

All abstracts are listed by first author. Institutions of authors are in the author index.

#### Hasan Abdel-Kareem, Charles Anderson

Comparing Palestinian and American Students' Accounts of Water in Environmental Systems

This poster reports on a study comparing American and Palestinian students in terms of their understanding of the water cycle. We were interested in how the reasoning of the two groups is affected by differences in location and culture. We administrated written tests to about 1000 students from both groups in upper elementary, middle, and high school. The test addressed three domains of the water cycle: general water questions such as estimating daily usage and water distribution on Earth, students' representations of water cycle and ground water, and learners' abilities in tracing water through human and natural systems. Analyses showed two types of results; within and between groups. Considering all participants as one group, younger children showed naïve conceptualizations of the water cycle. Most upper elementary participants equate water evaporation with disappearance. High school students used more sophisticated representations, yet few were able to draw reasonable diagrams of underground water or to interpret a three-dimensional map. Our work suggests that although many environmental problems are seen as global, learners' locations and cultures play a significant role in their understanding of such issues.

# Fouad Abd-El-Khalick, Saouma BouJaoude, Reinders Duit, AndrÈe Tiberghien, Maria Pilar JimÈnez Aleixandre, Justin Dillon

An "Ad hoc Committee on the History of Science Education" Sponsored Session: Science Education Research Traditions in Europe: Shedding Light on Didactics

Didactics is an established research tradition in science education with a long history in many European countries. This tradition, however, is largely absent from the Anglo-American science education research literature. Kansanen (2002) suggested that the word ididacticsî appears only in texts translated from non-English sources and when American educational researchers use the word, they do so with a icontemptuous nuanceî (p. 431). This situation may hinder communication across different researchers and research traditions and limit the access of science education researchers to a diversity of research perspectives. Moreover, a history of science education that does not account for such an important research tradition will necessarily be lacking. Consequently, the purpose of this session is to provide NARST members with an opportunity to interact with science educators from several European countries who are working with this research tradition in the hope of broadening the perspectives from within which the teaching and learning of science are viewed. Specifically, the session will focus on addressing the following questions: (1) How is didactics defined in different parts of Europe? (2) What are the advantages of using the didactics lens in science education research? (3) What are the differences between didactics and approaches to research in Anglo-American research traditions?

#### Fouad Abd-El-Khalick

Factors Underling Decisions to Pursue Alternative Routes to Secondary Science Certification

This study aimed to discern factors that underlie decisions to pursue an alternative route to teacher certification. Participants were two cohorts of students enrolled in an innovative alternative secondary science and mathematics certification program and their matched counterparts enrolled in the more traditional certification program at the same institution. In- depth individual interviews and examination of teaching-related artifacts served as the main sources of data. Analyses revealed little difference between students in the two certification programs with regards to factors that have traditionally been used to assess the potential of prospective secondary teachers. However, participants differed significantly in terms of pre- college informal and formal educational experiences, with the alternative certification students being less satisfied with such experiences. It is argued that what is promising about prospective teachers joining alternative certification programs might not be their advanced degrees and relevant work experiences in science or mathematics, but their being mavericks aiming to change the culture of pre-college science and mathematics teaching and learning.



#### Eleanor Abrams, Chuing-Fen Yen, Larry Yore, Pauline Chinn, Huei Lee, Erica Blatt, Chorgh-Jee Guo

The intersection of the influences of schooling, culture and nature on the motivation of Hawaiian and Taiwanese Indigenous children

Modern Indigenous students are described as living between two worlds (Barnhardt, 2005). This population faces unique challenges but also possesses untapped capabilities as they engage in learning within the school environment, especially in the areas of science. This symposium examines socio-cultural influences on the teaching of science as well as how nature influences the motivation of Taiwanese and Hawaiian Indigenous children to learn science. Tensions within the goals of the teachers and the students are examined. Specific examples of cultural bridging are discussed through the use of language, beliefs, values and place.

#### Omer Acar, Anita Roychoudhury, Bruce Patton

Undergraduate Students' Reasoning Skills and Conceptual Development in an Inquiry Class

This study describes undergraduate students' conceptual and reasoning development in an inquiry class. Students' reasoning and conceptual understanding were assessed by pre and post tests. Students' reasoning was assessed by the use of argumentation analysis. Two scenarios were developed for assessing the reasoning on sinking & floating, and balancing. Students' conceptual understanding was assessed by a conceptual test. The results showed that student reasoning scores significantly improved for the reasoning test on sinking and floating but not for balancing. However, students' normalized gains for reasoning scores on sinking and floating yielded to different outcomes. In addition, the gap between high achievers and low achievers at the pre-test (conceptual test) did not close. The implications for science classrooms are discussed according to the findings.

#### Emine Adadan, Kathy Trundle, Karen Irving

Progression in Grade 11 Students' Conceptions About the Aspects of the Particle Theory

The objective of this quasi-experimental study was to examine grade 11 students' developing conceptions concerning some components of the particle theory from the pretest to the posttest. One of the two groups received the Reform-Based Teaching with Multiple Representations (RBTw/MR), whereas the other group engaged in the Reform-Based Teaching (RBT). The data were collected through qualitative research methods, including openended questionnaires, interviews and student artifacts. Data analysis showed that before instruction, over 70% of the students in both groups held alternative conceptions about the spacing between the particles of liquids and the motion of particles in solid state. In addition, before instruction, only 10% of the students in both groups indicated an understanding regarding the concept of the existence of the attraction forces that act between the particles, whereas 90% of the students in both groups did not provide any evidence of understanding this particular concept. Following the instruction, the percent of the RBTw/MR students who developed a scientific understanding about the aspects of the particle theory, those of which they had conceptual problems before instruction, highly exceeded the percent of the RBT students.

#### Valarie Akerson, Cary Buzzelli, Lisa Donnelly

On the Nature of Teaching Nature of Science: Preservice Early Childhood Teachers' Instruction in Preschool and Elementary Settings

This study explored what hindered or facilitated the teaching of nature of science (NOS) for four preservice early childhood teachers at the preschool and K-3 levels. We investigated whether the preservice teachers' concerns about teaching NOS and their intellectual levels influenced whether and how they taught NOS. We used videotaped classroom observations to determine the science instructional practices at the preschool and elementary levels, and to track whether and how preservice teachers emphasized NOS. Pre and post internship we used the SOCQ to determine concerns about NOS instruction, and the LCQ to determine intellectual levels. We found that neither concerns about teaching NOS nor intellectual level were related to whether and how the preservice teachers emphasized NOS. The main factors that hindered or facilitated teaching NOS were the influence of the



cooperating teacher and the use of the science curriculum. The preservice teacher with the cooperating teacher who understood and emphasized NOS herself, and showed her how to modify the curriculum to include NOS, was able to explicitly teach NOS to her students. Those in classrooms whose cooperating teachers did not provide support for NOS instruction were unable to emphasize NOS. Implications for preschool and K-3 teacher preparation are made.

#### Valarie Akerson, Lisa Donnelly

Teaching Nature of Science to K-2 Students: What Can They Gain From Instruction and What Influences Changes in Their Views?

This study explored the influence of a Saturday Science program that used explicit reflective instruction through contextualized and decontextualized guided and authentic inquiry activities on K-2 students' views of NOS. The 2 ½ hour each week for six week program emphasized NOS culminating in an authentic inquiry designed and carried out by the K-2 students. The Views of Nature of Science Form D (Lederman and Khishfe, 2002) was used to interview K-2 students pre and post instruction. Copies of student work were retained for content analysis. Videotapes were made of each week's science instruction and were reviewed to determine instruction that was most influential on students' NOS views. Classroom observations and field notes tracked changes in teaching practice. We found that K-2 students improved their NOS views. Strategies found to be most effective at influencing students' NOS views were (a) introducing ideas of NOS through decontextualized activities, (b) embedding NOS into science content through contextualized activities, (c) using children's literature to emphasize NOS aspects, (d) verbal and written debriefings and embedded NOS assessments of NOS views, and (e) guided and student- designed inquiries that enabled discussions of NOS in the context of science investigations. Implications for K-2 education are made.

#### Virginie Albe

High School Students' and Science Teachers' Knowledge of the Socioscientific Controversies on Global Climate Change

In this paper, how students and pre-service science teachers perceive the controversies on global warming has been investigated. 177 high school students and 36 pre-service secondary science teachers were involved in this study. Questionnaires, individual semi- structured interviews and focus groups were used. A global warming seems to be accepted by most students and teachers. Uncertainties on the origins of the phenomenon were identified by some participants. The contribution to global warming of human activities was questioned by teachers. Students identified a natural origin and an anthropogenic hypothesis and some of them underlined its controversial nature. Perceived consequences show for both students and teachers a media influence. Confusions on the physical-chemical mechanisms of greenhouse effect and ozone depletion have been observed for both students and teachers. The Kyoto protocol and socio-political actions to take are discussed by teachers. Implications for teaching and learning of climate change controversies and more generally of sosioscientific controversial issues are discussed.

#### Elizabth Albro

Preparing Research Grant Proposals for the Institute of Education Sciences

This presentation will provide attendees with an opportunity to learn about available funding opportunities through the National Center for Education Research within the Institute of Education Sciences. The Center seeks research applications designed to examine ways to improve student learning through curriculum and instruction, through improving teacher quality, and through changes in the education system. Dr. Albro brings five years of experience as a program officer for the National Center for Education Research and will provide detailed insights into the grant preparation, submission, and review process. The institute supports research in the topic areas of: education research in reading and writing; mathematics and science; cognition and student learning; teacher quality; social and behavioral context for academic learning; education leadership; education policy, finance, and systems; early childhood programs and polices; high school reform; interventions for struggling adolescent and adult readers and writers; postsecondary education; and education technology. In addition, the Center holds competi-



tions for establishing predoctoral and postdoctoral research training grants, and for establishing National Research and Development Centers. Finally, the National Center for Special Education Research within the Institute of Education Sciences funds research targeting the educational needs and outcomes of students identified with special education needs.

