affected the building and expression of agency and identity. Focusing on the cognitive aspects (e.g. academic language acquisition and science content knowledge) alone might not be sufficient when accounting for ELL students' successes or difficulties, particularly when it comes to promoting active engagement in scientific argumentation.

# Intellectual Emancipation through Reading as Inquiry in Elementary Science Lorraine Otoide, York University, LOtoide@edu.yorku.ca

**ABSTRACT:** Intellectual Emancipation Through Reading as Inquiry in Elementary Science This paper addresses the correlation between science inquiry and "hands-on-activity", an association that does not reflect the importance of learning to read and write in science for meaningful learning and for the development of scientifically literate independent and autonomous thinkers. This study reconceptualizes traditional science education pedagogy in an elementary school classroom by theorizing science inquiry and science literacy using Rancière's (1991) concept of intellectual emancipation as expressed in the Ignorant School Master. The paper explores the emancipatory possibilities afforded by inquiry through interactions with science texts and describes an intervention that adopts a dynamic view of science inquiry that focuses on the development of student's personal growth, and the creation of their own knowledge and learning experiences.

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

Nature of Science and Attitudes toward Science and Scientists

1:00pm-2:30pm, King's Garden 3

Presider: Sarah Michaels, Clark University

### Third Grade Latino Students' Views of the Nature of Science

Leon Walls, University of Vermont, lwalls@uvm.edu

**ABSTRACT:** This study examined the nature of science (NOS) views of lower elementary grade level students, including their views of scientists. Participants were 24 third-grade Latino students from a large Southwestern urban settings. A multiple instrument approach using an open-ended questionnaire, semi-structured interviews, a modified version of the traditional Draw-A-Scientist Test (DAST), and a simple photo eliciting activity, was employed. The study sought to capture not only the students' views of science and scientists, but also their views of themselves as users and producers of science. The findings suggest that the young Latino children in this study hold very distinct and often unique

views of what science is and how it operates. Included are traditional stereotypical views of scientists consistent with previous research. Additionally, participants expressed excitement and selfefficacy in describing their own relationship with science, in and outside of their formal classrooms. Implications for teaching and learning NOS as it relates to young children and children of color are discussed.

### Assessment of Precollege Qatari Students' Attitudes toward Science

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

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Michael Culbertson, University of Illinois at Urbana-Champaign

**ABSTRACT:** This study reports on a large-scale project focused on identifying and assessing factors that impact precollege Qatari students' attitudes toward science. Qatar, an Arab nation located on the Persian Gulf, represents a particularly notable location for research into students' attitudes due to its progressive stance toward, as well as substantial investments and wide-ranging efforts to join, a 21st century knowledge economy (Qatar Foundation, 2009). The Qatari reform initiative "Education for a New Era," launched in 2002, outlined a sweeping, multi-step plan to rejuvenate the Qatari educational system (Zellman et al., 2007). The existing educational system was considered excessively rigid and outmoded with an emphasis on traditional instructional practices (i.e., rote memorization). The Qatari students' Interest and Attitudes toward Science (QIAS) project, employing a cross-sectional design and representative national sample, aims to assess students' attitudes toward science in grades 3–12, in the wake of these reforms, and examine the relationship between these variables and prevailing modalities of science instruction in precollege Qatari schools. Analysis of 3,027 responses to the ASSASS (Arabic Speaking Students' Attitudes toward Science Survey) revealed that students' attitudes toward science decreased, on average, by 0.049 standard deviations per grade level.

### Students' Uncertainty during Exoplanet Detection Tasks

Zoe E. Buck, University of California Santa Cruz, zbuck@ucsc.edu

Hee-Sun Lee, University of California, Santa Cruz

Joanna Flores, University of California, Santa Cruz

**ABSTRACT:** We explored how students are articulating uncertainty within the various elements of a scientific argumentation task around detecting exoplanets, and the relationship between the way the task is presented and the way students are articulating their uncertainty. We found that (1) while the majority of students did not express uncertainty in either their open-ended explanation (no explicit uncertainty prompting) or scaffolded uncertainty rationale (explicit uncertainty prompting), students were more likely to express scientific uncertainty in their explanations, without explicit prompting, (2) scaffolded uncertainty rations and rationales revealed a measure of students' personal confidence, rather than uncertainty related to science, and (3) if a task presented noisy data, students were less likely to express uncertainty in their explanations.

# Probing the Structure of Students' Attitudes towards Science: a Hong Kong Study at Senior Secondary Level May May Hung Cheng, The Hong Kong Institute of Education, maycheng@ied.edu.hk

### Zhi Hong Wan, The Hong Kong Institute of Education

**ABSTRACT:** Although there has been extensive research investigating students' attitudes towards science in the last four decades, little has been done to probe the internal structure of attitudes towards science itself. In the present study, the Structural Equation Modeling (SEM) method was adopted to compare five hypothetical models of attitudes towards science. The participants were 305 senior secondary school students in Hong Kong. Findings reflect that (i) the data consistently supported the three-factor structure of the practice dimension of attitudes towards science; (ii) four lower-level dimensions of attitudes towards science (i.e., value of science in society, self-concept in science, anxiety towards science, and enjoyment of science) could be further integrated; (iii) teachers' practice had a closer relationship with the practice component of students' attitudes towards science than the cognition and affect components; and (iv) compared with the relationship dimension, the pedagogy dimension of teachers' practice had a closer relationship with students' attitudes towards science.

Exploring Aboriginal Students' Perceptions of Science and Scientists Using the Draw-a-Scientist Test Wanja Gitari, University of Toronto, wanja.gitari@utoronto.ca Isha Decoito, York University

Stefano DiTommaso, University of Toronto

**ABSTRACT:** Stereotypical images of science and scientists have emerged from the research using the Draw-A-Scientist-Test (DAST), and these images have been found to be stable across time, age groups, gender, and culture. These perceptions have been shown to be influenced by gender, culture, and instructors' views on science. Since Aboriginal cultures have a different approach to scientific inquiry and learning, of particular interest is how this may have impacted Aboriginal students' perceptions of science and scientists. Using the DAST and interviews, this mixed-methods study explored Aboriginal students' views of science and scientists in an Aboriginal school in Eastern Ontario, Canada. Findings reveal that the drawings do not reflect images or environments that are highly relevant to Aboriginal students. There remains much to be done to ensure students are able to engage in meaningful science learning that is compatible with, and complementary to their cultural experiences, in order to bolster Aboriginal student interest and participation in scientific disciplines.

### Strand 2: Science Learning: Contexts, Characteristics and Interactions *Scientific Discourse and Dialogues*

1:00pm-2:30pm, Heinz

Presider: Katrien Van Der Hoeven Kraft, Mesa Community College

Exploring the Impact of Reality Pedagogy: Understanding its Implementation on Urban Immigrant Students Tanzina Taher, Columbia University, Teachers College, tt2137@columbia.edu

Felicia Moore Mensah, Teachers College, Columbia University

Christopher Emdin, Teachers College Columbia University

**ABSTRACT:** This ethnographic case study follows two urban immigrant students in their yearlong journey in an urban science classroom where the first two pedagogic tools of reality pedagogy, cogenerative dialogue, and coteaching were implemented. This study examines the role reality pedagogy plays in the science classroom lives of these two students, while focusing on their social capital and how distributed cognition is used to frame understanding. The three emergent themes that were generated and observed among the two participants indicated that the implementation of the first two tools of reality pedagogy increased the two immigrant students' participation with the classroom, increased opportunities for voice in the classroom, and increased ability to access the human and physical resources of the classroom for the participants' own benefit. The study revealed that both students' social capital was impacted and the frame of distributed cognition played a role in their science classroom participation.

Between the Lines: The Role of Curriculum Materials and Teacher Language in Communicating Ideas about Scientific Modeling

Carrie-Anne Sherwood, University of Michigan, casher@umich.edu Carrie Allen Bemis, University of Colorado - Boulder Savitha Moorthy, SRI International Cynthia D'Angelo, SRI International Tina Stanford, SRI International Christopher J. Harris, SRI International

**ABSTRACT:** Classroom discourse, specifically, the language teachers use to communicate science content is significant for the meaning it can convey to students both about science content and about the nature of science and science practices, such as developing and using models. Although teachers recognize the importance of incorporating explicit modeling instruction into their classrooms, they experience many challenges when attempting to enact the kind of reform-based instruction described in the Framework and NGSS. Therefore, most modeling "instruction" happens implicitly through teachers' language as students engage in a modeling activity, and the conceptions communicated in this way may provide students with inaccurate views of the nature of models and modeling in science. By examining teacher language during model-based activities, we interrogated both what teachers were communicating both explicitly and

implicitly to their students about the nature of models and modeling as science practice, and to what extent this language was supported by a reform-based curriculum. This study addresses calls for further research on teachers' discursive practices in model-based classrooms, and further contributes to this work by examining the role of teacher language in communicating ideas about the practice of scientific modeling.

Are African Children's Interest and Achievement in Primary Science Influenced by Dynamics of Classroom Interaction?

Rasheed Sanni, Lagos State University, Nigeria, riosan1@yahoo.co.uk Peter A. Okebukola, Lagos State University Kennedy O. Akudo, Lagos State University Yinka Orulebaja, Lagos State University Lateef Shekoni, Lagos State University Kemi Akinsanya, Lagos State University Olatunde Lawal Owolabi, Lagos State University Ayodele Ogunleye, University of Lagos Sunday O. Banjoko, Lagos State University Francis Onoriode, Lagos State University

**ABSTRACT:** This study peered into the dynamics of classroom interaction in primary science and explored linkages with interest and achievement of pupils in science. Using a mixed-method design, we case studied science lessons in a classroom of 23 pupils (mean age of 8 years) in a primary school in Lagos State, Nigeria over a three-month period. The instruments for data collection included observation schedule, pupils' and teacher's interview schedules, achievement tests and pupil's interest in science questionnaire. Classroom dynamics were mapped. Data showed that the quality and quantity of traffic of teacher-pupil classroom communication impacted on pupils interest and achievement in science. Our findings also revealed that three forms of Initiation Response Evaluation (IRE) sequences – simple IRE, extended IRE and enhanced IRE sequences were useful in describing the patterns of interaction in the primary science classes. Interview and observational data confirmed that teachers' knowledge deficiency – content and pedagogy – was mostly accountable for underachievement of the pupils in science, as the learners were found to the enthusiastic about, and have positive attitude to, the subject. Suggestions for improving the delivery of science in a way that will foster the interest and achievement of pupils in science are made.

Assessing the Quality of Classroom Discourse and Interaction in Science Teaching

Eric Berson, Stanford University, eberson@berkeley.edu Jonathan Francis Osborne, School of Education, Stanford University Hilda Borko, Stanford University KC Busch, Stanford University

Edit Khachatryan, Stanford University

Susan Million, Stanford University

**ABSTRACT:** In this paper, we develop a theoretically-based model for evaluating the quality of classroom discourse in science classrooms. Typically classroom discourse in science classrooms is dominated by a sequence of initiation by a teacher question, a short phrase like student response followed by a teacher evaluation. Such discourse rarely demands more than the lower order cognitive skills of recall and comprehension. Yet learning occurs by enabling students to engage in discourse that requires students to participate in the discursive acts of describing, explaining, predicting, arguing, critiquing and defining. Therefore, improving the quality of discursive interactions has substantial potential to improve the quality of student learning. In this paper, drawing on work in a range of other subject disciplines and empirical research we develop a model for the features of quality discourse and its rationale. The model has been tested for its validity by observations against a corpus of 116 videos of elementary teachers teaching science and we report the outcome of these tests.

### Strand 5: College Science Teaching and Learning (Grades 13-20) *Investigating Students' Understandings in College Science Courses* 1:00pm-2:30pm, Benedum **Presider:** Annette Kankelborg, Montana Tech

Assessing College Students' Interdisciplinary Understanding in Sciences Ji Shen, University of Miami, ji.shen1221@gmail.com Ou Lydia Liu, Educational Testing Service Shannon Sung, University of Georgia

**ABSTRACT:** College science education needs to foster students' habit of mind beyond disciplinary constraints. However, little research has been devoted to assessing students' interdisciplinary understanding. To address this problem, we formed a team of experts from different disciplines to develop interdisciplinary assessments that target introductory college-level science. We started our project by focusing on osmosis, a topic that involves knowledge from multiple science disciplines. We developed an instrument on this topic and administered it to three classes of college students. A Rasch partial credit analysis showed that the items demonstrated satisfactory psychometric properties. The findings also revealed the differences between students' basic and interdisciplinary understanding. The educational implications of the study were discussed.

Student use of Feedback from Written Formative Assessment

Shannon M. Burcks, University of Missouri, burckssm@missouri.edu

Marcelle Siegel, University of Missouri-Coluimbia

Jayleenkumar Patel, University of Missouri

Charlotte Phillips, University of Missouri

David Emerich, University of Missouri

Phuong Dung Nguyen, University of Missouri

**ABSTRACT:** Assessment and writing are powerful tools that can be used formatively to enhance student learning (Black & William, 1998; Champagne & Kouba, 2005; Shepard, 2000). However, there is little research on how students use feedback. In this study we aim to understand how undergraduate biochemistry students utilize formative feedback to increase their ability to communicate their own scientific understanding through writing. Therefore, our research question is: How does formative feedback in Writing-to-Learn assignments impact students' abilities to effectively communicate their science understanding in an undergraduate biochemistry program? We conducted an in-depth examination of written student assessments. Extensive formative feedback was provided through written comments and a rubric. Data sources included two assignments that consisted of two 1- page written drafts discussing key conceptual questions from two hundred college freshman and sophomore biochemistry students. Our findings were organized around the themes: Content Knowledge, Conceptual Understanding and Effective Communication (Reynolds et. al., 2012). We found that most students were able to use formative feedback to demonstrate two of the three focus areas in our conceptual framework. These categories are interrelated key features in understanding science and directly impact students' abilities to effectively communicate their science understanding.

Disciplinary Foundations of Solving Interdisciplinary Scientific Problems

Dongmei Zhang, The University of Georgia, dongmei@uga.edu

Ji Shen, University of Miami

Barbara A. Crawford, The University of Georgia

**ABSTRACT:** Science education has the responsibility to enhance students' ability of problem-solving, including solving interdisciplinary scientific problems. Although much research has been conducted on discipline-based problem-solving, little research has been done on how students solve interdisciplinary problems. Many questions remain unanswered such as how students' disciplinary learning experiences influence their interdisciplinary problem-solving and how their attitudes towards specific disciplines interact with their attitudes toward interdisciplinary approaches. To address these questions, we conducted an interview study with sixteen graduate students and asked them to solve two interdisciplinary science problems on the topic of osmosis. Through a careful content analysis of these interviewees' responses, we studied how disciplinary, cognitive, and affective factors influenced their interdisciplinary problems-solving. We found that

participants' prior discipline-based science learning experiences had both positive and negative impact on their interdisciplinary problem solving. These impacts were embodied in their conceptualization of the interdisciplinary problems, the strategies they used to integrate different disciplinary knowledge, and the attitudes they had towards interdisciplinary approach in general and specific interdisciplinary problems. This study sheds light on interdisciplinary science education by revealing the close relationship between disciplinary science learning and interdisciplinary problem-solving.

# The Influence of Preservice Chemistry Teachers' Particle Theory Understandings on their Understanding of Solution Chemistry

### Emine Adadan, Bogazici University, Turkey, emineadadan@hotmail.com

**ABSTRACT:** This mixed method study mainly explored whether the extent of preservice chemistry teachers' understanding of particulate nature of matter (PNM) affects their understanding of solution chemistry in the context of multirepresentational (MR) instruction. The ultimate goal was to describe the level of understanding about specific solution chemistry concepts held by a high PNM and low PNM group of participants before and immediately after the MR instruction. Data sources included questionnaires about the PNM and interviews on solution chemistry. Data from these sources were coded and analyzed using quantitative and qualitative methods. Results indicated a statistically significant difference between the high PNM and low PNM participants' understandings of solution chemistry both before and after instruction. Moreover, results demonstrated that when the participants were provided instruction with multiple levels and modes of representation, regardless of the extent of their PNM understandings, the majority of participants in both groups were able to develop sound understandings following the instruction. However, when the participants were involved in instruction with multiple levels but single modes of representation, results showed a considerable difference between the high PNM and low PNM participants' of understandings.

### Strand 8: In-service Science Teacher Education Conversations about Teacher Learning

1:00pm-2:30pm, Duquesne **Presider:** Tirupalavanam G. Ganesh, Arizona State University

### Learning to Teach Writing in Science through a Collaborative Study Group Lori A. Fulton, University of Hawaii at Manoa, fultonl@hawaii.edu

**ABSTRACT:** Although essential to the development of well-rounded citizens, science learning is often pushed aside for instruction in reading and mathematics or due to the teacher's discomfort with science. To improve this situation, teachers need professional development opportunities that allow them to learn to value and teach science. A professional collaborative study group has the potential to help teachers better understand science instruction and value its importance. This case study examined three elementary teachers' experiences in such a study group, focusing on how they used the study group to make sense of writing in science and the influence this had on their beliefs. Data consisted of video and field notes from four study group meetings, teacher surveys, and three semi-structured teacher interviews. Results suggest that the collaborative nature of the study group supported teachers at varying levels of implementation and influenced their beliefs about science teaching. Within the study group, the teachers grappled with important ideas related to the pedagogy of reform-based science instruction.

Conversations about Learning – Unpacking What Concept Maps Tell Educators

Chad M. Huelsman, University of Cincinnati, huelsmcm@hotmail.com

Lindsay Owens, University of Cincinnati

Helen M. Meyer, University of Cincinnati

**ABSTRACT:** In an effort to provide educators with more effective professional development (PD), educational programs have used reflective interviews as part of PD process to improve teaching and learning. However, the documented use of reflective interviews in STEM PD programs to improve teaching and learning is sparse and research examining how STEM faculty and in-service teachers interpret teaching and learning with concept maps during interviews is even more limited. In this presentation, we share the results of two cycles of our mixed-methods study -- exploring how

four STEM faculty members and two in-service teachers reflected on their teaching and learning successes and challenges based on the results of pre and post-concept maps in their summer classes. Using the quantitative scoring system detailed by West et al. (2000) and interviews, we sought to understand how the faculty understood the learning that took place in their classes. Similarly, we met with in-service teachers to discuss the quantitative scores of their maps and how they interpreted the learning represented in their pre and post maps. During the interviews, we also discussed formative instructional practices used by the faculty to assist in the development and adaptation of their curriculum and instruction.

### Learning and Motivation: Successful Professional Development Program for Palestinian In-Service Elementary Science Teachers

Iyad M. Dkeidek, Al-Quds University, idkeidek@edu.alquds.edu

Ziyad M. M. Qabaja, Al-Quds University

**ABSTRACT:** Helping people to be scientifically literate has been a central goal of science education reforms in many countries such as United State of America, Canada as well as in Turkey. With respect of this goal these countries have tried to make core changes in their science curricula and teacher training programs in recent decades in order to prepare scientifically literate people. In addition, technological developments and changes have altered pedagogies in classroom teaching but approaches to teacher professional development have remained largely unchanged. The purpose of current research is to describe a unique professional development program that was consisted from more than one element, it included face-to-face meeting, an on-line forum, a field visits, and a learning circles. This combination improves the effect of change in both CK & PCK of the trained novice teachers.

# Teachers' Perceptions of Working Conditions and Workplace Learning in the Context of China's Educational Reform

Chunlei Zhang, East China Normal University, lukezhg@gmail.com

### Enshan Liu, Beijing Normal University

**ABSTRACT:** In this study, an instrument Science Teacher Workplace Learning Survey (STWLS) was developed and sent out during an online teacher training session, 543 valid records were received. Exploratory factor analysis results showed that the teachers' perception of work conditions and learning included four factors: School Support, Application of ICT, Practice Reflection and Peer Collaboration. One-way ANOVA analysis showed that there were significant differences in teachers' scores between different teacher groups, such as different school contexts and teacher characteristics. The finding from this study suggested that biology teachers' characteristics do affect their perception of working contexts and workplace learning behaviors. This finding is different from Hirsch and Emerick's (2006) conclusion. And there is a modest positive correlation between teachers' perception of working contexts and teachers' learning. The instrument STWLS is sensitive to both environmental and personal characteristics. It can be a useful tool for assessing teachers' workplace learning. As there are significant differences in teachers' perceptions of working conditions and learning behaviors, a variety of supportive programs meeting teachers' special needs will be more helpful than unified training program. The result also suggests policymakers need to provide more supports to schools where teachers have lower perceptions of their working conditions.

# Behind the Scenes of a Professional Development Program: Teachers' Experiences in Engineering Research Nancy P. Morabito, St. John's University, morabitn@stjohns.edu

**ABSTRACT:** Recent movements in science education reform focus on providing opportunities for students to engage in the practices of science and engineering. Unfortunately, the teachers who are responsible for providing students with such opportunities may lack experience with these practices. Professional development programs aimed at providing K-12 science teachers with opportunities to participate in authentic science and engineering research environments are plentiful and may help address this gap. Despite the existence of these programs, there is a dearth of data describing the specific experiences of the teachers participating in them. Therefore, this comparative case study explores in depth the individual experiences for Teachers (RET) in Engineering. Differences in the experiences of these programs. Implications of such variation for program design are discussed with respect to teacher engagement in and learning about the practices of science and engineering.

### **Strand 8: In-service Science Teacher Education** *Elementary Teacher Professional Development* 1:00pm-2:30pm, King's Garden 2

Presider: Heidi Wiebke, Indiana University

# *Exploring the Relationship between Science Teaching Self-Efficacy and Reformed Teaching Practices of Inservice Elementary Teachers*

Corinne H. Lardy, San Jose State University, corinne\_lardy@yahoo.com

**ABSTRACT:** In this study, I examined the relationships among Personal Science Teaching Efficacy (PSTE) beliefs, observed science teaching practices, and the beliefs about these practices within a nationwide diverse sample of inservice elementary teachers. Data were collected from thirty-eight teachers using the Reformed Teacher Observation Protocol (RTOP), semi-structured interviews, and the Science Teaching Efficacy Beliefs Instrument (STEBI-A). Coded qualitative data and quantitative survey data were analyzed in order to compare the beliefs and practices regarding science teaching within and across PSTE levels. In addition, case profiles of eight teachers with varying levels of PSTE and RTOP scores were examined in closer detail. Results revealed that many positive behaviors commonly associated with greater science teaching self-efficacy, especially giving students more control over their own science learning, did manifest themselves in participants' beliefs about science teaching. However, many of these beliefs did not align with actual observed classroom practices. Interviews and observations of case profile teachers revealed how self-efficacy levels manifested themselves in different ways with different teachers. While there do appear to be some overall advantages to increasing elementary teachers' science teaching self-efficacy, the situation is much more complex than it is sometimes portrayed in the literature.

# Statewide Elementary Science Institute to Support Reforms-based Science Instruction: Results from Three Years of Implementation

Randy L. Bell, Oregon State University, randy.bell@oregonstate.edu

### Jennifer L. Maeng, University of Virginia

### Tyler L. St. Clair, Oregon State University

**ABSTRACT:** This investigation characterized the experiences of elementary science teachers enrolled a research-based statewide professional development program. We assessed changes in participants' understanding of and confidence in implementing problem-based learning (PBL), nature of science (NOS), and inquiry instruction. Participants included 195 elementary teachers (3 cohorts). Data consisted of responses to pre-/post Perceptions surveys and interviews, pedagogical content knowledge surveys, and classroom observations, with the goals of eliciting participants' professional development experiences and their understandings and intentions to implement PBL, NOS, and inquiry instruction. Preliminary analysis suggested that participants perceived positive changes in their understandings of the program's key objectives. Participants also experienced substantive improvements in their proficiency in implementing PBL, NOS, and inquiry instruction. Additional results reflected participants' perceptions of positive and negative aspects of the professional development experiences. Ultimately, the results of this investigation may inform science teacher preparation and professional development that supports implementation of PBL, NOS, and inquiry instruction by in-service elementary science teachers. Future research will explore the extent to which the interplay between this and other PD components facilitated the development of a state-wide infrastructure to support reforms-based science instruction.

Intervention's Effect on Teacher Change in Elementary Science Teaching with English Learners: Year 1 Results Shameka K. Hollimon, New York University, sh137@nyu.edu Okhee Lee, New York University Feng Jiang, New York University Alison Haas, New York University

**ABSTRACT:** This study examined elementary school teachers' knowledge and practices in teaching science to diverse student groups, especially English learners (ELs), across three urban school districts in one state. As part of a three-year professional development intervention, the study examined the effect of the intervention on teachers' perceptions of their science knowledge and teaching practices after their first year of participation. Using stratified random selection and

random assignment within each school district, the study involved 129 fifth grade teachers from 33 schools participating in the intervention and 136 fifth grade teachers from 33 control schools. At both the beginning and end of the first year of implementation, the teachers completed a questionnaire addressing the five domains of teaching science to ELs: (a) teacher knowledge of science content, (b) teaching practices to promote scientific understanding, (c) teaching practices to promote scientific inquiry, (d) language development strategies, and (e) home language use. Results revealed that, after one year of implementation, the intervention had a positive impact on teaching practices for understanding and language development strategies in the treatment group. Additionally, teachers' responses were found to be related to their demographic and professional background at both the outset and conclusion of the first year.

### Changes in Pedagogical Content Knowledge Brought About by Teacher Professional Development in Elementary Science

Joan I. Heller, Heller Research Associates, jheller@edservices.org Kirsten Daehler, WestEd

### Luke W. Miratrix, Harvard University

**ABSTRACT:** Findings are reported from a randomized experimental study in which three in-service teacher professional development courses significantly improved elementary student science achievement. This paper examines the first link in a causal chain from PD to student outcomes—direct effects on teacher knowledge. The three courses all had identical electric circuits content and collaborative science investigations, but different approaches to developing pedagogical content knowledge (PCK), including discussions of written cases (Teaching Cases), analysis of student work from teachers' current classes (Looking at Student Work), and reflection on teachers' own science learning (Metacognitive Analysis). Findings from 283 teachers showed that (a) only Teaching Cases and Looking at Student Work improved teacher PCK, (b) impact on student test scores is only partly accounted for by teachers' content knowledge and is significantly predicted by teacher PCK, and (c) the Teaching Cases course was especially effective at increasing teachers' explicit focus on conceptual learning goals for students, references to engaging students in active roles, and strategies for helping students make sense of science ideas. The findings suggest that districts invest in PD that integrates teacher content learning with analysis of teaching and learning.

A Hybrid Learning Mathematics and Science Partnership, Teacher Academy in the Natural Sciences (TANS): Blended Instructional Model for Effective Professional Development

Renee M. Clary, Mississippi State University, rclary@geosci.msstate.edu

James Dunne, Mississippi State University

Svein Saebo, Mississippi State University

Anastasia Elder, Mississippi State University

Deborah Tucker, Independent Science Education Consultant, Napa, CA

Debbie Beard, Mississippi State University

Charles Wax, Mississippi State University

Joshua Winter, Mississippi State University

**ABSTRACT:** Our Hybrid Learning Mathematics and Science Partnership (HaLs) implemented interdisciplinary science professional development workshops over a three-year period for middle school science teachers (n = 52, 52, 48 for years 1-3; N = 81 total ), who were provided specialized science content training in 1) chemistry, 2) geosciences, and 3) physics. Each summer, three groups of teachers participated in intensive instruction in one discipline. Groups rotated between sciences in subsequent summers so that ideally each teacher received in-depth training in all three content areas. The HaLs model included both face-to-face instruction (10 summer days, 3 academic days), with content extended through online science modules that are administered by a national science teachers' organization. Analyses revealed significant improvement in participating teachers' content knowledge (through institution-generated assessments, and online science module assessments). Analyses of teacher surveys also revealed positive impacts from the program. However, some HaLs content attrition occurred each year for some participants between the intensive summer instruction and the last academic workshop. Control teachers' data (N = 50) revealed no gains, and students of HaLs teachers performed better than students of non-HaLs teachers. The long-term effect of HaLs participation on teachers and their students is yet to be determined.

### **Strand 8: In-service Science Teacher Education**

# *Related-Paper Set – Impact of Science Professional Development on Student Learning: Four Studies Awaken Dialogue*

1:00pm-2:30pm, Sterlings 2 & 3 **Presider:** Kathleen Roth, BSCS

Discussant: Suzanne Wilson, University of Connecticut

**ABSTRACT:** This paper set presents four studies of science teacher professional development that examine the impact of PD on student learning as well as on teacher learning and practice. The studies represent PD programs with different conceptual frameworks and different methodological approaches, and they target teachers at different grade levels (elementary, middle, high school). But all of these studies look carefully at the relationship between PD, teaching, and student learning. The session will begin with anintroduction that highlights the theme of the paper set. After presentations of the four studies, there will be a discussion focused on these questions: 1. Does the student learning data from these studies provide (or show promise of providing) new understandings of effective PD? If not, why not? What kinds of data would be more informative for PD developers and providers? 2. What does each project reveal about the mechanism by which students are affected by PD and the conditions under which PD can best affect student outcomes? 3. What are the difficulties or barriers in this kind of research? 4. What do we as a field need to know about effects on student learning in order to improve science teacher professional development?