#### Konstantinos Alexakos

Dynamics of Successful Student Kinship Groups in a College Physics Class of Inner City High School Students

This paper explores group membership, perseverance, and success of minority high school students in a college physics classroom. The students were of racial/ethnic backgrounds not typically represented in the physical sciences. This critical ethnographic research was conducted in the class by the course instructor (the author) and informed by the voices of these students through in-class discussions and formal and informal individual and group conversations. While the students came from mostly challenging social and economic lives, many exhibited a high degree of resiliency and perseverance in the course. The most successful among these students were part of a kinship grouping forged over several semesters. These students had developed internal complex multidimensional mores and ethos of support, solidarity, and mutual cooperation that went beyond school work. Efforts by the instructor to artificially create new groups that integrated the remaining students of the class, while with the best intentions, could not duplicate the success of this kinship group.

#### Gilberto Alfaro-Varela

Scientific Perspective on Education as a Base for an Integral Education of Citizens

When science is commonly taught, there is a reduction of its potentials towards the promotion of concepts learning. The challenge is to move science beyond the traditional concepts in order for the teacher to have excellent opportunities to influence the ways students think, more that what students are able to memorize. We all know that changing teaching practices is not an easy task, since teachers usually promote what they experienced in their own learning experiences. As part of a group of educators in Costa Rica, with the collaboration of colleagues from different parts of the world (Mexico, Spain, Colombia, Chile, France, USA) I have been involved in the promotion of in-service teacher programs in the line of alternative ways to assume education. We are working with the idea that we do not have to limit our vision of science teaching to natural sciences, but to include social sciences, language, mathematics, plus the great contribution that arts and ethics contribute, in order for us to better express our ideas and understandings of our responsibilities as citizens of a particular country. Teachers in rural areas are responding openly to alternative ways, with creative ideas about knowledge integration as a base for students to generate better understandings of their own problems.

#### Alicia Alonzo, Mareike Kobarg, Tina Seidel

Content Knowledge for Teaching as Reflected in Teacher-Student Interactions: Two Video Case Analyses

Despite the theorized centrality of pedagogical content knowledge (PCK) for teaching, we have little evidence of the relationship between PCK and students' learning and know little about how to help teachers to develop PCK. This study is a preliminary attempt to address these gaps in our knowledge of PCK through exploration of two German physics teachers' use of content knowledge during classroom interactions in double lessons on optics. We show how video analysis can be used to gather evidence for one aspect of teachers' PCK – their conceptualization of the content they are teaching. By contrasting teachers with high and low gains in student achievement and motivation, we explore potential mechanisms by which PCK might affect student learning. Because German teacher preparation programs emphasize content more than pedagogical knowledge, these cases contribute to our understanding of the support that teachers with strong content knowledge may need in translating this knowledge into a form useful for teaching.

#### Janice Anderson

Using Educational Computer and Video Games in K-12 Classrooms to Promote Learning: A Critical Literature Review This manuscript focuses on issues pertaining to the use of computer and video games in the K-12 classroom. Our understanding of how children learn from using and interacting with educational video games is still in its infancy as there has been a lack empirical research conducted measuring how educational computer games improve student learning Statistics such as this suggest that computers and their games are clearly embedded within American culture and could potentially provide the opportunity for innovations within the classroom environment. The purpose of this paper is to draw together the existing body of literature that deals specifically with computer and video games in the K-12 classroom, to organize it into emerging themes, and to synthesize it into a productive discussion that future scholars can utilize as a resource and as a starting point for further inquiry where gaps in the literature exist.

#### Charles Anderson, Joseph Krajcik, Richard Duschl, Kristin Gunckel, Blakely Tsurusaki, Karen Draney

Learning Progressions for Environmental Science Literacy

Learning progressions are descriptions of increasingly sophisticated ways of reasoning about a topic. In this interactive poster symposium we describe and discuss the development of learning progressions from upper elementary through high school focusing on preparing students for environmentally responsible citizenship. We organize these learning progression around four strands: 1. Carbon. The role of carbon compounds in earth, living, and engineered systems, including carbon dioxide in the atmosphere, energy flow and carbon cycling in ecosystems, and fossil fuels in human energy and transportation systems 2. Water. The role of water and substances carried by water in earth, living, and engineered systems, including the atmosphere, surface water and ice, ground water, human water systems, and water in living systems. 3. Biodiversity. The diversity of living and engineered systems, including genetics and life cycles of individual organisms, evolutionary changes in populations, diversity in natural ecosystems and in human systems that produce food, fiber, and wood. 4. Citizenship: how students take on citizenship roles (consumers and voters) and explain their reasoning about personal decisions with environmental consequences. Individual papers and posters report empirical research on students' development of understanding in these strands, as well as addressing issues of methodology, assessment, and curriculum. This research is supported in part by three grants from the National Science Foundation: Developing a Research-based Learning Progression for the Role of Carbon in Environmental Systems (REC 0529636), the Center for Curriculum Materials in Science (ESI-0227557) and Long-term Ecological Research in Row-crop Agriculture (DEB 0423627. 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.

#### Janice Anderson, Cindy Jong, Mike Barnett

Virtual World, Real Impact: Gender, Race and The Use of a 3D Virtual World to Teach Concepts Around Water Quality

Computer/video games have been used in classrooms to promote learning and engage students to help them make sense of the world they live in. The purpose of this work is to study the implications of using a 3D virtual computer game to teach science concepts surrounding water quality. The study pays particular attention to gender equities and the achievement of both females and under-represented students of color. Pre- and post-test comparisons indicated that students demonstrated an increase in tests scores on a standardized assessment. Gains were particularly evident when looking at the breakdown in gender and race. These results indicate that the use of the game within the water quality curriculum demonstrates an increase in achievement on standardized or traditional assessments for students of color. The interactive nature of the game play as opposed to 'drill and practice' and other traditional models of teaching can potentially impact student learning and understanding of key science concepts.



#### Leonard Annettta, Shawn Holmes, James Minogue, Meng-Tzu Cheng

Learning Science Through Video Games: Examining Student Attitudes and Teacher Perspectives

The purpose of this special symposium is to disseminate to the science education community results on student (grades 5-9) attitudes as they relate to video games as learning tools. This study was part of a National Science Foundation ITEST project where teachers and students are creating video games that align with science and mathematics content standards. The symposium will discuss how the project participants are being instructed to create games through learner-centered design, followed by results and implications for practice from electronic reflections through Blog site and two attitudinal instruments: The My attitudes toward Science, Technology, and Society (MASTS) and the Science Interest Survey (SIS). Results from the 323 students participating indicate that both males and females have the same opinion about the effects of science and technology in society. Further there are no significant differences on students' self-perceptions of their understanding of STS-related issues in terms of grade level nor were there differences by race on five subscales of science. Finally, qualitative analysis of student journaling during a 5-day game development workshop suggested students 84% of the participants reported social, respectful, and learning relationship with their teachers by the end of the workshop as opposed to the 25% on day one.

#### Robert Anthony, Christine Tippett, Larry Yore

Pacific Crystal Project: Explicit Literacy Instruction Embedded in Middle School Science Classrooms

There is broad agreement by science education researchers that being literate in science requires more than a capacity to recount information. There are two senses of science literacy. The fundamental and derive senses interact to produce cognitive symbiosis which collectively can be said to represent scientific literacy. This paper reports on findings from the Canadian Pacific Crystal Project that aims to embed explicit literacy instruction in science programs to achieve both senses of science literacy in two different middle schools. A community-based research approach was used to set goals, identify instructional opportunities in the existing science programs, determine and address professional development needs, and develop appropriate classroom instructional activities. Initial data from Year 1 have identified: (a) many opportunities in programs for embedding literacy instruction and tasks, (b) difficulties generalist teachers have with fundamental and derived aspects of a new science curricula, and (c) difficulties specialist science teachers have with integrating literacy activities, strategies, genre, and writing-to-learn science tasks. Pretest-posttest comparisons on school-wide reading and writing goals indicated promising trends. These results have guided the planning and foci for Year2 professional development and explicit literacy instruction.

#### Isaak Aronson

Competing Horizons: Biology Instruction and No Child Left Behind

The aim of this case study is to explore how biology teachers understand and construct their practice in a highstakes accountability environment that is likely to be riddled with tensions. The results of this study provide insights into how teachers experience educational accountability, understand their role in the science classroom, and conceive the discipline of science and scientific inquiry-based instruction. Fear of failure has driven districts, schools, and teachers to make profound adjustments to the biology curriculum in order to prepare students for the high-stakes exam. Research on the implementation of No Child Left Behind in the classroom is critical to providing insights that may improve the science teaching and learning process.

#### Amy Arsenault, Maria Varelas, Christine Pappas, Anne Barry, Neveen Keblawe-Shamah

Intertextuality and Gender in Primary-Grade, Urban Classrooms: Girls Making Sense in Science Read-Alouds

We explored how young (1st-3rd grade) girls, relative to boys, used intertextuality during dialogically oriented read-alouds of children's literature information books, that were part of two integrated science-literacy units (Mat-



ter and Forest) to make sense of science ideas, concepts, and processes. We examined who (girls, boys, teacher) made what type of intertextual connections and how these were taken-up in the read-alouds to help children build science understandings. Our data offer ways to see girls using intertextuality in various waysóbringing up their everyday life experiences (in- and out-of-school) and talking and doing science with their peers and teacher; turning to hands-on explorations to organize their thinking, to wonder, to coordinate evidence and ways of seeing the world; and employing intertextuality about as much as boys in the Matter unit, but significantly more than them in the Forest unit. Such findings contribute to our nuanced understanding of girls' participation in science class in urban schools where teachers attempted to engage all children in meaningful, varied, and multi-dimensional curricular and instructional practices.