Impact of Videocase-based Lesson Analysis Professional Development on Teacher and Student Science Learning Christopher Wilson, BSCS, cwilson@bscs.org Joseph Taylor, BSCS Kathleen Roth, BSCS

Creating Effective, Sustainable Inquiry-Based Instruction in Middle School Science Classrooms Jeff C. Marshall, Clemson University, marsha9@clemson.edu

Learning Science as Inquiry with the Urban Advantage: Documenting the Effects of Professional Development on Teachers and Their Students Suzanne Wilson, University of Connecticut, Suzanne.wilson@uconn.edu James Short, American Museum of Natural History Jamie N. Mikeska, ETS Suzanne Elgendy, American Museum of Natural History

An Experiment Comparing Face-to-Face and Online Professional Development Effects on Teacher Learning, Practice, and Student Learning Beth W. Kubitskey, Eastern Michigan University, mkubitske1@emich.edu Barry Fishman, University of Michigan G. Park, University of Michigan Heather J. Johnson, Vanderbilt University Richard Vath, University of Michigan Spyros Konstantopoulos, Michigan State University

### Strand 10: Curriculum, Evaluation, and Assessment *Curriculum Evaluation* 1:00pm-2:30pm, Sterlings 1

# Cedar STEM High School: Connecting a Rigorous Early-College Curriculum with Mastery and Experiential Learning

Edmund M. Han, The George Washington University, edmundhan@gmail.com Sharon J. Lynch, The George Washington University Ann House, SRI International

**ABSTRACT:** This paper presents findings from a case study of Cedar STEM High School (CSHS, a pseudonym), an inclusive STEM-focused high school. With its well-established connections to the neighboring university, an industry partner, and the state STEM network, CSHS engages its students with a rigorous STEM-focused and early-college curriculum. The school has a strong record of student success, especially for students under-represented in STEM, including first-generation college goers, low-income students, and students of color. In particular, CSHS's educational program provides the crucial opportunity structures needed to support student success in STEM fields in high school, college, and beyond. Not only do 100% of CSHS's students graduate, many with two years of college credits earned, but they also enter college better prepared to succeed at handling the advanced work and increased workload. Such opportunity structures are not likely feasible at the classroom level alone, and CSHS is an excellent example of a school with a cohesive alignment across its innovative classroom practices, school-level reform initiatives, and partnerships with the university and other industry stakeholders in the state. This alignment provides a far more ambitious and extensive platform for innovation than can be found at most schools in the United States.

### *Evaluating the Impact of a School Improvement Program in Students' Science Learning* Melina Furman, Universidad de San Andres, Argentina, melifurman@gmail.com Maria E. Podesta, Universidad de San Andres, Argentina

**ABSTRACT:** Over the last decades, Latin American students have performed poorly in science both in national and international tests. PISA and other international examinations have shown, as well, the profound inequalities present in the region school systems. This scenario has led to different efforts in school improvement with the aim of fostering student learning in science, most of which have not been evaluated. In this study, we analyze the case of Bicentennial Schools, a 4-year school improvement program for elementary schools attending vulnerable populations of Argentina. We look at the results of the first 86 elementary schools that took part of the program. In doing so, we analyze 4th grade students science test results, both at the beginning and at the end of the intervention. Our findings show a significant level of positive change in student learning in all 5 states participating in the program. We also observe significant differences at the school level, which open the door for future analysis. Our findings point towards the urgent need of evaluating educational efforts in Latin America in order to build a solid foundation for school reform.

*'Sustainability Thinking' in the S-T-E-S-E-P Context: From* Uri Zoller, Haifa University - Oranim, uriz@research.haifa.ac.il David Ben-Chaim Naji Kortam Tami Levy Nahum

**ABSTRACT:** Given the current striving for sustainability and the corresponding paradigms shift in science, technology, R&D, environment perception, economy and politics; e.g., from unlimited growth-to-sustainable development, correction-to-prevention and passive consumption of "goods", culture and education-to-active participation, primarily in the science-technology-environment-society-economy-policy (S-T-E-S-E-P) contexts, the corresponding paradigms shift, at all subject matters, types and levels of education is unavoidable. These require paradigms shift in conceptualization, thinking, research and policy in science and STES/STEM education, particularly concerning the science-technology-environment-society interfaces. Consequently, 'STESEP literacy' for 'sustainability thinking' requires the research-based development of students' question asking, evaluative thinking, decision making, problem solving and transfer capabilities via the corresponding higher-order cognitive skills (HOCS)-promoting teaching, assessment and learning to THINK strategies. We have conducted 3 years and 2 semesters pre-post designed research projects in secondary school (grades 10-12),

higher education freshmen (biology) and master degree courses (non science majors) in the Israeli educational system. All courses studied focused on natural resources and the environment, primarily on water, air and the environment-health relationships. Our research results suggest that via purposed HOCS-promoting teaching, assessment and learning strategies the goal of 'sustainability thinking' is attainable.

# *Putting Physics First: Four Case Studies of High School Science Department and Course Sequence Reorganization*

Douglas B. Larkin, Montclair State University, larkind@mail.montclair.edu

**ABSTRACT:** The "Physics First" movement in the United States is a loose coalition of scientists and educators who seek to place physics as the first curricular offering in high school, usually ahead of chemistry and biology. This study examines the different ways in which Physics First is conceptualized and operationalized by school and district personnel in four school districts in the U.S., and examines the local contextual factors (curricular, district, school, and classroom) that influence the adoption of a Physics First approach. Findings from the four case studies in this work, include agreement across districts about Physics First as the realignment of the high school curricular sequence, but less consensus about other details such as how these programs are aligned with mathematics or whether they ameliorate or magnify inequities in schooling. The logistics of rearranging the course sequence was strongly influenced by the size of the school. This study details how Physics First does not represent one particular curriculum or set of pedagogies, and how accountability pressures such as state tests played a large role in driving these reforms.

### Measurement Uncertainties: What We Should Teach Our Students

### Julia L. Hellwig, ZfsL Recklinghausen, julia.hellwig@me.com

### Burkhard Priemer, Humboldt-University

**ABSTRACT:** Measurement uncertainties are an integral part of experimental scientific work. However, school curricula and teaching practice very often neglect this topic even tough experimental work is seen as a fundamental part of teaching science. In order to bring measurement uncertainties out of their shadowy existence we developed a model that structures and describes aspects of measurement uncertainties relevant for secondary school science classes. It contains nine basic concepts categorized by four dimensions: (1) Existence of Uncertainties as Basic Principle, (2) Uncertainties' Influence on a Measurement, (3) Evaluation of Uncertainties, and (4) Conclusiveness of Uncertainties. The model is based on an extensive literature review, a validation by six experts in metrology, and the evaluation of 108 physics teachers. Our work provides a base for developing learning progressions and instructions to teach measurement uncertainties in schools.

### Strand 11: Cultural, Social, and Gender Issues *Identity Development and Authentic Science Experiences* 1:00pm-2:30pm, King's Garden 4

Actions Can Speak Louder Than Beliefs: Coherence in Perceived Recognition between Teacher and Student Zahra Hazari, Clemson University, zahra@clemson.edu Cheryl A.P. Cass, North Carolina State University Carrie E. Beattie

Robynne M. Lock, Clemson University

**ABSTRACT:** Prior research has emphasized the importance of recognition to science identity development, and in particular, physics identity development. In this study, we examine the coherence between students' perceptions of their physics teacher recognizing them and the beliefs of physics teachers with regards to individual students. We draw on data from four case studies of physics teachers and their classes. Our quantitative analysis reveals that one of the teachers has a different coherence pattern than the others. This teacher's students also perceived greater recognition and identified more as being a "physics person" than the students of the other teachers. Focusing in on one particular student with the lowest coherence from his class, Kristina, we examine the ways in which Dr. D's actions served to help her feel recognized - actions which superseded his beliefs about her. Our results indicate that despite his beliefs (about her and his other students on average), his actions facilitated students seeing themselves in positive ways with respect to physics. Thus, a person's private beliefs do not necessarily translate into others' perceptions of that person's public actions. Subsequently,

identity research would benefit from examining both actions and beliefs simultaneously. This work was supported by NSF grant 0952460.

The Impact of a Research Apprenticeship Program Developed for Diverse High School Students Stephen R. Burgin, Old Dominion University, sburgin@odu.edu William J. McConnell, Old Dominion University Alonzo M. Flowers, Old Dominion University Sharon M. Blythe, Old Dominion University

Tania Moran, Old Dominion University

**ABSTRACT:** This study describes an investigation of a research apprenticeship program that we developed for diverse high school students (low socioeconomic background, minority, and/or female) often underrepresented in similar programs and in science, technology, engineering, and math (STEM) professions. Through the program, students spent two weeks in the summer engaged in authentic biofuels related research within university chemistry and engineering laboratories under the mentorship of STEM professionals. The experience was supplemented by explicit/reflective nature of science (NOS) activities in addition to explorations of STEM careers and self-identity. Participants completed a NOS questionnaire before and after the experience, were interviewed three times, and were observed on multiple occasions while working in the laboratories. Findings revealed positive changes in participants ' possible STEM related futures, and a participant sense of belonging within specific laboratory groups even with the demographic differences between the student population and those mentoring them. This last outcome was related to the development of positive science self-identities among our participants. Implications include the importance of recruiting underrepresented students into authentic out-of school experiences in STEM.

Exploring Science Identity Development at the Intersection of Race and Gender

Amy DeFelice, CUNY Graduate Center, amyferguson3@hotmail.com

Jennifer Adams, Booklyn College- CUNY

Alexia Cox, Brooklyn Academy of Science and the Environment

**ABSTRACT:** Understanding sources of performance bias in science assessment provides important insights into whether science curricula and/or assessments are valid representations of student abilities. Research investigating assessment bias due to factors such as instrument structure, participant characteristics, and item types are well documented across a variety of disciplines (e.g., Halpern, 2000; Hedges & Nowell, 1995). However, the relationship between these factors is unclear for tasks evaluating students' performance on scientific practices, such as explanation. Using item response theory (Rasch analysis), we evaluated differences in gender achievement on a constructed-response (CR) assessment about natural selection (ACORNS; Nehm et al., 2012). Three isomorphic strands of the instrument were administered to a sample of undergraduate biology majors and non-majors (G1:n=662 [Female=51.6%]; G2:n=184 [F=55.9%]; G3:n=642 [F=55.1%]). Our results identified several features that appear to contribute to differential test and differential item functioning between genders, including the familiarity of taxa and the polarity of trait change. Overall, our results suggest that females may have a slight advantage on explanation task about more familiar items and males for unfamiliar items, indicating that gender differences in explanatory practice may be a result of differences in how males and females interpret and respond to combinations of item features.

Effects of an Authentic Science Experience on the Science Identities of Marginalized High School Students Angela Chapman, University of Texas - Pan American, chapmanam@utpa.edu

Allan Feldman, University of South Florida

Fayez Alshehri, University of South Florida

Dilek Ozalp, University of South Florida

Vanessa Vernaza-Hernandez, University of South Florida

**ABSTRACT:** This study examined how marginalized students were affected by participation in an authentic science experience, with regard to their perception of the authenticity of the experience, their perception about who can do science, and their science identity. It has been argued that the science achievement gap has led to the underrepresentation of female, African-American, Hispanic, and Native Americans in many STEM related careers. Studies have shown that

marginalized students do not always have access to resources needed for high quality science instruction. Also, science identity is considered an important factor when examining student success in science. The intervention and study took place at an urban science magnet high school in the southeastern US. This school has a high percentage of low socioeconomic students and a heterogeneous student population. Students engaged in an authentic science experience with a research group from an environmental engineering department at a research-intensive university. We offer evidence that marginalized students can benefit from participation in an authentic science experience as this study shows that authentic science experiences and the students perceptions about the authenticity can influence their science identity, and change their perceptions about who can do science.

### Strand 11: Cultural, Social, and Gender Issues

### *Symposium – Professional Development for Access and Equity in STEM Education: Changing Teacher and Leader Mindsets*

1:00pm-2:30pm, Smithfield **Presider:** Liesl Chatman, Science Museum of Minnesota

### **Discussants:**

Kirsten Valentine Cadieux, University of Minnesota Rachelle A. Haroldson, University of Minnesota Vivian P. Johnson, Hamline University Amy Grack Nelson, Science Museum of Minnesota Nils C. Halker II, Science Museum of Minnesota Wren Walker Robbins, Consultant Liesl Chatman, Science Museum of Minnesota Erin J. Straus, Science Museum of Minnesota Travis O. Sandland, Science Museum of Minnesota Bhaskar Upadhyay, University of Minnesota ABSTRACT: This symposium provides a theoretical foundation, research, and evaluation for how professional development (PD) using the MUSE Framework for Access and Equity in STEM Education promotes transformati

development (PD) using the MUSE Framework for Access and Equity in STEM Education promotes transformative change in K-12 education resulting in improved student outcomes, particularly in districts with rapidly changing demographics. Developed by the Science Museum of Minnesota with NSF funding, the Framework is organized around five lenses: (1) Disparities and Inequities—STEM educational outcomes, expectations, and policies; (2) Curriculum and Pedagogy—culturally relevant STEM pedagogy and curriculum. (3) Reconstructing the Nature and Culture of STEM—the epistemologies of science, technology, engineering, and mathematics and societal/cultural values and beliefs in STEM. (4) Identity—the relationship between students' identity formation and STEM learning. (5) Community Leadership—distributed community leadership in institutional transformation. External research and evaluation from the University of Minnesota and Hamline University provide strong indications of teachers' and school/district leaders' profound shifts in beliefs, values, knowledge, and preparation for equity in STEM education that they, in turn, are integrating into their professional contexts. Further, there is growing evidence the PD is resulting in significantly increased STEM achievement that is equitably distributed across student demographic groups.

### Strand 12: Educational Technology

*Cognitive and Metacognitive Support Tools* 1:00pm-2:30pm, King's Garden 1

The Impact of Using Computers as Cognitive Tools on Grade 10 Lebanese Students' Attitudes and Conceptual Understanding in Physics

Sahar K. Alameh, American University of Beirut, sahar.alameh@gmail.com Saouma B. Boujaoude, American University of Beirut **ABSTRACT:** This study investigates, using a design-based research approach, the effect of using interactive technological tools, used as cognitive tools and digital resources, on students' conceptual understanding of and attitude toward physics and sought to investigate students' opinions regarding using the tool. Thirty nine Grade 10 students in two sections in a Lebanese school participated in the study. Digital resource group students received problems to solve, with procedures provided, while cognitive tool group students were given the same experiment with exploration space to design their plans and test their hypotheses. Data sources included an electricity knowledge test (pre-test and post-test), four physics tests (administered at the end of each chapter), students' responses on the computer tool, a physics attitude scale and individual interviews. Results of the four physics tests and the posttest indicated that students in the cognitive tool group achieved significantly higher than the digital resource group regarding conceptual understanding in physics. Finally, students showed positive but differing opinions regarding the computer tool. Implications for practitioners and for further research are discussed in light of the research findings.

### *iPad Self-monitoring Supports and Science Inquiry Methods for Students with Moderate Intellectual Disability* Bridget T. Miller, University of South Carolina, btmiller@mailbox.sc.edu Steven C. Smith, Purdue University

**ABSTRACT:** The purpose of this study was to investigate the use of guided science inquiry methods with selfmonitoring checklists to support problem-solving for students with moderate intellectual disabilities in both science and functional daily activities. The present study contributes to the literature examining guided inquiry methods as a means for student with a moderate intellectual disability to 1) gain access to the general curriculum standards and 2) build selfdetermination skills, and expands on the current literature by adding generalization conditions where students apply inquiry problem solving skills to functional daily applications that may benefit them directly in post school settings (Author, 2012). The study investigates two hypotheses; H1: When provided a self-monitoring checklist, students with a moderate intellectual disability enrolled in a functional curriculum will increase their level of autonomy when completing inquiry problem-solving activities linked to science content, and H2: When provided a self-monitoring checklist, students with a moderate intellectual disability enrolled in a functional curriculum will increase their level of autonomy when presented with novel problem-solving tasks related to daily living situations. The study resulted in a rejection of both null hypotheses.

### **Strand 12: Educational Technology**

Mobile Applications in Science Education

1:00pm-2:30pm, Birmingham **Presider:** Barbara Means, SRI International

How Can a Mobile Application Change a Teacher's Practices to Support Students' Scientific Explanations? Ibrahim Delen, Michigan State University, delenibrahim@gmail.com Wan-Tzu Lo, University of Michigan, Ann Arbor Alex Kuhn, University of Michigan, Ann Arbor Jennifer Duck, The Learning Partnership Steven Mcgee, Northwestern University Chris Quintana, University of Michigan

**ABSTRACT:** Several standard documents expect middle school students develop explanations with reasoning, but some studies noted not only middle school students but also teachers struggle to create scientific explanations. Therefore a number of studies have developed software programs to help students and teachers in this hard task. In a similar vein, the Zydeco group has designed a mobile application, which enables students to collect data inside and outside the classroom and then use the data to create scientific explanations by using claim-evidence-reasoning framework. Previous technologies designed to support scientific explanations focused on how these programs improve students' scientific explanations, but these programs ignored how scientific explanation technologies can support teacher practices. Thus, to increase our knowledge about using mobile devices in education, our proposed study aims to portray a teacher's

implementations about scientific explanations when she organized two investigations by using Zydeco in a year-long study. In addition, this study also explores how change in teacher practices affect students' scientific explanations.

Continuing to Flow: Student Experience during a Scaled-Up INPLACE Mobile Game Denise M. Bressler, Lehigh University, dmb309@lehigh.edu

Alec M. Bodzin, Lehigh University

**ABSTRACT:** INPLACE is an acronym that stands for: Interdependent, Networked, Participatory Learning, Augmented, Collaborative Experience. Previous research using INPLACE mobile games in science education revealed that such games can be used to promote deeper science understanding and high learner engagement. Some researchers have found that engagement in such mobile games is related to flow. This study investigated whether player's flow experience differs by learning setting, achievement track, or gender composition of working group. In an urban school district, 68 students from sixth, seventh, and eighth grade volunteered for the enrichment activity, while 203 students from two eighth grade science classes participated in the mandatory scale-up implementation. Data included a flow experience measure collected after the game using a survey. An independent samples t-test found no significant difference (p=.94) between the flow scores from the required activity versus the enrichment activity. Additionally, a one-way ANOVA model showed no significant differences among achievement levels (p=.17). Finally, a two-way ANOVA compared flow scores of males and females from single gender and mixed gender groups, with no significant interaction effect or main effects. Findings from this study provide support that INPLACE mobile games in traditional learning settings can engage all learners in science education.

Complementary Affordances of Virtual Environments and Mobile Devices to Support Ecosystem Science Learning

Shari J. Metcalf, Harvard University, shari\_metcalf@harvard.edu Amy M. Kamarainen, New York Hall of Science

Tina Grotzer, Harvard University

Chris Dede, Harvard University

**ABSTRACT:** This research looks at the complementary affordances of virtual environment and mobile device technologies as part of a blended curriculum for middle school students learning about causal relationships in ecosystems. In EcoMUVE, students explore an inquiry-based virtual ecosystem, which provides scaffolding by simplifying tasks, reducing cognitive load, and making salient relevant features of the ecosystem. In EcoMOBILE, students use mobile devices during real world field trips, with tools to support collection of real-world observations and data, and augmented reality that structures the student's activities, provides information in context and uses location-based hotspots to direct student attention. Evidence from student audio and video recordings, worksheets and surveys demonstrates how scaffolding in EcoMUVE supported students' observation, data collection and analysis activities in a virtual experience, and how those students were then able to apply their understanding in EcoMOBILE field-based experiences.

Designing Mobile Augmented Reality and Online Discussion Activities to Scaffold Students' Socioscientific Reasoning

Hsin-Yi Chang, National Kaohsiung Normal University, hsinyichang@nknucc.nknu.edu.tw Ying-Shao Hsu, National Taiwan Normal University

Hsin-Kai Wu, National Taiwan Normal University

**ABSTRACT:** In this study we report on our development of an online inquiry curriculum that incorporates mobile augmented reality and online discussion activities to facilitate 25 ninth-grade students' learning of a socioscientific issue on nuclear energy use and radiation pollution. Situated in the second cycle of our curricular development, the study focused on examining how well the students performed socioscientific reasoning with the scaffolds we designed. Using a mixed method approach, we collected and analyzed pretests and posttests that measured students' conceptual understanding and attitudes about nuclear energy use and radiation pollution, and students' socioscientific reasoning performed during the unit. The results indicate satisfactory performances of students' conceptual understanding and socioscientific reasoning. Moreover, after the unit the students changed their attitude to more against the development of nuclear power plants. We also tested and discussed associations among the students' conceptual understanding, attitude and socioscientific reasoning.

Strand 13: History, Philosophy, and Sociology of Science Socioscientific Issues 1:00pm-2:30pm, King's Garden 5

Breadth and Depth of Socioscientific Reasoning: A New Assessment Strategy Nurcan Cansiz, Ataturk University, nurcansiz7911@gmail.com Ozgul Yilmaz-Tuzun, Middle East Technical University Troy Sadler, University of Missouri

**ABSTRACT:** This study is a part of a larger study aimed to implement a SSI-focused course and help students improve socio-scientific reasoning (SSR). Specifically it aimed to propose a new strategy to assess SSR. 24 preservice science teachers were interviewed before and after the course. The interview data was first analyzed using the assessment rubric developed by Sadler, Klosterman, and Topcu (2011) by two independent researchers. This analysis led to the development of a second rubric (named as depth rubric) to evaluate SSR in addition to the first rubric (named as breadth rubric) and a combination of the scores according to the both rubrics. The rationale behind developing the depth rubric and combining both rubrics was discussed.

*Peace, War and Science Education: Preservice Science Teachers' Belief System about a Possible Integration* Ahmet Kilinc, Abant Izzet Baysal University, ahmet tr@yahoo.com

Dundar Yener, Abant Izzet Baysal University

Fatih Aydin, Abant Izzet Baysal Üniversity

Mehmet Bahar, Abant Izzet Baysal Üniversity

**ABSTRACT:** The purpose of this research is to investigate pre-service science teachers' (PSTs) beliefs about the relationships among science, peace and war (SPW) and about SPW education. We have used 'pedagogical content beliefs' framework in order to elicit PSTs' beliefs. We have conducted semi-structured interviews with fourteen PSTs at a Turkish university. The results have showed that all of PSTs are willing to incorporate SPW education into their future science teaching. Those who have approached war and peace from humanistic perspectives are keen to focus on social aspects of war science in SPW education. In addition, those who give importance to teaching scientific concepts have emphasized pedagogical practices about conceptual understanding of the relationships among science, peace and war. Even though present study is first attempt to put these concepts together and to embed them into science education, we believe that beliefs of PSTs may be used for the development of science teacher education programs covering SPW education.

Socioscientific Issues as a Context for Promoting Middle School Students' Understanding of Nature of Science Yoonsook Chung, Ewha Womans University, venuself@naver.com

Sung-Won Kim, Ewha Womans University

**ABSTRACT:** Citizens should be sensitive to the complex and controversial SSIs, be able to make a responsible decision with evidences and empathy, and furthermore take political actions for larger welfare. The premise of this research is that understanding of nature of science (NOS) takes an important role when students and adults participate in the discourse on SSIs. Because SSI reasoning requires individuals to examine information and counter-information with skepticismTherefore, we designed SSI programs which were incorporated with NOS by adapting explicit-reflective approach. The leading research question was to what extent SSI contexts contributed to promoting students' understanding of NOS. A total 72 11th grade students participated in this program. The school located urban city nearby capital city of Seoul, South Korea. We designed SSI programs to cover the issues of genetically modified organism, virus and vaccine, climate change, and nuclear energy. Each issue required 4 to 6 class periods to complete. We conducted pre-and post- test using revised VNOS-C, recorded group discussions or debate and collected student worksheets to observe the increase of student NOS understanding. As a result of this program, students showed moderately improvement in their understanding of NOS.

*Embracing Controversial Nature of NOS: Design Based Research on Developmental NOS Program* Hyun Ok Lee, Ewha Womans University, Republic of Korea, philian@empas.com Kyunghee Choi, Ewha Woman s College

**ABSTRACT:** Despite lack of agreement on NOS among HPSS scholars, science educators have developed a consensus framework containing a set of non-controversial NOS aspects for educational purposes. An approach that embraces controversies about NOS with the established consensus framework is known as a developmental NOS framework. This suggests a continuum of a level of depth on the target NOS aspects, with the controversies about NOS at one end. The purpose of this research is to illustrate contexts of controversial issues of NOS aspects for college and teacher-level education, and develop a program containing controversial issues about NOS to enable college students to develop a more nuanced understanding of NOS. For this process, we surmise the effects of a program containing controversies about NOS on students' NOS understanding and specific mechanisms of change or the dynamics of change on NOS understanding.

### **Strand 15: Policy**

*Contextual Implications for Science Education Policy* 1:00pm-2:30pm, Fort Pitt **Presider:** Sarah J. Carrier, North Carolina State University

### Policy, Pressure, and Administrative Decision Making in Elementary Science Education

Cheryl O'Connor, George Mason University, coconn12@gmu.edu

Donna R. Sterling, George Mason University

David E. Long, George Mason University

**ABSTRACT:** In the post No Child Left Behind (NCLB) accountability 'audit' culture of contemporary schooling, incentives line up to see science teaching take a minimal role in crucial early education if not totally eliminated. This system places job security related pressures on principals and teachers that are interpreted in practice to eliminate science to a significant degree in U.S. elementary schools in favor of literacy and numeracy coursework. This research study is based on multiple perspectives about the effects of federal and state testing requirements on administrative decision making in elementary science education. This study also connects federal and state level policy to district and school level implementation. Additionally, the data reflects the juxtaposition of best practices in science education from a large professional development institute and constraints on science instruction resulting from federal and state testing policies.

Time Allocation for Science in Elementary Classrooms

Andrew J. Keck, George Mason University, andrew.j.keck@gmail.com

Kristofer Pachla, George Mason University

David E. Long, George Mason University

**ABSTRACT:** Elementary school teachers strive to make the most out of the time they are given with students, but decisions about the time allotted for enactment of the curriculum are often not in their control. Length of dedicated lesson time is just one of the many decisions that are made on an ongoing basis by educators in their curricular process. The purpose of this study was to identify the controlling influences of curricular time allocation, particularly in elementary science. This study used data obtained from interviews with elementary teachers associated with a state-wide science professional development program and interviews with elementary principals. State and federal standards, testing requirements, and high-stakes consequences of that testing influenced time allocation in elementary science.

*Earth Science Curricular Reform in Secondary Education: A Systems-Based Approach* Catherine Hantz, Stony Brook University, cpohlot@gmail.com

Angela M. Kelly, Stony Brook University

**ABSTRACT:** Nearly two decades ago, the concept of cultivating scientifically literate citizens presented itself in the form of K-12 science education literacy goals established through federal government initiatives. The justification for these education goals pointed to the fact that rapid advancements in science and technology were outpacing the sophistication of science content taught in schools. To obtain Earth science literacy in secondary schools, the goals stressed a systems-based approach for teaching the Earth sciences. State adoption of Earth system science standards, as

outlined by the National Science Education Standards, is encouraged by many professional and academic organizations. Yet many states' curricula are in non-alignment with systems-based national science standards resulting in statewide Earth science curricula (e.g., New York State) that stress canonical methodologies and limit students' attainment of scientific literacy. To understand the cultural, societal and political influences that shaped the Earth science syllabus into its present form, and to establish a framework upon which recommendations for future curricular development can be made, a theoretical review of the origin and evolution of secondary Earth science is warranted.

# The Role of Motivation, Encouragement and Physics Education in Secondary School Students' Physics Aspirations

Michael J. Reiss, Institute of Education, University of London, m.reiss@ioe.ac.uk Tamjid Mujtaba, Institute of Education, University of London

**ABSTRACT:** This submission investigates the factors that influence 15 year-old students' intentions to study physics post-16, when it is no longer compulsory. The analysis is based on the year 10 (age 15 years) responses of 5034 students from 137 England schools as learners of physics during the academic year 2008-09. Factor analyses uncovered a range of physics-specific constructs, seven of which were statistically significantly associated with intention to study physics post-16 in our final multi-level model; in descending order of effect size these are extrinsic material gain motivation, intrinsic value of physics, home support for achievement in physics, emotional response to physics lessons, perceptions of physics lessons, physics self-concept and advice-pressure to study physics. A further analysis using individual items from the survey rather than constructs (aggregates of items) supported the finding that extrinsic motivation in physics was the most important factor associated with intended participation. In addition, this item-level analysis indicated that within the advice-pressure to study physics post-16.

### Concurrent Session #13 2:45pm – 4:15pm

### **Research Committee Sponsored Session**

Symposium – Learning as a Community: Maximizing the Impact of Research Syntheses in Science Education 2:45pm-4:15pm, Heinz Presider: Christopher Wilson, BSCS Discussants: Joseph Taylor, BSCS, jtaylor@bscs.org James Pellegrino, University of Illinois at Chicago Robert Slavin, Johns Hopkins University Daphne Minner, The Arnold Arboretum of Harvard University Alina Martinez, Abt Associates Erin Furtak, University of Colorado, Boulder M. Suzanne Donovan, SERP Institute Susan Kowalski, BSCS Molly Stuhlsatz, BSCS

**ABSTRACT:** This interactive panel session is intended to facilitate dialogue about current research practices and how these practices influence synthetic research (e.g., research reviews, meta-analyses). The session will integrate a variety of perspectives on synthetic research and the potential these studies have for advancing science education research. The session brings together a set of highly experienced researchers, all of whom have done influential synthesis studies or meta-analyses with implications for science education research. The panelists will each describe their synthetic research as well as make recommendations for primary researchers regarding methods and reporting practices that can facilitate more rigorous and valid synthetic research. Panel attendees will also have an opportunity to engage in small group

discussions with a panelist of their choice. The closing discussion of this session will seek to derive themes across the panelists' presentations as well as the small group discussions.