#### Harika Arslan, Aylin Cam, Ceyhan Cigdemoglu, Omer Geban

#### An Analysis of Teachers' Scientific Epistemological Views and Reactions to Incidents with Misconceptions

The purpose of this multiple data sources study was investigate the relationship between constructivists teachers' and empiricist teachers' line action in critical incidents containing misconceptions. To determine whether teachers are constructivist or empiricist, a survey about teachers' instructional practices in science teaching and an interview related teachers' scientific epistemological views (SEV) were conducted. To reveal teachers' line of actions to critical incidents three cases related with chemistry or biology were given during the interview according to teachers' major area. Ten teachers participated in the study; five of them were chemistry teachers and five of them were biology teachers ranging in experience from 2 to 30 years. Data obtained from survey were analyzed independently and examined to find out the relation between responses to critical incidents. Data obtained from interview about teachers' scientific epistemological views was analyzed and results related with teachers line of action to critical incidents. The results indicated that the line of action in critical incidents show differences between the constructivist oriented and the empiricist oriented teachers for both survey results and interview results. These results have significant implications for teacher education as well as the successful implementation of current reforms.

#### Bijaya Aryal, Dean Zollman

#### Peer Scaffolding and Transfer in the Context of Learning

We present the effectiveness of group interaction in learning and transfer of learning. Teaching interviews were conducted with nine groups of students enrolled in an introductory level algebra-based physics course and consisted of two sessions – a learning session and a transfer session. The students were engaged with hands-on activities to learn various physics ideas in the learning session. They were expected to apply the physics learning to understand positron emission tomography (PET) in a transfer session. Worksheets were provided and they were asked to write their responses before and after the group discussion. To present the dynamics of group learning and the influence of peer scaffolding we compared the results of this study with our prior study where students were engaged with a similar set of activities but individually. Results suggest that peers were effective in activating and challenging each other's conceptual resources as well as facilitating transfer of learning.

#### Anila Asghar, Jason Wiles, Brian Alters

Exploring Pakistani High School Student Understanding of Evolution

This study attempts to explore how Pakistani high school students understand evolutionary science in relation to their Islamic beliefs about the origin and evolution of life. Religion and science are entwined in the Pakistani national biology curriculum. Data were collected through an anonymous survey from 2527 high school science students from various government and private schools in the Punjab province. Evolution is introduced in grade 9th biology textbooks and revisited in detail in grade 12th. The majority were Muslims (98.2%). Most (~ 87%) were first exposed to evolution in their school classes. Over 50% noted that evolution was covered "fairly well" and 36% thought that it was covered "very well" in their science classes. It appears that although most students are informed, and agree, that evolution is supported by extensive scientific evidence, many believe that it cannot



be accurate since it contradicts their interpretation of the religious text. Additionally, these students carry misconceptions regarding the contents and interpretation of different component concepts of scientific evolution. This study informs North American science educators about how Muslim students might think about the evolutionary science being taught in relation to their religious beliefs.

#### Scott Ashmann

What Influence Does Regularly Using a Hands-On Science Curriculum Have on State Standardized Science Test Scores?

The purpose of this study was to determine the extent to which the regular use of a hands-on science curriculum (provided by the Einstein Project) influenced the performance of students on a state standardized science test. The Einstein Project is a non-profit organization that partners with schools and communities to provide hands-on curriculum units for science education in Wisconsin. This study was based on a number of comparisons, such as the percentage of students who were classified in either the "Advanced" or "Proficient" categories in school districts that were regular users versus state averages and a similar comparison between school districts that were regular users of Einstein kits. The findings from this study strongly support a positive influence of the use of Einstein Project materials on state standardized science test scores. Furthermore, the findings show that the use of Einstein Project materials helps to close the achievement gap for students with disabilities, students with limited English proficiency, and minority students. In addition, female students, students with disabilities, students with limited English proficiency, and Asian students from Einstein Districts were found to significantly outperform their counterparts from Non-Einstein Districts.

#### Hakan Atar, Alejandro Gallard

Investigating the Influence of Teachers' NOS Conceptions on Their Ability and Willingness to Integrate Inquiry into Their Instruction as Revealed through Online Learning

The purpose of this study is to understand the factors that influence the teachers' ability and willingness to incorporate inquiry into their science instruction and how the sophistication of the teachers' NOS conceptions contribute the teachers' ability and willingness to integrate inquiry into school science as revealed through online learning. The participants of this study were in-service teachers who were accepted into the online Masters Program in science education program at a southern university. Multiple data sources were in order to understand the relationship between participants' NOS views and their conceptions and beliefs about inquiry-based science teaching. These include: (1) VNOS questionnaire, (2) Electronic postings, (3) Semi-structured interviews, and (4) email correspondence. Findings of this study suggested that a better understanding of NOS concepts helps the teachers become more confident in their ability to implement inquiry based science lessons. Also, a better understanding of NOS concepts assists the teachers of this study to develop a higher appreciation of inquiry science instruction. It also helps them develop a new perspective of science and science instruction. It further enables them to realize how NOS concepts, inquiry science instruction, and the goal of creating a scientifically literate society fit all together.

#### Mary Atwater, Tonjua Freeman, Georgia Hodges, Weiling Li, Rhonda Rackley, Regina Suriel

Sociocultural Studies and Issues Related to Students and Teachers: Believing, Caring, and Performing

This interactive symposium of six presenters focuses upon sociocultural issues related to students and teachers. More specifically, the findings from a quantitative study on the science achievement of ìLEPî students and qualitative studies on teacher beliefs about Latino students' abilities to learn science, caring science teachers of ESOL students, and effective teachers of Black students will be presented. In addition, the impact that national policy has had on urban high school science students' performances will be discussed. Common themes in these different studies will be identified, along with a discussion on the future research studies needed in multicultural science education related to beliefs, caring, and performance of students and teachers. Culturally relevant curriculum materials, specific teaching strategies, beliefs and values of students of color and teachers enhance the opportunities for quality science learning of students in different school settings. Students whose first language is not English



face additional challenges that teachers and schools can meet so that they will be successful science learners.

#### Mary Atwater, Joe Krajcik

Membership and Elections Committee-Organized Session: Graduate Student Forum

The Graduate Student Forum aims to guide and encourage beginning researchers by discussing dissertation completion and productive job searches: panellists will advise on writing, publishing, job applications, the interview process and negotiating your first appointment. Panelists include Professors Obed Norman, Morgan State University; Malcolm Butler, University of South Florida; Glenda Carter, North Carolina State University; Leslie J. Jones, Valdosta State University; Thomas Andre, Iowa State University, Mark Guy, Iowa State University; and Regina Suriel, a doctoral student at the University of Georgia. In the past this has been a popular session for Graduate Students as it focuses on their special interests. Attendees can question the panel on all matters of academic interest.

#### Dana Atwood, Douglas Huffman

Collaborative Evaluation Communities in Urban Schools: Developing the Capacity of Teachers to Evaluate Science Programs

The purpose of this poster is to describe the impact of a model of evaluation capacity building in science education. The Collaborative Evaluation Communities Project was funded by The National Science Foundation to develop the evaluation capacity of urban schools, and specifically develop the evaluation capacity of elementary teachers in the area of science education. The project tested out a new model of immersing elementary teachers in the evaluation process. Building the evaluation capacity of teachers and schools is an important goal for the field of science education. Teachers are overwhelmed by data; however, they do not always have the capacity to use data. The Collaborative Evaluation Community Project immersed teachers in the evaluation process as a means of improving their science instruction and capacity to use data. Survey and interview results indicate the project significantly improved teachers' ability to engage in evaluation. In addition, results suggest the project altered the extent to which teachers engaged students in more inquiry-oriented science activities. Implications of results for developing evaluation capacity of schools and teachers are discussed.

#### Claudia Aufschnaiter, Christian Rogge, Jan Fleischhauer, Tanja Riemeier

Argumentation and Scientific Reasoning - An Exploration of Their Interrelationship

Argumentation can be regarded as an important aspect of the nature of science which should be taught in school science. Current research indicates that students can be trained to argue, in particular, if specific prompts or scaffolds help students to identify when an argumentation is an expected pattern of reasoning. However, several situations require students to distinguish between evidence and conclusion or to evaluate claims and corresponding evidences without the opportunity to draw on prompts or scaffolds. Our research project aims to explore the interrelationship between argumentation and science learning. This broader research focus includes analyses of students' argumentations as they "naturally" occur during instruction that has a focus on activities which are assumed to promote conceptual understanding. In order to investigate students' argumentations in such situations, a distinction between argumentation and other types of reasoning is necessary. Video data from students of different age working in groups on physics and biology instruction are used to develop a coding manual which is based on Toulmin's Argument Pattern but distinguishes explicitly between argumentation and processes of clarifications and explanations. Results indicate that both argumentation and clarification occur in about up to 30% of the time spend with the instruction.

#### Barbara Austin

Concept Mapping to Promote Acquisition of Pedagogical Knowledge in Secondary Education Students

Concept mapping is a learning device used to understand the knowledge structure of an individual. Although concept mapping has been used extensively in the area of science education to study understanding of science



content, there is little work on using it as a tool for science teacher education, specifically for the use of promoting pedagogical knowledge. Additionally, concept mapping is used primarily as a tool for measuring understanding or conceptual knowledge. Jonassen (1996) suggests that concept mapping is a powerful tool for stimulating learning, rather than merely as a tool for assessing learning. The question posed by this research is whether or not regular concept mapping during preservice teacher education promotes acquisition of meaningful and sophisticated pedagogical knowledge.

#### Mehmet Aydeniz

#### What is Hindering Reform-Based Teaching: Cultural Constraints or Professional Limitations?

This study looks at the interaction between the school culture and teacher competency to account for challenges to the implementation of reform-based ideas in science classrooms. A qualitative methodology guided this inquiry. Data collection involved interviews with four science teachers, classroom observations and document analysis. Findings suggest that although school culture was not conducive to the implementation of reform-based ideas, lack of accountability and teachers' naive pedagogical content knowledge (PCK) accounted for the failure to implement reform-based teaching in science classrooms.

#### Dale Baker, Elizabeth Lewis, Sibel Uysal, Senay Yasar-Purzer, Michael Lang, Perry Baker

Using the Communication in Science Inquiry Model to Facilitate Learning Biology

Using the Communication in Science Inquiry Model to Facilitate Learning Biology Abstract The issue of highly qualified teachers in content necessitates a new way of thinking about professional development. This research provides evidence that instruction through laboratory activities enhances teachers' science content knowledge when placed in the context of the Communication in Science Inquiry Project (CISIP) model. The CISIP model includes inquiry; linking facts to conceptual frameworks; establishing performance expectations; fostering metacognition; using formative assessments and feedback; identifying prior understandings; and using academic language development, writing, and oral discourse strategies. Twenty-one teachers (10 science, 13 English/ELL) attended a three week Summer Institute to learn how to infuse lessons with the CISP model and collaborate with each other. Content focused on genetics. A test was created (KR20=.80) to correspond to the facts and concepts in the genetics activities. Analysis of the pre and post tests indicated that there was a statistically significant increase in scores for the entire sample as well as for science and English/ELL teachers separately. Gains were similar for science and English/ELL teachers. All tests were significant at p

#### Brian Baldwin

Hybrid Coursework in Teacher Preparation: Teacher Education's Structural Response to Increased Demand for Highly Qualified Science Teachers

This study was undertaken to investigate the somewhat clashing viewpoints of teacher education programs' quality standards for the education of prospective science teachers with the reality of many school districts' continued vacancies for science teachers. While the coming NCLB standards for teacher education programs loom large in the education of high- quality science teachers, programs are concomitantly hit with the calls from local districts crying for more science teachers. To address both needs, one program in teacher education has instituted a "hybrid" nature to many required education courses (courses which structurally contain both face-to-face class sessions with required online course components). This study investigated a hybrid course entitled Teaching and Learning. Students in the course were observed, surveyed, and interviewed regarding their experiences with different portions of the course both online and in-person. Results indicated that students responded favorably to different course events online and in-person. Notably, most students desired an increased amount of face-to-face time for events requiring greater degrees of interaction and feedback, namely microteaching. In conclusion, hybrid courses seem to be a viable option for colleges and universities as they gradually expand their teacher education programs.



#### Meena Balgopal

The Role of Identity and Motivation to Resolve Misconceptions

Socio-cultural factors, such as motivation, beliefs, and achievement goals likely influence conceptual change. In this study, it was found that the role of personal and professional affiliations affected learners' motivation to resolve their recognized dissatisfaction of conceptions. Six biology education students' composite personal and professional identities and motivation to understand evolution were explored through pre and posttests, written discourse, in-depth interviews, and classroom observations. All six learners had strong professional identities as future teachers and personal identities as Christians with creationist backgrounds. Case study analysis using grounded theory revealed that learners' self-identities both hindered and enhanced their motivation to resolve recognized confusion about evolution. Two learners were motivated by their desire to be able to defend their religious beliefs to their classmates and instructor, while the other four learners were motivated by their desire to defend the teaching of evolution to their future students, students' parents, and school administrators. One implication of this study is that instructors should foster learners' affiliation to a learning community because this may increase learners' motivation to resolve their conceptual confusions within the learning environment.

#### Yael Bamberger

Hands-On or Minds-On? Zones of Interaction and Expressions of Curiosity in an Interactive Science Center

The purpose of this study was to describe and understand students' interactions in an interactive exhibition in a science center. Since the museum setting is strongly socio- culturally mediated, the theoretical framework is based on the socio-cultural theory that emphasizes social interactions and cultural symbols as an essential opportunity for meaning- making. One class visit of eighth graders to an interactive exhibition of a science center was observed and videotaped. Students' conversations were analyzed by using a scheme for critical discourse analysis developed by Shaperdson and Britsch (2006, Journal of Research in Science Teaching, 43, 443-466) for the classroom settings, that takes into account the spatial zones of interaction: individual, multiple and collective. Since museumbased learning relies on curiosity, each zone of interaction was also examined by looking at different expressions of curiosity: technical, emotional and intellectual. Findings indicate several expressions of curiosity, mainly in the collective zone, and minimal intellectual expression during the students-guide interaction. The framework suggested here, which included graphic representation of interactions, enables an innovative method for investigating how conversations rely on curiosity in museums, as well as in other novel stimulus environments.

#### Bongani Bantwini

Teachers' Perceived Meanings of Their New Curriculum Reforms: Lessons From One School District in South Africa

The meanings that each teacher attaches to new curriculum reforms acts as his/her map to the new curriculum implementation journey, and that usually determines the success of those reforms. In this study, I explored the meanings attached to the new science curriculum reforms by elementary school teachers in one large school district in South Africa, where they emanated from, as well as the role they played in the classroom implementation of the new reforms. This mixed method study is part of a major study conducted in 2006 focusing on professional development and new curriculum reforms in one large district. The data sources were semi-structured interviews, classroom observations and questionnaires. Some data analysis employed the iterative process (Miles & Huberman, 1984) while some was analyzed quantitatively using SPSS software. The findings revealed that teachers held various concerning meanings about the new reforms including being an overload with lots of paper-work. These meanings emanated from lack of clear understanding of the reform vision and that created frustrations resulting to lack of implementation in classrooms. In conclusion I suggest way that would help avoid meanings that hardly resonate with the new curriculum vision.



#### Mónica Baptista, Ana Freire

Learning About Sound Through Inquiry. A Study With 8th Grade Pupils

Society has been confronted with controversial questions of scientific and technological nature. School is responsible for habilitating individuals to survive in society. In Portugal emerged a national debate that culminated in a reform of science teaching for Middle School which has a constructivist focus, values the scientific inquiry approach, promotes the Science- Technology-Society perspective and specifies competences. New curriculum pushes teachers towards new teaching approaches but the teachers' existing conceptions about the teaching and learning of science can constitute a barrier to the innovation of science teaching. Curriculum success depends on teachers' ability to put it on action. So, there's a need to explore various approaches to help them to develop a will to implement, reflect and retry new teaching approaches and become involved in a process of practical research, collecting data and reflecting about pupils' skills in order to contribute to a better teaching. This study is part of an extended one that involved schoolteachers implementing scientific inquiry, during a sequence of lessons about sound, according to the curricular guidelines. This presentation aims at describing the type of learning that took place when pupils were involved with scientific inquiry and showing its consistency with the proposals of national curricular guidelines.

#### Miri Barak, Shulamit Witenoff, Judy Dori

Action Research and Support Groups - An Induction Framework for Novice STEM Teachers

Novice STEM (science, technology, engineering, and mathematics) teachers face several problems in their first years of teaching, a period which is frequently accompanied by anxieties and feelings of frustration. To overcome these crucial problems, we implemented an induction framework that included support group meetings and an action research project. The research goal was to examine whether and how the induction/action research framework enhances novice teachers' expertise, within the science education domain. The research was conducted during three years, in which data were collected via observations of mentor-trainee meetings, interviews with novice science teachers, mentors' questionnaire, and analysis of the action research projects. The results of this study show that there was a noticeable effect of the support group meetings on the self-image and confidence of the novice science teachers, due to their feelings of "community" and their ability to work out personal and educational problems in a supportive environment. In their conversations and analysis of classroom problems, the novice teachers began to view their teaching in a more reflective and critical manner and indicated that the induction/action research framework enhanced their science teaching expertise.

#### Marianne Barnes, Lehman Barnes, Jerry Everhart

Attitudes and Behaviors of Teachers Exposed to Action Research

Science educators follow national and state standards when they implement inquiry into courses and professional development venues, including inquiry into teaching practices. Teachers in a southwestern state are exposed to reflective practice research techniques including action research (AR) through graduate coursework and statewide action research grants, among other professional development sources. Little data exist that describe teacher attitudes and behaviors related to action research and whether those who have employed action research strategies continue the practice to improve student learning after initial exposure to teacher researcher methodologies. In this study, researchers asked fundamental questions that can better inform "teacher as researcher" supporters as well as funders of research. Key questions include: Are use of action research methods limited to the term of grants and university courses? What internal mechanisms promote or impede the use of action research methods? Investigators used surveys, interviews, and archival analyses to uncover patterns in teachers' attitudes and behaviors. Subjects of the research include past grant recipients, others who have experienced action research, and a control sample. Research was conducted in fall 2006 and spring 2007.