### Strand 1: Science Learning, Understanding and Conceptual Change

*Disciplinary Perspectives on Learning and Assessment* 2:45pm-4:15pm, Commonwealth 2 **Presider:** Andy Johnson, Black Hills State University

Beyond a Misconceptions-Based Approach to Curriculum and Learning Progressions: A Case of High School Physics

Alicia C. Alonzo, Michigan State University, alonzo@msu.edu Alexander Robinson, Thornapple Kellogg High School May Lee, Michigan State University

**ABSTRACT:** Misconceptions research has had a significant influence on classroom instruction and early work on learning progressions (LPs). This paper describes the first year of a multi-year design research study that explores how the mechanics portion of the introductory high school physics curriculum might be redesigned and a LP might be proposed, such that both treat students' intuitive ideas about motion as productive starting places, rather than as misconceptions. A design team, composed of two university-based researchers and a high school physics teacher, collaborated to redesign the curriculum—based on the premise that students' intuitive ideas about motion are consistent with the definition of momentum, rather than force—and make iterative revisions—based upon video-recordings of classroom instruction, weekly interviews with four students, and student responses to an assessment administered five times during the trimester. Evidence of student learning from the interview and assessment data indicated: 1) areas for improvement (both during the trimester and in preparation for year 2) and 2) significant improvement in students' understanding relative to the "impetus" misconception (as compared to students experiencing the "status quo" curriculum). These data also allow us to identify when students' ideas are changing and, thus, to begin proposing a LP for the redesigned curriculum.

The Growth of Evolutionary Thought: A Cross-Sectional Study of Elementary to College Students' Evolutionary Reasoning

Minsu Ha, Stony Brook University (SUNY), minsu.ha@stonybrook.edu

### Ross H. Nehm, Stony Brook University (SUNY)

**ABSTRACT:** This study explored the development of students' evolutionary thinking by studying cross-sectional samples of elementary, secondary, and college-aged students using the same set of open-ended explanatory prompts. Participants were drawn from five age bands (i.e., elementary, middle, and high school students, science undergraduates [non-biology], and biology majors; n = 128 for each group) from South Korea. Quantitative analyses of scientific (KC) and naïve ideas (NI) (and their interrelationships) among samples revealed: (1) younger students possess not only naïve ideas, but also scientific ideas about evolution; (2) participants' KC and NI scores both increased from the elementary level to the high school level. Although college students' KC scores were much higher than those of secondary school students, college students' NI scores were similar to the elementary school students' NI scores; (3) the percentage of students' with mixed models did not significantly decrease with increasing age and education; and (4) Our findings suggest that the interrelationships between KC and NI change through ontogeny; the correlations between elementary and secondary students' KC and NI were not significant whereas the correlations between college students' KC and NI were negatively correlated. We discuss the implications of these findings for the development of learning progressions.

Investigating the Evolution of Students' Conceptions about the Scientific Method

Ozcan Gulacar, Texas State University-San Marcos, og14@txstate.edu

Charles Bowman, Drexel University

Maria Tomasso, Texas State University-San Marcos

Alpaslan Sahin, Texas A&M University

**ABSTRACT:** A study is presented that explores how students' knowledge structures, as related to the scientific method, evolve over time. A word association test is used to probe the knowledge structure, using ten total stimulus words,

amongst them experiment, science fair, and hypothesis. Students from grades four, five, and eight, as well as first-year college students were tested to measure their knowledge structure. Students' conceptions about the scientific method begin focused around science fair and data collection, but eventually focus around experimentation. The evolution of more complex knowledge structures is also observed.

The Situated Nature of Evolutionary Understanding: Implications for the Design of Learning Progressions in Biology

Xin Wei, Beijing Normal University, lakewe@gmail.com

Minsu Ha, Stony Brook University (SUNY)

Ross H. Nehm, Stony Brook University (SUNY)

**ABSTRACT:** A growing body of work in science education, encompassing more than 30 years of investigation, has demonstrated the situated nature of student reasoning in many different science domains. The purpose of this study is to quantify the contextual and situated nature of reasoning about evolutionary change, and document patterns of predictable reasoning changes characteristic of the growth of evolutionary expertise. Specifically, we use Rasch methods to: (1) describe the progression of novice-to-expert evolutionary reasoning proficiency; (2) quantify the impact of contextual features on evolutionary reasoning as expertise develops. A total of 428 participants from novice to expert completed four written evolution explanation tasks. Findings revealed that participants' evolutionary reasoning proficiency progressed from low to high coherence, and the impact of contextual features was easily observed in most groups, although to a lesser extent in experts. Although context effects typified most participants, the magnitudes of context effects varied as expertise increased. Thus, while predictable context effects occurred, the magnitudes of these effects were not constant. Both factors helped to illuminate evolutionary reasoning patterns, which are crucial for conceptualizing and designing learning progressions.

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

### *Related-Paper Set – Exploring Contexts and Content Influence on Teaching and Learning Argumentation* 2:45pm-4:15pm, Sterlings 2 & 3

**ABSTRACT:** Recent reform documents (NRC, 2012) highlight the importance of argumentation in science education. Even though there are still a variety of challenges involved in introducing argumentation to students and pre-service teachers. Specifically, there is scarce evidence on the role of contexts in argumentation. In order to address this gap, this session brings together five studies exploring the role of context and content in argumentation. The aim is to examine the influence of discursive contexts –involving different processes as evaluating causal explanations or making decisions–, task contexts –disciplinary or socio-scientific–, and content knowledge –both about science and about argumentation– in teaching and learning argumentation. The paper set offers new insights into the relevance of the discursive context in argumentation, and the operations involved in different contexts, the relevance of the understanding of the nature and norms of scientific argumentation, in particular for its epistemic aspects, and the challenges involved in the appropriation by pre-service teachers of the norms and practices of scientific or socio-scientific argumentation, in disciplinary and socio-scientific contexts. Understanding how contexts influence argumentation is needed for supporting students' engagement in argumentation, which in turn requires supporting teachers in the appropriation of the norms and practices of argumentation.

The Role of Discursive Contexts in Argumentation

Maria Pilar Jimenez-Aleixandre, Universidade De Santiago De Compostela, marilarj.aleixandre@usc.es Blanca Puig, Universidade de Santiago de Compostela Beatriz Bravo, Universidad de Granada Beatriz Crujeiras-Pérez, University of Santiago de Compostela

How Content Knowledge and Past Experiences can influence an Episode of Argumentation Jonathon Grooms, The Florida State University, jgrooms@fsu.edu Patrick J. Enderle, The Florida State University Victor D. Sampson, Florida State University Organic Chemistry: From Memorisation to Argumentation in Educational Contexts Aybuke Pabuccu, Abant Izzet Baysal University, aybuke@ibu.edu.tr Sibel Erduran, University of Limerick, Ireland

Transferring Knowledge about Socio-scientific Argumentation to Teaching Practice Maria Evagorou, University of Nicosia

*The Importance of Context in Supporting College Freshmen to Argue About SSI* Barbara Barnhart, University of Pittsburgh at Greensburg Michael Ford, University of Pittsburgh

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

*Engineering and Science Learning* 2:45pm-4:15pm, King's Garden 2 **Presider:** Robert H. Evans, University of Copenhagen

Elementary Science Learning through Engineering Design: Effects Explored Using HLM

William S. Carlsen, Penn State University, wcarlsen@psu.edu

Matthew Johnson, Penn State University

Christine M. Cunningham, Museum of Science, Boston

Cathy Lachapelle, Museum of Science

**ABSTRACT:** Although current science education policy discussions emphasize the importance of engineering in K-12 instruction, little is known about the relationship between participation in engineering education and science learning. As curricular changes are made to address new expectations, it will be important to ensure that they do not contribute to inequities in access to STEM careers by students from underrepresented populations. This paper presents an analysis of science learning outcomes for 949 elementary school students from five U.S. states, comparing the effects of instruction on electricity with similar instruction that was supplemented with a second unit on electrical engineering, from Engineering is Elementary. The engineering curriculum had been designed as a project-based learning module meant to engage students in authentic and meaningful activities, and to promote content learning while addressing the achievement gaps of groups typically underrepresented in science and engineering. Our analysis, using hierarchical linear modeling, confirms the benefits of the supplemental engineering instruction for student science outcomes, and explores how those benefits were distributed among different demographic groups.

### Middle School Students' Conceptions of NOE (Nature of Engineering)

Anita M. Martin, University of Illinois, abmartin@illinois.edu

Maya Israel, University of Illinois at Urbana Champaign

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

**ABSTRACT:** The Next Generation Science Standards require science teachers to teach engineering design principles, which entail an imperative need for examining students' understandings of 'engineering'. This study explored middle school students' conceptions of the field of engineering, what engineers do, and how engineers work and think. We refer to these as student conceptions of the "nature of engineering" (NOE). Participants were 61 seventh and eighth graders enrolled in a Midwestern United States school. They responded to an open-ended questionnaire, probing their ideas of NOE. Data were analyzed using Epistemic Network Analysis (ENA) and situated in the expertise literature. Findings revealed that students' views of NOE ranged from novice to expert in strength and connectedness, with experts exhibiting access to more complex networks of information and superior cross-referenced knowledge than do novices. Novices thought that engineers design/build things for consumers, and that while engineers build/invent/do, scientists research/learn/theorize. Competent students expressed these ideas, but held more complex understandings of engineering and science, and the multidimensional nature of the societal impact of engineers. Participants categorized as "experts"

demonstrated greater cross-connections, and a stronger breadth of understanding of the ways of thinking/modes of action of engineers, and the iterative process of engineering design.

### *The Impact of Instructional Materials on Dialogue Patterns and Learning in Collaborative Dyads* Muhsin Menekse, University of Pittsburgh, muhsin@pitt.edu

Michelene T. H. Chi, Arizona State University

**ABSTRACT:** This study investigated the effect of instructional materials on group processes and student learning. Specifically, two studies were conducted to understand the factors for productive interactions in collaborative settings in the domain of materials science and engineering. In study 1, engineering students were given an instructional activity and asked to interpret graphs and figures; whereas, in study 2, a new cohort of engineering students were given scientific text and asked to generate graphs and figures based on the information in the text. For both studies, dyads' performances in collaborative learning conditions were compared with students' performance in solo conditions. Students' performance on pre and post tests indicated while dyads in study 1 outperformed the individual students, there were no differences in Study 2. Results indicate that the type of instructional materials influence dyads' dialogue patterns and students' learning in collaborative conditions. In addition, verbal analysis revealed that the quality of dyads' verbal interactions and the frequency of certain discourse moves are significant predictors of learning.

# *Exploring Cognitive Processes in Solving 3D Rotation Problems and the Relation to Science Concept Learning* Yi-Chun Chen, National Taiwan Normal University, 898450023@ntnu.edu.tw

### Fang-Ying Yang, National Taiwan Normal University

**ABSTRACT:** This study was designed to explore cognitive processes during spatial problem solving, and to probe the relations between spatial ability and science learning. Purdue Visualization of Rotations Test (PVRT) was used to assess the spatial ability. Eye tracking and interview methods were employed to analyze the cognitive processes. Meanwhile, a concept-learning task after a science-text reading activity was conducted to test the relation to the online spatial problem-solving processes. The main findings included that, first, students could not correctly answer every mental rotation problem even though they were given unlimited time for the test. Second, there exited a background effect that students with science-related major achieved better spatial-problem performances than humanities-related students. Third, the interview analysis showed that students used not only mental rotation strategy but also other analytic strategies when solving PVRT problems. Fourth, while there was no statistically correlation between science concept achievements and PVRT scores, cross-analyses on the eye movement data and interview responses indicated that students' concept achievements were associated with their 3D spatial memory and uses of problem solving strategies.

### Strand 2: Science Learning: Contexts, Characteristics and Interactions Models of Authentic Scientific Inquiry

2:45pm-4:15pm, King's Garden 3 **Presider:** Lynn D. Dierking, Oregon State University

### Scientists' Contribution to Students' Science Proficiencies via Online Mentoring Gokhan Ozturk, Texas A&M University, gozturk@tamu.edu

**ABSTRACT:** The aim of this study is to explore how scientists contribute to students' science proficiencies through online scientist-student interaction in PlantingScience platform from by using the scientific proficiency framework. An embedded mixed method design in which quantitative data are embedded within a case study was used. The data were collected thorough examining the online dialogs within the PlantingScience learning environment used in a middle school science class over a six-week time span. Constant comparison approach was administered to the qualitative analysis and descriptive statistics were used as quantitative measures. The results revealed that scientists participating in online authentic science with students contributed to students' online inquiry experiences in all four dimensions of science proficiencies in their inquiry summaries and also completed their project with higher percentages. Although these findings are limited to the sample we studied due to the nature of a case study, the results and indications can be used for

further studies. The reflexive and productive discourse between scientists and students via online environments can serve as a tool to move science education to the next generation of practices.

# *The Discourse of Design in Long Term Investigations in Inquiry Based Middle School Classrooms* Patricia Bills, Northern Kentucky University, billsp1@nku.edu

**ABSTRACT:** With the advent of the Next Generation Science Standards, we will need descriptive studies of experienced science teachers' pedagogical practices. Our baseline knowledge about inquiry-based science teaching and learning, especially during long-term investigations (LTIs), a commonly used inquiry-based teaching strategy, is diffuse at best. This study attempts to contribute a detailed portrait of how teachers engage students in LTIs through micro and macro analytic discourse analysis strategies. Using a sociocultural frame, this paper describes patterns of utterances in terms of teachers' engagement of students with the eight science practices as outlined in the NGSS. I specifically explore in fine-grained detail how teachers engage students during the investigation design phase, a phase along the LTI which involved the greatest amount of instructional time for all participants. I found that the discourse during the design phase included all eight practices - although some more than others - and were engaged iteratively. The discourse patterns, called here a "discourse of design", may have the potential to help us to develop strategies for future research on long term investigations, as well as enhance our understanding of teacher practice in light of the science practices.

Multilevel Mediation Modeling of a New Inquiry Based Approach to Teaching Science

Luke Fostvedt, Iowa State University, fostvedt@iastate.edu

Brian M. Hand, University of Iowa

Mack Shelley, Iowa State University

William Therrien, University of Iowa

Marcia Laugerman, University of Iowa

**ABSTRACT:** In a longitudinal cluster randomized study, we investigate the role of the quality of instruction in mediating the effect of a new inquiry-based learning approach for teaching science, the Science Writing Heuristic (SWH), to Iowa students in third, fourth, and fifth grades. There are 48 schools (clusters) participating in the study, with a total of roughly 2300 students per grade per year enrolled in the schools. The students' standardized test scores in math, reading, and science were collected each year. We are primarily interested in student-level outcomes and in quality of implementation at the teacher level as a mediator of those outcomes. The method for teaching science was assigned randomly to the school building; given this configuration, we will use a 3-2-1 mediation design (Pituch et al., 2010).

*Thirty-two Lessons: Snapshots of Classroom Complexity and Student Success in Orchestrations of Authentic Scientific Learning* 

Carol L. Stuessy, Texas A&M University, c-stuessy@tamu.edu

Cheryl Ann Peterson, Texas A&M University

Jennifer K. LeBlanc, Texas A&M University

**ABSTRACT:** A conceptual framework of classroom complexity guided this mixed-methods investigation of relationships between students' inquiry performance and science teachers' classroom orchestrations of a complex, technology-mediated authentic science inquiry learning (ASIL) environment, PlantingScience (PS). Underlying the framework is a conception of inquiry as a series of connected modeling cycles transforming initial concrete experience into more complex models of understanding, facilitated by students' engagement in productive modeling discourse at critical phases within a cycle of inquiry. Merging of data from observations of 32 PS classroom lessons taught by 12 PS teachers with teachers' student inquiry teams' (n=67) inquiry performance scores revealed different patterns of ASIL orchestration for student teams grouped into high-, mid range-, and low-performing groups. High-scoring groups' ASIL experiences occurred in appropriate open-ended inquiry contexts in which high levels of classroom complexity were documented in teachers' orchestrations, while low-scoring groups' ASIL experiences showed extreme differences in classroom complexity and other features of orchestration. Overall, results provide evidence of association between successful inquiry performance with patterns of appropriate ASIL orchestration. Information regarding orchestration practices could be useful to science teachers and professional development providers desiring to "refocus" teachers' science learning environments on higher levels of classroom complexity.

### Strand 4: Science Teaching--Middle and High School (Grades 5-12): Characteristics and Strategies Learning Progressions for Teachers or Students in Middle/Secondary Grades

2:45pm-4:15pm, Benedum **Presider:** Irene U. Osisioma, California State University

### Testing PCK Learning Progressions with Teacher Leaders

Patricia J. Friedrichsen, University of Missouri-Columbia, friedrichsenp@missouri.edu

Patrick L. Brown, Fort Zumwalt School District

Andrew B. West, Western Kentucky University

Deanna Lankford, University Of Missouri - Columbia

**ABSTRACT:** Based on a review of the PCK literature, Schneider and Plasman (2011) proposed a set of PCK learning progressions for teachers. Teacher leaders, at the end of the professional continuum, were under-represented in the review. In the study, we conduct a secondary data analysis of two datasets of teacher leaders to test the end targets of the PCK LPs for curriculum and instruction. We recommend the following revisions to the curriculum LP: 1) Teacher leaders are familiar with vertical curriculum, especially at the lower grades, think purposefully and flexibly about curriculum and make horizontal curricular connections explicit to their students. 2) Teacher leaders are guided by state and district science learning standards. 3)Teacher leaders use multiple resources based on learning goals. 4) Teacher leaders design and modify curriculum based on learning goals. For the assessment LP, we recommend the following revision: Teacher leaders use pre-asessments to determine students' prior knowledge, experiences or ideas OR use past student data, and seamlessly use informal questions during teaching to guide instructional decisions.

Describing a Performance Trajectory for Model Based Teaching in Middle and Secondary Science Classrooms Christopher A Bogiages, University Of South Carolina, Knowles Science Teaching Foundation, cbogiages@gmail.com

### Christine R. Lotter, University of South Carolina

**ABSTRACT:** Scientific models represent both the product and process of science. As such, it stands to reason that scientific models should play a central role in science education. Professional development aimed at improving teachers' knowledge and use of models and modeling in science classrooms is a complex and challenging endeavor. With these challenges in mind, this study investigates the impact of teachers' knowledge of models and modeling, the Nature of Science, and ability to facilitate classroom discourse through questioning on the implementation of model based teaching. Findings of this research include the description of a performance trajectory for science teachers who attempt to implement model based teaching in their classrooms. This trajectory was developed using a mixed methods, multiple case study approach that utilized the Interconnected Model of Teacher Growth (IMTG) as a framework for cross case analysis. Implications for professional development are described.

# Using Learning Progressions to Enhance Lebanese Students' Understanding of Complex Genetic Concepts Enja Osman, Lebanese University, ptc@aub.edu.lb

Saouma B. Boujaoude, American University of Beirut

**ABSTRACT:** The purpose of this study was to develop a genetics learning progression, a learning progression-driven genetics unit and investigate the impact of the unit on student understanding of genetics. The study consisted of a descriptive phase followed by an intervention that used a quasi-experimental design with a designed-based research approach. The descriptive phase investigated students' level of genetics understanding and evaluated the existing genetics curriculum. Questionnaires were administered to 729 students (grades 7-12) and 20 biology teachers followed by semi-structured interviews with a representative sample of students and teachers. Data analysis revealed misconceptions in basic genetics concepts possibly caused by a genetics curriculum that is incoherent and traditional teaching methods. Data from the first phase were used to develop, implement and evaluate a learning progression and a learning progression-driven genetics unit which was validated by four biology teachers and implemented in one section of a grade 9 class while another section used the official textbook. Data came from pretests and posttests, classroom observations, student focus groups and teacher questionnaires and interviews. Findings revealed that the genetics unit was coherent and logically

sequenced but did not improve student understanding of genetics. Causes for the results and implications to practice are discussed

# Strand 4: Science Teaching--Middle and High School (Grades 5-12): Characteristics and Strategies *Teaching Science through its Incorporation with Other Fields* 2:45pm-4:15pm, King's Garden 5

Presider: J. Steve Oliver, The University of Georgia

# "I teach Science not Literacy": Developing Teachers' Pedagogical Design Capacity for Literacy in Secondary Science

Kirsten K. N. Mawyer, University of Hawaii, kirkamaile@yahoo.com

**ABSTRACT:** Literacy, the ability to read and write, is foundational to science and essential for the attainment of scientific literacy. Recent calls for reform emphasize Obtaining, Evaluating, and Communicating Information (OECI) as an important STEM practice Achieve, Inc., 2012; NRC, 2013) and highlight that science teachers need to become teachers of science communication and domain-specific literacy. Unfortunately, few teachers have received preservice or inservice training in these areas and most are ill prepared to teach reading and writing. This study examines three secondary science teachers' modifications and integration of literacy strategies embedded in curriculum materials during planning and classroom instruction. Additionally, it provides insight about the development of teachers' pedagogical design capacity (PDC) to teach OECI as a scientific practice as they take on the task of teaching literacy in the science classroom. Findings suggest that in addition to adapting and integrating literacy strategies novice teachers may abandon literacy strategies in favor of teaching science content. Also, analysis of the planning and enactment data revealed two patterns of PDC, undeveloped and emergent. These findings can be used to inform preservice science teacher education, inservice professional development, and the design and development of educative curriculum materials.

The Effects of Science-Arts Integration on Developing Scientific Imagination of Korean Middle School Students Jiyeong Mun, Ewha Womans University, jiyeong86@gmail.com

Sung-Won Kim, Ewha Womans University

**ABSTRACT:** The premise of this research is that it is necessary to recognize value of imagination in science education. This study is aimed to develop the instructional model for students' imagination and to understand to what extent to and how students utilize their scientific imagination during the SAI program. For this, we focused on Science-Arts integration (SAI) and developed instructional model of the SAI programs. Instructional model was developed using AIPCC model (Ask, Imagine, Plan, Create, and Communicate). Total twenty three Korean middle school students who were taking gifted education were participated in this study. We implemented the developed program over three weeks. Data analysis was conducted based on students' output and activity sheets. Data was analyzed using a coding scheme based on a conceptual framework of scientific imagination suggested by Mun et al. In result part, one example of the SAI program was presented. Result revealed that students used their scientific imagination during the SAI program and they showed profound involvement in the program. Based on the results, we suggested educational implications for utilization of scientific imagination and the SAI program in science education.

Analysing the Impact of a Comedy/Drama Enrichment Program to Engage Students with School Science Bernard J. Carr, University of Western Australia, 19013785@student.uwa.edu.au

Grady J. Venville, University of Western Australia

Marjan Zadnik, Curtin University

David G. Blair, University of Western Australia

**ABSTRACT:** This paper demonstrates that an innovative comedy/drama based science program addressed concerns of student scientific literacy and improved student attitudes towards science in schools. With the increasing trend of negative student attitudes towards science in many countries (eg. TIMSS 2007; PISA 2009), there has been a concomitant decrease in student uptake with post-compulsory science. The paper presents data and findings (n=158) from a comedy/drama structured science education enrichment program conducted at a suburban middle school in 2013 with seven Grade 7 classes. During a 10 hour program (one lesson per week), students were engaged with rehearsing a comedic science script

which highlighted some of the history and ideas of Einsteinian physics. The self devised play, Quantum Weirdness, was supported by a structured carefully designed science program and an excursion to the Gravity Discovery Centre(a science outreach centre), to reinforce learning of Einsteinian physics. A pre-test/post-test and survey of students' content knowledge and attitudes was conducted, with data supported by video recording of students' questions and responses. Preliminary analysis of the data supports the introduction of a comedy/drama structured Einsteinian physics program to positively engage Grade 7 students with science on a cognitive and affective level.

### The Influence of Image Designs on Reading Comprehension and Perception of Science Concepts

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Hsiu-Ting Yang, National Changhua University, Taiwan

Kuo-Hua Wang, National Changhua University, Taiwan

Huey-Por Chang, National Changhua University, Taiwan

**ABSTRACT:** This study intends to explore the influence of image designs on students' reading comprehension and perception. Based on the theory of grammar of visual design (Kress & van Leeuwen, 2006), the image meanings can be inferred in terms of three metafunctions: ideational, interpersonal, and textual, and are suggested designed with salient structure and simplified composition to facilitate learning. Accordingly, an online reading comprehension test is developed to invite 122 students from junior high schools as our participants. The analysis of reading scores and reading time reveals that the suggested image design referring to Linnaean taxonomy did help the participants encoding meanings significantly. Due to the underlying concepts of taxonomy of fish, which are less complex, though the result is not significant, it is not recognized as evidence against the suggested image design. The further analysis of the participants' perception unfolds the interplay and tension among the three metafunctions. The participants who scored higher did not appreciate the image with efficient ideational metafunction. Their preference seems to be influenced by the interpersonal metafunction. The degree to which an image serves each metafunction can be inferred based on the specific image design against a base of disciplinary knowledge.

### Strand 5: College Science Teaching and Learning (Grades 13-20) *Faculty Perspectives on College Science Teaching* 2:45pm-4:15pm, Fort Pitt **Presider:** Adam Kirn, Clemson University

# Faculty Views of the Relationship between Discipline-Based Educational Research and College Science Instruction

Marilyne Stains, University of Nebraska Lincoln, mstains2@unl.edu Sue Ellen DeChenne, University of Nebraska - Lincoln

**ABSTRACT:** The Discipline-Based Educational Research (DBER) report highlighted the existence of a researchpractice gap in science instruction in higher education. However, there is little evidence about how the faculty involved in the change process view the relationship between DBER and science instructional practice. The purpose of this study is to explore this relationship. In particular, the guiding research question is: How do faculty involved in DBER, professional development of science faculty, and reformed science instruction view the relationship between DBER and science instructional practice? This study uses grounded theory to develop a theoretical framework for this relationship. Currently, fourteen faculty representing biology, chemistry, and physics have been interviewed. These faculty are variously involved in DBER, science faculty professional development, or are reformed science instructional practitioners. Preliminary results indicate that DBER faculty disagreed with their science colleagues' perception that being involved with DBER implies exemplary teaching. Science faculty indicate that they see DBER research as directly related to instruction, such as classroom or laboratory exercises, curriculum, or teaching strategies. Faculty, indicate that there are many factors that impact college science instruction such as personal theories of teaching, the local context and disciplinary culture, and educational research. Investigating the Specialized Knowledge that Faculty Draw Upon While Using Mathematical Representations to Teach Science

Stephen B. Witzig, University of Massachusetts Dartmouth, switzig@umassd.edu Kristen A. Degnan, University of Massachusetts Dartmouth Margaret M. French, University of Massachusetts Dartmouth Yenny F. Otálora, University of Massachusetts Dartmouth Heather L. Trahan-Martins, University of Massachusetts Dartmouth **ABSTRACT:** Recent science education reform documents call for more integration within and between science,

technology, engineering, and mathematics (STEM) disciplines. The purpose of this study was to investigate the specialized knowledge that university science professors draw upon while using mathematical representations to teach science. The theoretical framework that guided the study involved the nature of specialized knowledge for teaching – Pedagogical Content Knowledge (PCK). This qualitative research utilized case study methodology with interviews, observations, and artifacts as data. Data was initially analyzed deductively using our theoretical framework as a guide, followed by an inductive analysis to generate emergent trends and themes. Through case profiles of four faculty teaching in different science disciplines – biology, chemistry, physics, & bioengineering, we elucidate the experiences that shaped their knowledge for using mathematical representations to teach science. The results of the analysis revealed two assertions that emerged from the case profiles: (1) College science faculty use mathematical representations as tools from experiences old and new to help student understand science concepts, and (2) College science faculty view math in science as embedded and contextual. These findings have implications for graduate student training and faculty professional development.

Defining the Roles of Graduate Student Mentors and Faculty Advisors in Undergraduate Research Programs Megan F. Campanile, Illinois Institute of Technology, mfaurot@hawk.iit.edu

Norman G. Lederman, Illinois Institute of Technology

Elana R. Jacobs, Illinois Institute of Technology

Eric M. Brey, Illinois Institute of Technology

**ABSTRACT:** More undergraduate students are seeking out and participating in undergraduate research in the science disciplines at research universities. The increase in undergraduate student participation in research has influenced the model of mentoring used in undergraduate research programs. Recent studies have indicated that faculty members involved in undergraduate research are more often assigning their graduate students to mentor undergraduate students. The purpose of this study was to examine the roles and influences of graduate student mentors and faculty advisors on undergraduate students who participate in undergraduate research. This study focused on the 23 undergraduate students who participate at a research university in the U.S. Midwest. Assessments used for data collection were a pre- and post-survey and an exit interview and the constant comparative method was used to analyze the data. Preliminary data analysis identified three main themes of the mentors roles in undergraduate research: academic and careers, teaching and learning, and building relationships. Knowledge gained about mentors in undergraduate research program will be useful information to present to research universities, particularly the graduate programs. Mentoring is not a typical component built into graduate programs even though it is critical skill needed to succeed in faculty careers.

Connecting Faculty Conceptions of Teaching, Instructional Practices, and Student Learning Outcomes: A Case Study

Stanley M. Lo, Northwestern University, stanley-lo@northwestern.edu Su Swarat, Northwestern University Denise Drane, Northwestern University Greg Light, Northwestern University

**ABSTRACT:** Research on how people learn indicates that teaching practices could improve to enhance undergraduate learning and retention in science, technology, engineering, and mathematics. However, traditional practices have been slow to change. The simple approach of implementing active-learning methods in the classroom is not sufficient for improving student outcomes, as instructional practices are informed by faculty conceptions of teaching. As such, professional development programs aimed at changing faculty conceptions of teaching are more likely to achieve sustainable changes in practices. Previously, we reported a study that examined the impact of such a professional
development program on biology faculty conceptions of teaching. As a follow-up, in this paper, we explore the relationship among faculty conceptions, practices, and outcomes of teaching. Specifically, we focused on two instructors who taught different sections of the same course as a comparison to examine how their different conceptions of teaching are related to their instructional practices and student learning outcomes in their courses.