#### Michael Barnett, Meredith Houle, Michelle Smith

Leveraging GIS Technology in Urban Schools to Visualize Impact of Urban Forests on Climate, Energy Use and Air Quality

Researchers have argued that cities are critical factors in our efforts to recover and maintain the earth's ecosystems. Unfortunately, the current cohort of students who will be the future caretakers of urban ecosystems have never been given the opportunity to either understand or appreciate the ecological richness of their city, nor do they have the scientific skills to understand how their actions impact their urban ecosystem. In this paper we describe how using the new science of urban ecology -coupled with Geographic Information Systems and modeling technologies - has enabled our project team to engage urban students in learning about their environment and developing an understanding of the value of their urban ecosystem. We have found that participation in our curriculum, using mixed method approaches, that students' understanding of the impact of their urban ecosystem on their own lives and health is rather significant.

#### **Celeste Barthel**

Middle School Aged Students Interactions with 3-D Visualizations on a Spherical Display at a Science Museum

A pilot study conducted at a large US East Coast Science Center focusing on middle-school aged students' interactions with 3-D visualizations on a spherical display (specifically the Science on the Sphere exhibit) reveals the following preliminary points: 1) Participants display a distinct, repeatable pattern of exhibit exploration with the exhibit, including immediate, quick exploration of the entire exhibit area, followed by touching the display monitors circling the exhibit. When a docent is present, students spend more time at the exhibit, and when images on the exhibit change students returned to look at the new image, and 2) the lack of control over the exhibit hinders participant holding time and interaction. Results from observational data, interviews, and written responses from participants are used to examine and explore these interactions with 3-D visualizations on spherical displays to gain information on the learning experiences that are occurring in this free-choice environment.

#### Oksana Bartosh, Jolie Mayer-Smigh, Linda Peterat

Examining Elementary Students' Understanding of Farming and Food Growing Related Issues

Understanding issues related to food and farming and the ability to make decisions that would benefit the environment are important parts of environmental literacy. However, research indicates that many children have limited understanding of food, farming, and land- related issues. This quantitative study explores how a yearlong environmental program affects elementary students' understanding of food, farming, and sustainable food growing practices. Two groups of students are compared: grade 4/5 students who participated in the Intergenerational Landed Learning on the Farm Project (ILLP) in 2006-2007 and grade 4/5 students from the same schools, who did not participate in the project. The results of this study indicate that students in ILLP had a better understanding of farms and farming and more positive attitudes toward the environment than students in the comparison group.

#### Tamar Basis, Nir Orion

Characterization of High School Students' System Thinking Skills in the Context of Earth Systems

The current study deals with the characterization of systems thinking in the context of earth systems among high school students who major in earth science. The study addressed the following research questions: (a) what are the system thinking skills of earth science students in the beginning of the learning process? (b) Do earth science students improve their system thinking skills during the learning process? (c) What are the factors influence the developing of system thinking skills among earth science students? The research combined qualitative and quantitative methods. The collected data included pre/post-instructional questionnaires of system thinking skills, student-generated artifacts and the teachers' perspectives. The population included 74 high school students from a single prestigious high school, divided into three cohorts during the ë05-ë07 academic years. Most of the students began with poor systems thinking skills. Following instruction of an earth science curriculum, these skills devel-



oped significantly in many, but not all students, due to the following factors: the initial cognitive ability of the students, the outdoor learning experiences, knowledge integration activities, the teachers' mediation and guidance, the students' level of involvement, and the students' perception of the learning process. Students develop systems thinking skills only when all these factors are synergistic.

#### Nazan Bautista

Revisiting Elementary Teachers' Physical Science Conceptions After the No Child Left Behind Act

This study investigates elementary teachers' conceptions of elementary grade level physical science concepts. The study reveals that even after attending several professional development workshops in science content area, elementary teachers still hold misconceptions about basic physics concepts.

### Gillian Bayne

Making Meaning of Shared Experiences Using Cogenerative Dialogues

The research described in this paper is situated in a small urban New York City public high school. It explores how students and teachers in a ninth grade biochemistry class utilize cogenerative dialogues (Roth, Tobin & Zimmermann, 2002) to improve the teaching and learning environment. Within the cogenerative dialogue field, participants engage in critical reflection by making meaning of shared experiences through polysemic and polyphonic opportunities, ultimately catalyzing change at the individual and collective levels. The dynamic interactions of cultural, social and symbolic capital are examined through theoretical lenses grounded primarily in those that are socio-cultural in nature, explore social life through the agency|structure relationship (Roth & Tobin, 2002) and examine the emotional dynamics that are involved in face-to face encounters.

#### Ian Beatty, Allan Feldman, Hyunju Lee, Karen St. Cyr, Robby Harris

Teacher Learning of Technology-Enhanced Formative Assessment

iTeacher Learning of Technology-Enhanced Formative Assessmentî (TLT) is a five-year NSF-funded research project studying how secondary science and mathematics teachers learn, adjust to, and adapt a particular technology-based pedagogic approach when exposed to a sustained, intensive professional development program. The project blends instructional technology, innovative pedagogy, in-service teacher professional development, and teacher learning research. iTechnology-Enhanced Formative Assessmentî (TEFA) is a pedagogical model built on four pillars: question-driven instruction, dialogical discourse, formative assessment, and classroom response system technology. Each of these, independently, is of well-established value to science instruction. Integrated into TEFA, they form a powerful, coherent, self-reinforcing, tractable whole. Previous research reveals that teachers have difficulty learning to implement TEFA. For the TLT project, we are conducting an intensive, sustained, on-site TEFA professional development program for 32 science and math teachers from three different schools. We are studying their learning and implementation of TEFA through a delayed-intervention, repeated-measures, mixed-methods longitudinal study. The project is slightly more than half-way through its five years of funding. Preliminary results suggest key internal and contextual factors that determine the ease with which teachers become comfortable with TEFA, common difficulties they encounter, and ways to improve our professional development design.

### **Christopher Beccles**

Improving the Quality of Science Instruction in Primary Schools in Cape Coast in Ghana

Many factors play supportive roles in improving the quality of education in primary schools. The purpose of the study was, therefore, to examine the level of interaction with teaching and learning materials (TLMs), the frequency and place of doing practical work, the teaching method used during instruction, and the use of computers among pupils, in primary schools in Cape Coast, in GhanaTown. The study revealed that, majority of the pupils do not interact evenly with the TLMs during science instruction, and many pupils performed science practical



work only once in a month. Besides, there was no science laboratory in the schools. However, majority of the pupils liked the teachers' method and the pace of instruction. The pupils did not use computers to learn science, and only a small number learnt about how to use computers at school.

#### Philip Bell, Leah Bricker, Suzanne Reeve, Carrie Tzou, Heather Zimmerman, Richard Duschl

Listening to children: Understanding the development of everyday expertise in using evidence, keeping healthy, and understanding scientific practices

In this symposium, we report on findings from our ethnographic research, as well as from the first iteration of our curriculum design effort that incorporates insights from our ethnographic work into classroom science instruction. We focus on the themes of personally consequential biology, images of science, and argumentation. Our everyday expertise framework works to analytically synthesize these various themes and efforts, in order to answer questions such as, what do the words science, evidence, and healthy actually mean to young people? What are some of the factors influencing young people's meanings for these concepts? How, if at all, are young people's meanings for these concepts formed by and/or incorporated into their activity systems? How can we incorporate our ethnographic findings into the design of K-12 science instruction? We believe that research efforts guided by such questions are critical because they help us begin to untangle the mysteries associated with how young people learn across the various settings of their lives, as well as how the meanings young people associate with given concepts affect their K-12 science classroom experiences and future non-school learning experiences.

#### Katherine Bellomo

STSE (Science, Technology, Society, and the Environment): Interactions between Policy, Curriculum Development, Social Justice Issues and Political Content Knowledge.

STSE (science, technology, society and the environment) curriculum seems difficult to develop and challenging to implement. This study explores how science/biology teachers develop and implement curriculum that will support the STSE expectations in science courses and further social justice issues in the classroom. Action research would seem an ideal way to develop curriculum that supports student needs and STSE expectations yet it has proven difficult to accomplish. Teachers face a variety of personal and institutional barriers and often feel ambivalent about the value of STSE curriculum. I suggest that the development of their own political framework and a clarification of political content and context knowledge would enhance their teacher knowledge and would facilitate curriculum development that supports STSE themes and justice issues. This is important to teachers in Ontario, Canada as they implement new policy documents as well as to science educators everywhere who have a commitment to the themes in STSE.

#### Orit Ben zvi-assaraf, Nir Orion

System Thinking Skills at the Elementary School Level

This study deals with the development of system thinking skills at the elementary school level. The sample included 44 fourth grade students from one school in a small town in the Israel. The students studied the hydro cycle through an earth systems curriculum that involved lab activities, direct interaction with components and processes outdoors and knowledge integration activities. The data was collected through a battery of research tools that integrated qualitative and quantitative approaches. In spite of their minimal initial system thinking abilities most of the students significantly increased in their ability to analyze the hydrological system into components and processes and to identify interconnections between components of a system. Few students even reached higher system thinking abilities. The direct contact with real phenomena in the outdoors, the lab activities and the knowledge integration assignment enabled the 4th grade students to develop basic system thinking abilities. Although system thinking is a high order thinking skill, it can be developed to a basic level in the elementary school. Following our previous study with junior high students, it is suggested that this basic level will enable the development of the higher system thinking ability in the middle school.



#### John Bencze, Steve Alsop, E. Sperling, J. Nazir, M. DiGiuseppe

Science Teachers' Motivation for Encouraging Students to Promote Individual, Social & Environmental Wellbeing

School science often seems to contribute to pathological global economization — in which profit-motivated production and consumption of commodities takes precedence over the wellbeing of individuals, societies and environments. To address this situation, a framework for an 'altruistic' school science is presented that may replace a Social Darwinist ideology with one that promotes human evolution based on love, ethics and education for all. Qualitative data from teachers' evaluations of this framework suggest that its effectiveness may depend on teachers' motivation for altruistic science education which, in turn, may depend on: the 'tightness' of associations between participation in issues and representations of them, their views about science, and their religious perspectives. Meanwhile, factors limiting implementation included school culture and resource availability.