### **Strand 6: Science Learning in Informal Contexts** *Developing Identities through Experiences in Informal Science Settings* 2:45pm-4:15pm, King's Garden 1

Presider: Camellia Sanford, Rockman et al

Teaching Outside the Box: Science Hobbyists' Role in Science Education M. Gail Jones, NC State University, Gail\_Jones@ncsu.edu Thomas Andre, Iowa State University Gina Childers, North Carolina State University Elysa N. Corin, North Carolina State University Vanessa Stevens, North Carolina State University

**ABSTRACT:** Why do people engage in extensive, but informal science learning? Science hobbyists learn considerable science and contribute to informal science education through club activities and public presentations, but little research has examined their developmental histories and motivations. We utilized in depth interviews with 107 astronomy and birding hobbyists and examined the development of their science hobby and their outreach to other communities. Results showed the influence of: early science experiences, social needs within the hobby, a desire to provide service to others, and aesthetic response as motivations for participation. The significant role of hobbyists as teacher educators, science learners, and science educators is documented and discussed.

## Engaging Underrepresented Undergraduates in a Culture of Research through a Natural History Museum Internship

### James F. Kisiel, California State University, Long Beach, j.kisiel@csulb.edu

**ABSTRACT:** As the push for developing a strong and diverse STEM work force grows, it is critical to examine how best to engage (and retain) learners with different cultural norms and identities that may be inconsistent with current practices of science. A small group of underrepresented community college students engaged in authentic paleontology research experiences at an urban natural history museum. Participants conducted fieldwork, attended skills seminars (e.g. fossil preparation), and presented their own research findings at a local paleontology research, although impressions of research as 'book work' lingered. Their pre-existing commitments to school, family and other jobs challenged a traditional 'graduate student' model (singular focus on research with prior content knowledge) of developing practice. Findings suggest that although students found the experience to be important professionally, such experiences must more carefully consider the students' pre-existing practices to better support the transition to the new community of science practice and subsequent identity development.

## Examining the Role of Learning Conversations on Students' Identity Development as a Learner of Science during a Girl Scout Field Trip

Kelly Riedinger, University of North Carolina Wilmington, riedingerk@uncw.edu

### Amy R. Taylor, University of North Carolina Wilmington

**ABSTRACT:** Our study investigated the identity development of Girl Scout participants as learners of science during learning conversations at an informal science education camp. The central research question guiding the study was: What is the role of conversation in influencing science learner identity development during a Girl Scout field trip to an informal science education camp? Our work draws on Wenger's (1998) notion of a community of practice and the ways in which learners have to negotiate various communities. In this study, we specifically looked at the role that membership as a Girl Scout, along with membership in communities, influenced participants' identities as learners of science. The study used an exploratory case study. Data collection included videotaped observations, field notes, and focus group interviews with

participants as well as adult troop leaders. We used qualitative methods to analyze data including discourse analysis and the constant comparison method. Our preliminary findings suggest that participants used language in several ways to negotiate their identities as learners of science. Further, being a member of the community of Girl Scouts influenced participants' identities as learners of science. This study has implications for those involved with informal science education.

### A New Theoretical Framework for Researching Environmental Identity Amanda Jaksha, University Of Arizonia, ajaksha@mac.com Bruce Johnson, University of Arizona

**ABSTRACT:** The goal of most environmental learning programs is to influence not only knowledge but also students' attitudes and ultimately their behaviors. One of the problems to this is gauging how well the program is reaching this goal. There are many ways of measuring effectiveness, but how do we know if a program is really influencing students' long term behaviors? One area that has received little attention in the research on environmental learning programs is identity. Learning more about students' identities and how their experiences in environmental learning programs and elsewhere influence their identities may help us to better understand the true effect that programs have on students. This paper provides an analysis of the applicability of Crompton and Kasser (2009) framework for environmental identity to an educational setting, more specifically the Sunship III Earth Education program. This analysis is a first step in being able to use Crompton and Kasser's framework to analyze how participants of environmental learning programs express their environmental identities.

### Strand 6: Science Learning in Informal Contexts

# Understanding the Diversity of Learners' Needs in Informal Science Environments 2:45pm-4:15pm, Rivers

Presider: Chantal L. Barriault, Curtin University

## Identifying Opportunities to Align Informal Educator Perceptions with Audience Expectations in Climate Change Education

Cathlyn Stylinski, University of Maryland, cat@al.umces.edu Renae Youngs, Lifelong Learning Group Joe Heimlich, Lifelong Learning Group Sasha Palmquist, Palmquist & Associates, LLC Deborah Wasserman, Lifelong Learning Group

**ABSTRACT:** Attention-perception and cognitive schema theories suggest that people enter informal learning contexts with prior experiences, beliefs, values, and ideas that shape their expectations and the things to which they give attention. This study explored informal educators' perceptions and their audiences' expectations with regard to climate change (CC). Educators indicated strong acceptance of CC and a lack of perceived barriers to climate change education (CCE); however, CC programming was fairly limited at respondents' institutions (and often focused on K-12 teachers). Their core audiences appeared to view visits to ISE institutions as leisure time but perceived CCE as more relevant to their jobs. Educators indicated improving audiences' CC understanding was a primary goal. Yet, while audiences expressed high interest in learning about CC and believed ISE institutions should conduct CCE, they also reported relatively high confidence in their existing CCE knowledge. Educators pointed to the need for program materials and resources to expand their CCE efforts. Overall, these results suggest that the complexity of this issue, compounded by competing expectations and perceptions, will not support visitor learning about CC; better alignment may facilitate more appropriate interchanges. We are applying this in a capacity-building practitioner effort focused on critical thinking and reflective practice.

## An Examination of Culturally Sustaining Experiences for Hispanic Mothers at an Inquiry Based Science Center Ingrid S. Weiland, University of Louisville, ingrid.weiland@louisville.edu

**ABSTRACT:** The purpose of this study was to examine if and how an inquiry-based science center offered Hispanic mothers and their children opportunity for culturally sustaining experiences. Paris' (2012) "culturally sustaining pedagogy" extends the theoretical underpinnings of Ladson-Billings' (1995) culturally relevant pedagogy to include the

fluidity and plurality of cultural and linguistic diversity, supporting multilingualism and multiculturalism in practice and perspective for learners. Through a case study approach, eight Hispanic mothers were observed with their children at the science center and then interviewed to elicit an understanding of their experiences. Results indicate that mothers were largely unfamiliar with museums in general, yet the science center supported their socio-cultural ways of learning and engaging with their children. Nevertheless, from the perspective of the mothers, the science center fell short in providing them equitable cultural/linguistic access to the exhibits. While prior research has shown that informal science education can encompass culturally meaningful experiences by affirming cultural identities, results from this study suggest that this inclusive and affirming approach be extended to all informal science venues and should include culturally sustaining pedagogy to support multilingualism and multiculturalism in a pluralistic society.

## Informal Science Education Professionals' Goals for and Beliefs about Working with Preschool-age Audiences Michele Crowl, Penn State University, michelecrowl@gmail.com

### Julia Plummer, Penn State University

**ABSTRACT:** A significant body of research points to the importance of early educational opportunities for preschoolaged children, yet more research is needed to understand how informal settings support this age group in science learning opportunities. We examined informal science education professionals' goals for and beliefs about engaging young children in science. Through interviews and observations with 33 professionals, we identified a range of goals that encompass affect, awareness of nature, and support for parents. Practitioners in our study hoped to spark interest and curiosity in audiences, show that science is all around us and engage parents in ways that allow the learning to continue at home. Further, these goals often align with the ways practitioners describe the ways they engage young audiences in science. Practitioners expressed beliefs about how they engage young children in doing science in informal environments: participating in science involves interest and curiosity, doing science is about engaging with natural phenomena, and doing science involves engaging in the practices of science. Findings point to gaps between how practitioners see their role in engaging preschool children in science and the Six Strands of Science Learning articulated in Learning Science in Informal Environments (NRC, 2009).

## Stepping-stones or Dead-ends: Understanding and Developing Learning Pathways across Science Programs in an Urban Setting

Meghan E. Bathgate, University of Pittsburgh, meb139@pitt.edu Amaro Tuninetti, University of Virginia Christian D. Schunn, University of Pittsburgh

**ABSTRACT:** As science learning environments become increasingly dynamic, educators and practitioners are creating science-learning pathways across contexts to deeply engage students in holistic and authentic experiences. Yet, little research has explored the nature and success of these pathways, raising the question: How can we design cross-programmatic learning experiences that support and scaffold students' passion, engagement, and success in science? To this end, it is foundational to understand student motivation across programs, as motivational patterns give rise to differences in behavior and engagement. We examine a pathway between two programs (N=94): Program 1 is a multicited after-school science/technology program for middle-school girls largely in lower-income and underserved areas; Program 2 is a museum-based science and history program for teenagers. A pathway is being designed in which students in Program 1 participate in programming at Program 2. We explore differences across students' reasons for attending their program, and how they vary in motivation (Fascination, Competence Beliefs, Values, Perceived Autonomy) towards science. Differences among students within and across programs will be discussed. These findings propel our understanding of how to frame and develop effective pathways across students who vary in science motivation and informal programming goals.

### Strand 7: Pre-service Science Teacher Education *Preservice Teacher Knowledge* 2:45pm-4:15pm, Brigade **Presider:** Sevim Sevgi, Middle East Technical University

## Analyzing Prospective Elementary Teachers' Conceptions of Dissolving Using the Ladder of Explanations Framework

Karthigeyan Subramaniam, University of North Texas, Karthigeyan.Subramaniam@unt.edu Pamela Harrell, University of North Texas

**ABSTRACT:** This exploratory qualitative study investigated 61 prospective teachers' conceptual understanding of dissolving salt and sugar in water. The study was set within a 15-week elementary science methods course that included a 5E learning cycle lesson on dissolving, the instructional context. Oversby's (2000; 2002) ladder of explanations for the context of dissolving, current scientific explanations for dissolving and perspectives on conception and misconceptions provided the unified framework for the study. Concept maps, interview transcripts, written artifacts, and drawings and narratives were used as data to investigate these prospective teachers' conceptual understanding of dissolving. Analysis revealed that participants' explanations of dissolving were predominantly descriptive explanations (39%) and interpretative explanations (38%), with lower percentage occurrences of intentional (14%) and cause and effect (9%) level explanations. Most of these explanations were also constructed by a set of loosely connected and reinforcing everyday concepts abstracted from common everyday experiences making them misconceptions. Implications include: (1) the need for science teacher educators to use multiple platforms to derive their prospective elementary teachers' conceptual understandings of science content; and (2) to identify and help them identify their own scientific conceptions and misconceptions and how they influence the construction of scientific/nonscientific explanations.

### Teachers Need to Be As Smart As A 5th Grader: What Pre-service Teachers Know About Density Pamela Harrell, University of North Texas, pam.harrell@unt.edu

Karthigeyan Subramaniam, University of North Texas

**ABSTRACT:** A mixed-methods study was used to investigate 55 elementary pre-service teachers' content knowledge about density. Pre/post concepts maps (Cmaps) and pre/post face-to-face interviews were used to document changes in teacher knowledge over a 15-week science methods course. Thematic analysis was used to capture patterns within the data and a paired-sample t-test was conducted to compare pre/post Cmap scores. The analysis of pre-intervention data unmasked participants' weak framework of prior knowledge for density which was a mosaic of alternative conceptions and a few learned concepts. Post-intervention data showed a decrease in alternative conceptions, but many participants continued to utilize a single variable conceptualization (density is weight) and were unable to engage in relational causality. The majority of participants presented two (30) learned concept(s) and one (21) or two (19) alternative concepts with most holding an equal or greater number of alternative conceptions alongside the learned concepts. Results of the paired sample t-test demonstrate a statistically significant difference between the total proposition accuracy scores for pre/post Cmaps (t = -3.178, p < .002) with the instructional intervention larger for post-Cmap scores (M = 1.02; SD = 1.063) than for pre-Cmap scores (M = 0.55; SD = 0.812). The effect size was medium.

## Promoting Korean Pre-service Science Teachers' Understanding of Students' Misconceptions in Physics through the Research Experience

Yeonjoo Ko, Ewha Womans University, rlokdalok@naver.com

Hyunju Lee, Ewha Womans University

**ABSTRACT:** Recent studies have shown that teachers should have knowledge of understanding students' misconceptions, which is one of the major components in PCK. However, teachers had difficulties in understanding misconceptions and in applying appropriate instructional strategies to eradicate misconceptions. Thus, we designed a method course for pre-service teachers (PSTs) adapting the concept of "teacher as researcher." In the course, PSTs conducted research to investigate students' misconceptions in Physics. Twenty five female PSTs participated in the study. They went through the research process including creating question items, administering items to their target populations, and collecting and analyzing student responses. Data source included individual interviews with the PSTs. The results were as follows. First, the PSTs experienced discrepancies in between their conjecture and research findings. They were

embarrassed with the students' low level of understanding basic concepts. Second, the PSTs recognized lack of their physics content knowledge. They realized that physics teachers should develop sound understanding of physics concepts for guiding students to have less misconception. Third, the research experience provided the PSTs opportunities to consider the role of teachers in teaching Physics. They emphasized the role of diagnosing and understanding students' ideas in order to design and implement appropriate lesson plans.

### Investigating Pre-service Physics and Chemistry Teachers' Conceptual Integration between Physics and Chemistrv

Mustafa Tuysuz, Middle East Technical University, mtuysuz@metu.edu.tr

Oktay Bektas, Erciyes University

Omer Geban, Middle East Technical University, Faculty of Education

**ABSTRACT:** It is difficult to deeply understand chemistry without understanding physical concepts behind it or vice versa. There are a few studies about conceptual integration and this study will put a brick to the construction. This study examines how pre-service physics and chemistry teachers think about conceptual integration. Research method of this study is the case study which is one of the qualitative research methodologies. Sample of the study included six preservice physics and chemistry teachers. Data was collected by semi-structured interviews. Qualitative data analysis steps were used. Codes and themes were employed for the data analysis. The results of the study were given with respect to the themes which are "conceptual integration (CI) levels", "background usage of CI", "attitude toward CI", "difficulty faced with applying CI", "contribution of CI on learning", "frequency of CI usage", "teaching methods used while applying CI", "assessment and evaluation of CI", and "curriculum knowledge about CI". Based on results, researcher saw that preservice teachers had some difficulties in making conceptual integration between physics and chemistry concepts. Replication studies should be investigated pre-service physics and chemistry teachers' conceptual integration between physics and chemistry.

### **Strand 8: In-service Science Teacher Education** Assessing Teachers' Orientations, Practices, and Concerns of Reform-Based Science Teaching 2:45pm-4:15pm, Duquesne

Presider: Stephanie B. Philipp, University of Louisville

Problem-based Assessment of Science Teaching Orientations: Formative Use in Teacher Education William W. Cobern, Western Michigan University, bill.cobern@wmich.edu David Schuster, Western Michigan University Betty Adams, Western Michigan University Brandy Skjold, Western Michigan University Amy E. Bentz, Western Michigan University Kelly Sparks, Western Michigan University Ebru Z. Mugaloglu, Bogazici University

**ABSTRACT:** Teachers must be able to combine knowledge of science content and science pedagogy. Teachers must be able to integrate them to make instructional decisions for a variety of topics in actual classroom. Science teacher education normally includes both science content courses and science teaching courses. In the former, science content is promoted and assessed using a variety of problems. Less attention has been given to promoting and assessing understanding of science pedagogies in this way. Our focus has been the design, development, evaluation of pedagogy test items for concept learning, and primarily for formative use. Items are posed as teaching problems rather than in terms of generalities about pedagogy. Items begin with a teaching vignette, followed by a question about preferred teaching approaches. Four response options lie along a spectrum of instructional approaches. Items can be sorted and selected by grade level and science content. For formative use in science teacher education, individual items are designed to spark engaging discussions about contextualized alternative teaching approaches. This paper describes the nature and development of the assessment items, gives results from several example items used by pre-service teachers, and concludes with comments on applications and future research. All items are publically available.