#### John Bencze, Gervase Bowen, Maurice DiGiuseppe, Marijana Kanisek

Scientists, Profit-driven Science, and School Science

Academic scientists frequently influence the content and character of school science. Consequently, it is important to understand how they perceive the nature of their work and what about that should be shared with school students and other members of the public. An aspect of scientific work that they may or may not want to share with others pertains to possible adverse effects of profit-motivated funding on knowledge building and dissemination. Recent studies suggest that ideals of scientific practices frequently are compromised for the sake of profit-making. To determine the extent to which academic scientists would be willing to educate students and the public about possible adverse effects of profit-driven science on the integrity of science, we video-recorded semi-structured interviews with twenty scientists and collected artifacts of their work. Qualitative data analyzed using constructivist grounded theory suggest that there were four groups of scientists in terms of their willingness to educate others about profit-driven science; i.e., Informers, Para-Informers, Idealists and Protectionists. Their tendencies to educate about profit and science, in turn, appeared to be influenced by their: personal experiences, science 'guardianship' and views about science. Ramifications of these findings for school science, public education and education of scientists are discussed.

#### Cheryl Berg, Stephanie Touchman, Muhsin Menekse

Biology Students' Ideas about Germs and Illness: An Exploratory Study of Conceptual Change

The purpose of this exploratory, qualitative study was to investigate misconceptions college biology students have about germs and illness, and to observe conceptual change facilitated through science teaching. Naïve ideas about germs and getting sick are typically constructed early in childhood. These ideas can be resistant to change because of the strong connection to personal experiences and "what mom taught". Through tests and interviews we captured insight into what common misconceptions college students have about germs and getting sick prior to participation in a microbiology lesson, and how some of these ideas are resistant to change. Our research focused on three basic themes: 1) What is a germ? 2) Does the weather have any direct impact on the chances of getting sick? 3) Is a virus a living cell? Each theme was addressed and analyzed with 16 students through pre-tests, post-tests and one-on-one interviews. We feel our results can provide biology teachers with valuable insight into the different ideas students have about germs, and provide awareness of the tendency for students to memorize concepts for lesson exams but fail to retain concepts over time. Overall our results make a unique contribution to the study of conceptual change and pathogens.

#### Stuart Bevins, Marilyn Brodie, Eleanor Brodie

The Student Associates Scheme: Implications for the Quality of Initial Teacher Training (ITT) in England and Wales

Abstract This paper reports findings from a study which explored undergraduate perceptions of the Student Association Scheme in England and Wales. The scheme was established by the Teacher Development Agency in an



attempt to increase the number of graduates entering the teaching profession, particularly shortage subjects such as science and maths. The scheme places undergraduate students on short-term placements in secondary schools throughout England and Wales to provide them with experiences that may encourage them to consider teaching as a career option. Nominal Group Technique was used to elicit students' perceptions about their palcements through a focus group approach. Students identified five key themes and ranked them in order of importance. Semi-structured interviews with individual students allowed deeper exploration of these themes.

#### Carrie Beyer, Barbara Hug, Lisa Kenyon, Leema Kuhn, Katherine McNeill, Ted Willard

Using Evidence: What are students able to do and how do we best support them across elementary, middle, and high school?

This symposium is designed to explore how students' think about and use evidence, how their thinking and use of evidence changes over time, and how they can be supported in using evidence while engaging in the practices of scientific inquiry. One of the trends in science education is towards students constructing meaning through engagement in scientific practices, asking questions, designing investigations, gathering data, and using that data as evidence to construct and argue about explanations regarding the phenomenon under study. Another trend in science education is the effort to use learning progressions to describe a sequence of more and more sophisticated ways of thinking about a scientific inquiry practice or content over time. This symposium will address these issues in two steps. First, the session will begin with an interactive poster session in which each researcher will present their work that explores the challenges and successes that students face when using evidence, in various grade levels and contexts. For the second part of the session, we will reconvene to discuss the practical implications. We conclude this symposium by looking across our individual studies and related research to discuss possible axes on which a learning progression for using evidence could vary.

#### Carrie Beyer, Elizabeth Davis

Supporting Preservice Elementary Teachers' Critique and Adaptation of Science Curriculum Materials Using Two Types of Educative Supports

Critiquing and adapting curriculum materials are essential components of teachers' work. However, preservice teachers encounter many challenges in engaging in these tasks and thus need support. This study explores the use of educative curriculum materials in helping preservice teachers develop beginning levels of proficiency in critiquing and adapting curriculum materials. These materials contain educative supports specifically intended to support teacher learning, in addition to student learning. However, little is known about how educative supports should be written in order to support teacher learning. This study examines the affordances and constraints of two different forms of support, general educative supports and lesson-specific educative supports, in helping preservice elementary teachers critique and adapt science curriculum materials. Results show that the narratives helped the preservice teachers identify specific instructional strategies to use with their students and view the educative supports supports supports helped preservice teachers identify important principles of practice to use in their analysis of lesson plans and see that the ideas in the educative support extended to other lessons. Implications for science teacher education and the design of educative curriculum materials are discussed.

#### Julie Bianchini, Barbara Crawford, Betsty Davis, Julie Luft, Mark Olson, John Tillotson

Beginning/Newly Qualified Science Teachers: Guiding this Emerging Domain

Research pertaining to newly qualified teachers is just beginning. In order to initiate the discussion in this area, science educators who work with beginning teachers will reflect on several aspects of this emerging field. Our symposium will begin with a discussion of our current work, and then proceed to contemplating lines of research that are critical in the field. The final part of our symposium will be a discussion regarding the promise and pitfalls of working with new science teachers, as well as a discussion with the audience about potential research topics that pertain to beginning science teachers.



#### Alice (Jill) Black

Does Completion of University Science Courses Affect the Spatial Ability of Preservice Elementary/Middle Teachers?

Preservice elementary/middle education majors (N = 131) were administered tests that measured three spatial ability factors: spatial perception, mental rotation, and spatial visualization. One group of students were early in their university science careers, and had not yet begun content study in the first of three required science courses. The second group had completed at least two of the required courses. The second group was composed of two subgroups; one had received instruction designed to include spatially-related science activities related to course content. Results showed significantly higher combined spatial ability scores in the group that had completed more science content courses, as well as higher scores on most of the individual spatial tests. Spatial perception scores were much lower for the subgroup of the second group that did not receive spatially-related instruction. Results suggest that a preservice program with several required science content courses, especially those that include spatially-related instruction, may possibly benefit spatial abilities, which are known to be related to acheivement in science.

#### Margaret Blanchard, Sherry Southerland, Len Annetta

Investigating the Effectiveness of Inquiry-Based Versus Traditional Science Teaching Methods in Middle and High School Laboratory Settings

In this quantitative study, 23 middle and high school science teachers at 7 schools in 3 school districts taught approximately 1,750 students a laboratory-based forensics unit. Teachers with inquiry-based research experiences employed the inquiry-based method Teachers from these same schools employed the traditional method. Teaching fidelity was verified using the RTOP instrument. Pre, post, and delayed post test were analyzed through a Hierarchical Liner Model (HLM) that compared students' scores by method (and the effects of teachers, schools, and districts). Results indicate statistically significantly higher post test scores for middle school students using the inquiry-based method. School SES, district, and teacher significantly affected achievement at the middle school level.

#### Janet Bond-Robinson

What Can a Laboratory Study of Chemistry Tell us About Learning?

Chinn & Malhotra (2002) found a need for detailed studies of scientists' actual reasoning processes to show epistemologically authentic learning in science because of the wide variety of descriptions of scientific inquiry and reasoning (Boujaoude, Duschl, Mamlok-Naaman, Hofstein, Niaz, Treagust, & Tuan, 2004). We investigated a research group synthesizing novel organic molecules at an R-I University in the USA to discover what it can tell us about epistemologically authentic inquiry. Ethnographic methods explored the material, intellectual, and social context in a similarly sized research group to Latour & Woolgar's (1979) study at the Salk Institute. Our intentional divergence is our study's focus on cognition during day-to- day activities involving inquiry and scientific reasoning through data collection and analysis of videotapes and field notes supplemented with informal and semistructured interviews with the key participants. This non-classroom style of learning was coordinated through researchers' intentions to meet cultural goals in organic synthesis that led to necessary constraints on all researchers' reasoning: Mechanical reasoning and skill to produce and troubleshoot organic reaction systems; macro-level work based on nano-level understanding of organic reaction mechanisms; and grasping and aligning with tacit and explicit norms and rules for production of novel molecules.

#### Janice Bonner, William Holliday

The Metacognition of College Science Students

This focus on the metacognition of college science students had two purposes: to examine the relationship between what college science students say they do when they study and what they actually do; and to compare participants' theory of study with the Metacognition of College Studentship (MCS) (Pressley, Van Etten, Yokoi, Free-



bern, & Van Meter, 1998) and a model of self-regulated studying (SRS) (Winne & Hadwin, 1998). We worked with 23 biology majors enrolled in a semester-long upper-level genetics course. We analyzed course notes, course textbook, corrected and graded exams, and mid-term and final grades. We also interviewed participants five times and engaged them in Study Alouds in three of those interviews. We divided the course into three segments based on the placement of course exams. For each segment, we compared what participants said they did to study with what they did in the Study Alouds and compared their theory with the MCS and with the SRS model. Results suggest that thinking about thinking, a key aspect of metacognition, was not very evident in either the students of the MCS or in our participants. Recommendations included instructor practices that might improve college science students' metacognition and suggestions for future research.

#### Saouma BouJaoude, Murad Jurdak

Integrating Physics and Math Through Microcomputer-Based Labs (MBL): Effects on Discourse Type and Quality and Mathematization

The purpose of this study was to understand the nature of discourse in terms of knowledge types and cognitive process, source of utterances (student or teacher), and time use in microcomputer-based labs (MBL) and verification type labs (VTL) and to gain an understanding of the role of MBL in promoting mathematization. The study was conducted in two Grade 11 classes in which students studied Hooke's Law and Newton's Second Law of Motion using MBL during one year while a different group of students studied the same topics with the same physics teacher using a VTL approach. All sessions were videotaped, transcribed, and coded using a taxonomy developed by DeVito and Grotzer (2005). In addition, evidence to support each of the five steps of mathematization was sought from the actions of the teachers and their discourse with the students. Results showed that conceptual knowledge type utterances were significantly more frequent in MBL sessions, cognitive processes of remembering and understanding were significantly more frequent in the MBL sessions, students spent most of their time analyzing the graphs in the MBL sessions, and that MBL has a potential to promote mathematization in favorable instructional environments in physics laboratory classes.

#### G. Michael Bowen, J. Lawrence Bencze, Elizabeth Sampson, Nicole Arsenault

Understanding Science (Fairs) in the News Media

Science fairs are an almost ubiquitous experience for students at some stage in their attending public school. This paper examines how science fairs (and science) are portrayed in newspaper media coverage of national and local science fairs. Despite the high participation rate media coverage appears quite low and often focuses on three main themes: i) The idea that science is judged competitively is prominent in the articles. "Science is competitive" is an overriding theme. ii) That science is engaged in for financial gain permeates the commentary. The financial benefits that accrue to 'winners' is a clearly pronounced theme. iii) Science inquiry fills a 'functional' purpose (i.e., in that it solves recognizable issues or problems usually for which there are corporate/financial interests). We discuss in detail how this presentation may occur because of the author<-> audience dialectic and the corporate profit needs of newspaper media.

### G. Michael Bowen, J. Lawrence Bencze, Bradley Tucker

A Cultural-Historical Activity Theory Perspective on Science Outreach Programs

School science presents a perspective on the nature and practice of science that has oft been criticised, because science is portrayed as composed of discreet generic parts, as value-free, and because scientific theories are presented as facts. Outside of schools, science learning happens primarily through media and science centres. Here we examine the practice of science outreach activity from a cultural-historical activity theory perspective. Results suggest that the outreach scientists taking part in this activity presented a traditional view of science, as is typically propagated in schools and that participating in this activity did not substantially contradict students' previously-held perceptions of the nature and practice of science. Suggestions are made for the improvement of practice within these systems.

#### Bryan Anthony Brown, Shawn Holmes, Sanghee Choi, Crystal Gomillion, Edna Tan, Gillian Bayne

How identity and cultural frameworks shape access to and appropriation of science literacy

The NARST Equity and Ethics committee has established a tradition of providing scholarships to under represented scholars and for those conducting research on under represented communities. The 2007 award winners submitted a collection of research that critically examines the intersection between individual identity and cultural participation. This symposium introduces NARST scholars to emerging young researchers who engage in research that critically analyzes the impact of culture and identity on students learning. The work extends contemporary research by offering a synthesis of empirical and theoretical directions for future scholarship.

#### Patrick Brown, Sandra Abell, Patricia Friedrichsen

Investigating Teacher Knowledge of Learners and Learning and Sequence of Science Instruction in an Alternative Certification Program

Alternative certification programs (ACPs) have been designed to address the teacher shortage and still meet the goals of science literacy by creating highly qualified teachers. However, science education researchers know little about the development of teacher knowledge during an ACP. The purpose of this study was to investigate how science teacher knowledge of learners and lesson structure develops in an ACP. Data sources included a lesson planning task at the beginning of the program, interviews after the first summer of ACP coursework, and an interview-observation cycle during the teacher's first semester teaching. We constructed profiles of four individuals and generated a set of assertions from a cross-case analysis. Participants demonstrated the consistent belief that science learning should be student-centered and developed knowledge about students' prior science knowledge, while at the same time maintaining a focus on teacher-centered instructional sequences. Participants' knowledge was influenced by their participation in the ACP, including coursework and field experiences. Understanding future teachers' knowledge about science learners and their sequencing of science instruction is critical for improving science teacher education.

#### Lynn Bryan

External Policy and Relations Committee-sponsored Session: Taking action---What can NARST members do to inform policymakers and the public-at-large?

In this interactive session, NARST members will have a chance to hear from and speak with a science education lobbiest about ways in which science eduction research can inform policymakers and the public-at-large.

#### Lynn Bryan, David Sederberg, Alan Szeto, Shanna Daly, Kelly Hutchinson, Fatima Benaissa

Middle and High School Teachers' Emerging Conceptions of Nanoscale Science

Nanoscale science is an emerging, interdisciplinary field of science that presents both opportunities and challenges to those who are called to design and incorporate nanoscience instruction into their classroomsóin particular, grade 7-12 teachers. This interdisciplinary nature necessitates a blurring of the curricular separations that have traditionally been made between the science disciplines. In addition, it necessitates that teachers who desire to infuse nanoscience into their instruction engage in learning opportunities to enhance their knowledge and skills for teaching nanoscience. Concomitant with the development and implementation of a nanoscience professional development program, our research group embarked on a multi-year effort to examine teachers' knowledge and beliefs about nanoscale science and the teaching of nanoscale science in middle and high school classrooms. In this paper, we report findings from a study that examined teachers' emerging conceptions of nanoscience phenomena, including size and scale, structure of matter, size-dependent properties, forces and interactions, self-assembly, models and simulations, and tools/instrumentation.



#### Gayle Buck, Julianne Kaftan, Jennifer Nelson

Making Formative Assessment Discernible to Pre-Service Teachers: A Pragmatic Self-Study

The purpose of this pragmatic self-study was to explore our re-conceptualization efforts in preparing pre-service teachers to guide the inquiry process with formative assessment and subsequently using the understandings to improve our teacher preparation program. The process was guided by the questions, "Did our re-conceptualization efforts lead to a more informed understanding of formative assessment?" and "What strategies fostered or hindered progress toward our desired outcomes?" Our paper will provide data to support the following findings and guide the subsequent discussions: 1) A significant pre- to post- experience difference was realized in the participants' understanding of formative assessment; 2) An explicit-reflective approach to teaching about formative assessment led to increased understandings; 3) An implicit approach lead to improvements in the course structure but did not foster an improved understanding of the reflexive nature of formative assessment; and 4) A case-study involving actual experiences with guiding elementary students' inquiry learning with formative assessment both hindered and fostered our efforts. The findings from this study are useful for persons seeking to foster inquiry-based science instruction through pre-service teacher education.

#### Paul Bueno de Mesquita, Betty Young, Celeste Bowler, Laurie Cente, Cristen Henderson

Teacher Talk, Science Questions, and Depth of Inquiry of Preservice Elementary Teachers During an Initial Inquiry Science Lesson

This study investigated the verbal interactions and questioning behaviors of six preservice teachers during initial instructional experiences while enrolled in an elementary science methods course. Students were assigned to teach a hands-on science lesson using inquiry methodologies designed to lead children to deeper understanding of science concepts. Videotaped lessons were analyzed for observed instances of teacher talk directed to whole class, small group, or individual instruction. Instances of science questions were identified and categorized according to Webb's depth of knowledge levels for rote/recall, skill/concept, strategic, or extended thinking. Frequencies and rates per minute were calculated for instances of teacher talk and science questions, as well as percentages of the total lesson time devoted to each. Results indicated that, although using hands-on science lessons, the majority of inquiry questions employed by these beginning teachers were posed in a way that elicited surface level recall and rote responses, across grade levels and lesson topics. Preliminary findings suggest that behavioral analysis of preservice elementary teacher verbalizations during initial classroom teaching experiences has significant implications for improving teacher preparation. Findings contribute to understanding the importance of depth of questioning, inquiry pedagogy, and teacher discourse during the early development of effective elementary science teachers.

#### Nievita Bueno Watts, Steven Semken, Monica Pineda, Cheryl Alvarado

Visitors' Geological Conceptions and Meaning Making at Petrified Forest National Park

When observing the natural landscape at National Parks, how do visitors make meaning of the geology? Interpretative geologic displays and programs here are typically uninformed by knowledge of visitor conceptions. We investigated visitors' ideas about geological processes and landscape formation at Petrified Forest National Park in Arizona by interviewing 80 visitor groups (N= 235) at a landscape overlook and analyzing the results using Verbal Analysis methodology. Visitors were asked to explain landscape formation, depositional environments, and regional uplift of the Colorado Plateau. In the absence of normative geological knowledge about the landscape, visitors frequently used familiar-place knowledge: a connection to a particular place with which the visitor has had experience. Our qualitative data analysis indicates that visitors: (1) relate landscapes to familiar places, (2) build on religious explanations, (3) superimpose past landscapes on modern ones, (4) patch together bits of information from media sources, and (5) have problems visualizing climatic change. Drawing on these findings, we present specific recommendations for design and implementation of new interpretative geological displays and programs.



#### Barbara Burke, Dennis Sunal, Glenda Ogletree

Women in Undergraduate Physics, Chemistry, Mathematics, and Computer Science: How Can We Sustain Them Through Graduation?