Views of Classroom Inquiry: Differing Perspectives

Katrina Roseler, Florida State University, kr09e@my.fsu.edu

Michael Dentzau, Florida State University

Sherry A. Southerland, Florida State University

**ABSTRACT:** The use of inquiry as an instructional practice in science classrooms has been identified as a necessary to support the science learning for all students. The National Science Foundation has funded many Research Experiences for Teachers (RETs) professional development programs during which teachers engage in scientific research in order to experience the practices of inquiry and hopefully translate those experiences into practice. This research describes how researchers and teachers differentially identify and describe example classroom inquiry as provided by teachers who participate in RET programs through use of the Science Teaching Inquiry Rubric (STIR) (Beerer & Bozin, 2003). Teachers identified a greater number of inquiry practices in their lessons than the research team as well as indicated a shift in their implementation of these practices toward more student centered after participating in an RET. The implications of these results are discussed.

*The Evolution of Secondary Science Teachers' Concerns about Teaching in an Innovative, Technology-rich Space* 

Georgia Bracey, Southern Illinois University, Edwardsville, gbracey@siue.edu

Mary Stephen, Southern Illinois University, Edwardsville

### Jessica Krin, Southern Illinois University, Edwardsville

**ABSTRACT:** High-tech learning spaces are increasingly providing teachers and students with new resources and opportunities for STEM learning experiences, but these new types of learning spaces also bring challenges in their adoption and use. Encouraging teachers to change existing curriculum and teaching practices and to adopt innovations in teaching frequently requires the rethinking of teaching philosophy, current practices and even values. In this longitudinal case study we examine how two science teachers' concerns about teaching in a technology-rich, innovative high school classroom evolved over time and influenced their teaching practices. Using the Concerns-Based Adoption Model (CBAM) as our framework, teachers' levels of concerns were tracked over two years using the Stages of Concern Questionnaire (SoCQ). Classroom observations, interviews, focus groups, and artifacts provided supporting data. Results showed that teachers had the highest levels of concern in Stages 0-3 (Awareness, Information, Personal, and Management) at the beginning of the study. Personal concern levels dropped after two years, though awareness, information, and management concerns remained high. Concerns related to consequences remained relatively low throughout the study, and a shift in teaching practice towards more student-centered activities was observed.

## Single Case Study Analysis of Secondary Science Teacher Using an Observation Protocol (UTOP) Professional Development

Audrey De Zeeuw, University of Texas at Austin, audreyruth@utexas.edu

**ABSTRACT:** Over the course of two years, Mr. Lamar, a high school astronomy teacher, participated in a study involving classroom observations coupled with discipline-specific feedback about teacher's practice. He was observed multiple times over the course of one year by a content expert using the UTeach Observation Protocol (UTOP). After receiving training on the instrument, he was provided detailed feedback from his observation, then given the opportunity to observe his peers using the UTOP instrument. Using a single-case study design in the qualitative tradition, Mr. Lamar illuminated the challenges and successes of using an observation protocol as a lens for professional development. Mr. Lamar's journey through this pilot professional development uncovers the challenges of designing an in-service professional development for science teachers. His journey also supports the notion that providing teachers the opportunity to observe each other to explore the art of teaching in detail creates a space for professional growth and reflection.

### Strand 8: In-service Science Teacher Education *Exploring Teacher Identity* 2:45pm-4:15pm, Sterlings 1 **Presider:** Sarah Michaels, Clark University

## Overcoming Status Differences and Conflicts in K-20 Partnerships: Towards Productive Communication and Reform-Oriented Identities

Stacy Olitsky, Saint Joseph's University, solitsky@sju.edu

**ABSTRACT:** This paper focuses on a qualitative study of a K-20 Math and Science Partnership in order to compare the outcomes of several different formats for collaboration in terms of how well they reduced the salience of status differences, supported inquiry-based instruction, and facilitated mutual learning. Drawing on theories of interaction ritual, I discuss how formats that seemed similar to college classrooms tended to reinforce both social distance and traditional practices. However, two of the formats, one involving faculty members and teachers working together to develop a new curriculum and one involving faculty members serving as advisors while teachers learned a new curriculum, were particularly effective because they provided a situated context for learning through joint engagement with hands-on science materials, and therefore fostered micro-level interactional solidarity between participants and the development of collective identities. This solidarity mitigated conflicts that arose due to professional culture differences, providing the incentive for persistence in order to achieve resolution. This study suggest that K-20 partnerships could benefit from a direct focus on developing reform-oriented collective identities that encompass both teachers and faculty members, which can support teachers' ability to articulate their needs, solicit science content, negotiate wording and meaning, and pose their own explanations.

## Disruptive Pedagogy, Disrupting Identity: Science, Elementary Schools, and Policy Ideals in Practice David E. Long, George Mason University, dlong9@gmu.edu

Wendy Frazier, George Mason University

**ABSTRACT:** This study examines the factors influencing the enactment and dissemination of a large, federally-funded, reform-based science professional development for elementary teachers. Researchers were embedded in a four-week science education professional development (PD) for elementary school teachers training to use problem-based learning and an associated battery of reform-based STEM pedagogies, including scientific discourse to support data-driven argument and decision-making in the elementary classroom. Working as a team across four research university sites where the PD was concurrently being conducted, each site had one ethnographic researcher stationed, collecting multiple forms of data, building rapport with program implementers and participants, and working to familiarize themselves with the field site intimately. Findings highlight the power-laden narrative of negotiation that determines an elementary teacher's teaching assignment in the school as well as their self-selection for STEM-focused professional development. Additionally, findings illuminate the importance of teacher identity in overcoming or taking on a new role as adopters of innovation in their school based on their comfort zone for reform-based science teaching. Professional development and data collection continued into the academic year to illuminate teachers' successes with implementing this strategy back in their schools, focusing on the factors that led to success, or presented pedagogical challenge.

## *Exploring Teachers' Identity Development: The Role of Affirmations and Challenges in Transforming Science Pedagogy*

### Maria S. Rivera Maulucci, Barnard College, mriveram@barnard.edu

**ABSTRACT:** This paper explores the impact of a science professional development seminar on the identity development of two in-service elementary teachers who participated in a science professional development seminar. Both teachers co-taught in a 3rd grade, dual language classroom that also served nine special education students. Grounded in theories of social justice pedagogy, the Science in the City seminar helps teachers develop inquiry-based science curricula drawing on unique resources of the city and students' funds of knowledge. Through in-depth case studies, we explore how teachers' identities as science learners and as science teachers developed over time and the role of affirmations and challenges in their identity development. We draw on notions of positional identity to unpack data from the teachers' life history interviews and observations of their experiences of science and science teaching in the seminar and in their science classroom. We develop a framework for characterizing the types of identity development we observe.

Science and Mathematics Teachers' Reflections on a Multifaceted Approach to Equity Professional Development

Hilary A. Dwyer, University of California, Santa Barbara, hdwyer@education.ucsb.edu Alayna Wearly, University of California, Santa Barbara Julie A. Bianchini, University of California, Santa Barbara

Mary E. Brenner, University of California, Santa Barbara

**ABSTRACT:** In this study, we examined a subset of data from a 2.5-year, equity-oriented professional development program for practicing mathematics and science teachers (2003 - 2005). This program was unique in its multi-faceted approach to equity. Teachers participated in four professional development strategies: reflecting on personal experiences, learning reform-based instructional practices, participating in teacher research, and analyzing data from schools and districts. Three types of data were collected: individual teacher interviews, teacher written reflections, and video recorded discussions about the strengths and limitations of each professional development strategy. We then qualitatively analyzed teachers' reflections of these four professional development strategies, attending to the equity-oriented content that emerged, the education-related issues discussed, and the ways teachers planned or enacted change to address these issues. We found that each strategy elicited different equity content, issues, and possible change. In our discussion, we explore distinctions only captured using a multi-faceted professional development model and offer recommendations for future equity professional development.

Strand 10: Curriculum, Evaluation, and Assessment Science Attitudes 2:45pm-4:15pm, Smithfield Presider: Ling L. Liang, La Salle University

*Middle School Students' Preferred versus Experienced Instruction and their Attitudes toward Science* Gavin W. Fulmer, National Institute of Education (Singapore), gavin.fulmer@nie.edu.sg Hongjia Ma, Nanjing Normal University

Ling L. Liang, La Salle University

**ABSTRACT:** This study explores the relationships between students' experience of science instruction and their attitudes toward science. In particular, the study examines the students' experiences of cooperative, conceptual, or direct instruction in explaining differences in attitude toward science. Additionally, the study examines possible effects on attitude of discrepancies between students' preferences for instruction and their actual experience. The sample consists of 1334 Chinese middle school students' in physics and chemistry classrooms. Results indicate that students' attitudes toward science are positively related to their experiences of cooperative teaching strategies like group work in class or developing small-group projects. However, there is not a significant effect of conceptual instruction or of direct instruction, either positive or negative, on students' attitudes. This suggests that teachers' day-to-day instruction could contribute to positive attitudes toward science by incorporating such cooperative learning strategies.

Activity-Based Science Learning Style Preferences

Xiaoqing Kong, University of Virginia, xk4wa@virginia.edu John T. Almarode, James Madison University Adam V. Maltese, Indiana University Robert H. Tai, University of Virginia

**ABSTRACT:** Many existing measurements of students' interest in and attitudes towards science mainly concentrate on assessing students' general views and perceptions about science and science learning. This study validated a newly developed survey instrument measuring students' seven activity-based science learning style preferences—collaborating, competing, making, discovering, presenting, caretaking, and teaching; and investigated whether and how these factors were significantly associated with students' career interest in science and engineering. Participants were 7,382 students in Grades 3 through 12 from 25 schools. We conducted confirmatory factor analysis to validate the typology of students' activity-based science learning style preferences, and logistic regression analysis to examine their relationships with

whether students reported a career interest in science and engineering. Results indicated that our survey instrument for measuring seven factors was validated. In addition, students who reported a career interest in science and engineering had higher levels of preferences for making and discovering in science focused activities. Future researchers and administrators are suggested to develop science focused activities with emphasis on the aspects of making and discovering.

Attitudes toward Science, Technology, Engineering, and Mathematics (STEM) Subjects and Careers Selcen Guzey, University of Minnesota, kendi003@umn.edu Tamara J. Moore, Purdue University

Michael Harwell, University of Minnesota

**ABSTRACT:** There is a need for more students to be interested in science, technology, engineering, and mathematics (STEM) careers to advance U.S. competitiveness and economic growth. Students develop positive attitudes toward STEM when they engage in quality learning experiences. A survey to measure student (grades 4-6) attitudes toward STEM was developed and administered to 662 students from two STEM-focused and three comprehensive (non-STEM focused) schools. Cronbach's alphas for the whole survey and subscales indicated a high internal consistency. Statistically significant difference in means between students attending the STEM-focused and comprehensive schools on the two subscales of the survey and the overall survey were found. The survey is a useful tool to assess efficacy of STEM programs on student attitudes toward STEM.

A Comprehensive Review of Science Attitude Instruments Used for Middle School Students 2006-2012 Phonraphee Thummaphan, University of Washington, phonrt@uw.edu Min Li, University of Washington

**ABSTRACT:** The purposes of this review were to present a comprehensive evaluation of science attitude instruments based on published psychometric evidence and to provide information about the specific items used in the questionnaires. A multitude of instruments about attitude towards learning science have been used through the years. Several databases were searched for peer-reviewed articles that discussed the development and use of science attitude instruments. A data abstraction was used to summarize and evaluate 22 published articles that spanned 20 instruments. Most instruments (15) had single study usage and showed an absence of psychometric evidence. This review demonstrated that there are few instruments available with the necessary psychometric data to merit recommendation. The review quantifies the current state of the research regarding the measurement of science attitude in students; the results should elicit further discussion and encourage more rigorous analyses of instruments. The findings may assist other researchers to select an instrument and alert them to its strengths and weaknesses. This review points the way forward for research in this field. Instruments and items already in existence should be used in repeat studies, and reliability and validity evidence should be collected and shared.

### **Strand 12: Educational Technology**

**Digital Games in Science Education** 

2:45pm-4:15pm, King's Garden 4 **Presider:** Barbara Means, SRI International

An Analysis of Gender Differences in a Virtual Environment-Based Science Assessment

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Xiaoyang Gong, University of Maryland, College Park

Diane Jass Ketelhut, University of Maryland, College Park

**ABSTRACT:** The present study examines how middle school students conduct scientific inquiry in a virtual environment (VE) setting and whether boys and girls differ in how they seek solutions to the given inquiry task. Gender differences are perennial concerns in designing and promoting computer-mediated learning environments; however, scholars addressing gender differences suggest different conclusions as to whether or not computer-mediated learning environments favor boys over girls. In this study, we investigate various aspects in students' engagement in VE-mediated science assessments (i.e., self efficacy, VE investigating behaviors, hypothesis construction, and performance on multiple

choice questions) in an attempt to draw an insight into gender differences in these assessment settings. A quantitative analysis of the data shows that while boys demonstrated higher degrees of self-efficacy in computer games, boys and girls did not significantly differ in their VE investigating behaviors, hypothesis construction, and performance on multiple-choice questions. The implications for designing and implementing VE-mediated science teaching and assessment will be discussed in terms of providing science learning environments equitable for boys and girls.

### Impacts of Gaming, Teachers, and Interest on Student Science Learning Associated with Innovative Biotechnology Curricula

Troy D. Sadler, University of Missouri, sadlert@missouri.edu William L. Romine, University of Missouri Deepika Menon, University of Missouri Columbia MO Michelle Leigh Klosterman, University of Missouri Len Annetta, George Mason University

**ABSTRACT:** Computer-based games are popular media for entertainment among adolescents, and mounting empirical evidence supports the efficacy of games as tools for learning. However, few analyses address how well games support learning relative to other interventions designed to support learning. In this study, we compare student learning associated with two biotechnology curricula designed to teach basic biological principles. One curriculum features Mission Biotech, a computer-based game; the other curriculum, Viral Quest, features a biotechnology related narrative with no game. We collected multiple pre- and post-intervention measures of student interest and understanding of biological content with 1888 high school students from 36 different teachers' classes. Students in both intervention groups showed statistically significant gains in content knowledge. The between-group intervention effects were small in comparison to improvements across time. We found positive effects of interest and teachers for both programs. This study provides evidence for the effectiveness of innovative curricula situated in biotechnology as tools for supporting learning of biological content. Given the high costs of game development, designers may want to think carefully about how other curricular innovations might be leveraged to achieve similar learning goals, as well as learning targets best aligned with the affordances of game-based curricula.