An intervention model at a major urban university was designed to increase the graduation rate of women in mathematics, computer science, and physical sciences. The program created experiences for upper division women to build a support network that focused more precisely on their needs. The purpose of this research was to examine the factors associated with sustaining academic progress for undergraduate women and the effects of an intervention program model. Qualitative inquiry supported with quantitative data was utilized with over 100 women involved in the program over the past two years. Data for factors influencing women in the targeted majors to graduate were analyzed The intervention program created significant change, concrete and psychological, for women to sustain efforts to complete their academic goals.

#### Allison Busch, Kimberly Tanner

Utilizing K-12 Science Education Partnerships to Develop Better Scientists: Integrating Pedagogy and Partnership Experiences into Graduate Science Training

Research on the impact of science education partnership experiences on scientists and scientific trainees is a new avenue of science education research that is of interest to a diverse audience of K-20+ policymakers, funders, and administrators. This study addresses several questions around whether the integration of a formalized K-12 partnership and pedagogy experience into their graduate experience influenced participating scientists' professional identities, specifically examining whether their newfound pedagogical knowledge impacts scientists' future teaching and research endeavors. Analysis of reflective essays from participating scientists noted fall in to five overarching themes: 1) Communication Skills, 2) K-12 Education Insights, 3) Partnership Insights, 4) Pedagogical Skills, and 5) Professional Identity Shifts. The most remarkable benefits that scientist participants describe relate to how their pedagogy and partnership experiences have significantly impacted their professional identities and expanded their definition of what it means to be a scientist. In addition, when scientists were probed they strongly agreed that their partnership and pedagogy experiences had made them better scientists.

#### Sanlyn Buxner, Christopher Harris, Bruce Johnson

Creating Tightly Aligned Assessments That Measure Student Growth in Primary Science in the Realities of an Urban School District

In this paper we present results from a collaboration between a university science education research group and a local school district to create, implement and revise science assessments for grades 1 - 8. The collaboration was in response to the district's need to create assessments that aligned with state standards, and matched their local curriculum, and could be delivered through an existing online infrastructure. The process included an initial summer workshop that brought together the research team, district science coordinators, and experienced teachers to create 27 assessments that could be administered to 40,000 students across the district during the year. Rasch analysis and teacher feedback was used to revise the assessments in two subsequent workshops during the year. An additional analysis and alignments of assessments was conducted modeled after the AAAS Project 2061 Symposium on Assessment presented last year. In the process the model was revised to meet the needs of the local district curriculum. Lessons learned include the real world challenges of writing assessments without a professional group of test writers, administering assessments district-wide, and working with an independent assessment firm to implement assessments within an existing online environment.



#### Clara Cahill, Namsoo Shin, Joseph Krajcik

Emergent Conceptions of Size and Properties in the Context of Nanoscale Science

If teachers are to facilitate students understanding of nanoscale science concepts, they must develop a thorough understanding of how these important concepts fit into student models of the way phenomena work. This study aims to clarify how middle school students, exposed to principles of nanoscale science, including principles of size and scale, and the relationship between size and properties, tend to incorporate such concepts into their mental models. This study follows twenty-two diverse middle school students from a Midwestern urban school district who participated in a summer science camp. The learning trajectories of individual students were evaluated through student-instructor dialogue and written artifacts. Through investigating students' emergent concepts of size and properties, as well as size and scale, we are able to evaluate how students attempt to make sense of complex nanoscale concepts. These emergent conceptions will enable teachers of nanoscale science to design curricula to address common alternative conceptions, and to encourage more scientifically accurate models of these big ideas.

### Angela Calabrese Barton, Heidi Carlone, Alberto Rodriguez, Bryan Brown, Pauline Chinn, Jomo Mutegi

#### Conceptual Frameworks for Research into Equity Issues in Science Education

Realizing a truly equitable science education means reconceptualizing ideas about science, knowledge, learning, and engagement. What this means, in part, is that science educators interested in pursuing goals related to equity in science education must become cultural brokers (Wenger, 1998) or boundary spanners (Buxton, Carlone, & Carlone, 2005), fluent in historical ideas about science, knowledge, and learning (dominated by psychological perspectives), but also fluent and able to educate others about contemporary theoretical perspectives on learning (bringing in ideas from anthropology, sociology, and Soviet psychology). Equity projects in science education may even demand that we push the envelope to develop new theoretical tools. This session will bring in prominent scholars with expertise in equity [in science education], who will discuss one primary conceptual tool that has been fruitful for conceptualizing their research. Each scholar will outline the concept (and theoretical foundations of the concept), discuss the methodological implications of the concept, and provide one short example of how the concept was/has been used in an actual research study. We expect that this session will be helpful to new researchers who might struggle with appropriate uses of theory and the development of conceptual frameworks, and also established researchers who are looking to expand their theoretical and methodological repertoires.

#### Brenda Capobianco

#### Reflective Practice as a Mechanism for Fostering Science Teacher Educators' Identity Development in an International Context

Building upon existing teacher identity literature and utilizing data gleaned from a study abroad program in science education, this paper provides insight into how an international experience affects how graduate students begin to construct and re-construct their professional identities as prospective science teacher educators. Data were collected via interviews; daily reflections; digital images; narrative accounts; and supporting documents. Data analysis entailed open-coding and the development of themes grounded in narratives. In this study, reflective practice is used a vital mechanism to promote meaningful ways of researching the complex nature of identity formation among prospective science teacher educators.

#### Stephan Carlson, Joe Heimlich, Martin Storksdieck, Dawn Tanner

Best Practices for Field Days Assessment Tool

Developing an Assessment Tool for Field Days Environmental Field Days are a way to get teachers and students outdoors into the natural setting to study ecology and natural resource issues. It uses the environment as a handson learning laboratory. Students visit 6 to 8 learning stations in work groups of 12-15 kids that are taught by natural recourses professionals. The Best Practices for Field Days Assessment Tool is an observational tool that was developed to provide a systematic way of evaluating Field Days in order to help them meet their intended outcomes.



A literature review synthesized the constructs and a Modified Delphi Method was used to verify components and help identify items that were used in the observational scales. The tool is designed to address the overall Field Day experience along with individual learning stations. It is to demonstrate the strengths of Field Day programs and provide guidance for way to help reach the programs intended outcomes.

#### Sarah Carrier, Anthony Guarino

Gender Differences in Elementary School Students' Environmental Education

This study assessed the efficacy of Schoolyard lessons in environmental education. Participants were 109 fourth and fifth graders. A 2 (Group: Treatment/Traditional) x 2 (Gender) M ANOVA with gain scores for (a) Environmental Knowledge, (b) Attitudes, (c) Behaviors, and (d) Comfort Levels as the dependent variables was conducted. Boys demonstrated statistically significantly greater score gains in the treatment group than in the traditional curriculum for all four outcome variables. Additionally, boys scored statistically significantly greater in the treatment group on Attitudes and Behaviors than girls in the treatment group. These results suggest that Schoolyard lessons help meet the unique needs of boys in elementary school.

#### Glenda Carter, Angelia Reid-Griffin, Eric Wiebe, John Park, Susan Butler

Sixth Graders' Approaches to Maps and Mapping

Sixth Graders' Approaches to Maps and Mapping This paper reports on 6th grade students' approaches to interpreting maps and making maps. The study examined three mapping tasks assigned to 6th grade students (n=17) enrolled in a six-week elective science course focused on earth science topics. Self-selected small groups typically consisting of three students worked through the small group activities throughout the term of the project and each small group activity was videotaped using independent cameras. One of the mapping tasks was to interpret flat maps. Results indicated that students often ignored features of the map that were not salient to them and therefore misinterpreted some aspects of the flat maps. The second mapping task was to draw a map using verbal instructions. Results indicated that a majority of students were not successful in completing the task. The primary reason for lack of success was failure to orient the map correctly. The third task was to interpret contour maps. Results indicated that tasks that required a 2-D to 3-D translation were more difficult for the students to accomplish. The ability to read and interpret maps has important implications for cognition.

#### Lyn Carter, Philip Clarkson

Interactive Whiteboards: Beginning a Study on Their Impact in a Wholly Wireless / Laptop Classroom Environment

Schools are rapidly adopting IWBs. The rapidity of uptake has not been in step with any well designed, comprehensive research effort that might inform patterns of adoption and implementation by teachers, nor any sufficient understanding about the impact IWBs might have on students and their learning. In this theoretical proposal we concentrate on insights from some of the relevant IWB research literature, noting gaps and deficiencies that need to be addressed. In particular we note usually only self-report methods are used, few rigorous studies describe the impact of IWB use on cognition, the need for more data on documenting actual changes in classroom interaction, and the need for studies to clearly focus on IWBs. These shortcomings make it difficult to assess the impact of IWB technology, if not impossible, in terms of any changes in the quality of student learning. We conclude with brief comments on the first case study school in our developing project.

#### Jennifer Cartier, Wendy Sink, Jeanetta Kochhar, Carla Zembal-Saul, Cynthia Passmore

Pre-Service Elementary Teachers' Appropriation of an Instructional Planning Framework

Pre-service elementary teachers (PETs) do not typically view science as an explanation-driven practice. This lack of understanding of the disciplinary practices of science often results the enactment of unstructured experiential idiscoveryî lessons (Tobin, 2001). Thus, our challenge as instructors is to help PETs develop the skills necessary



to draw on instructional materials to create learning experiences that are congruent with fundamental practices in science. Toward this end, we developed an Instructional Planning Framework (IPF) incorporating particular pedagogical practices into an overarching organizational structure. We analyzed the work of two PET cohorts on two written tasks: (1) selection and sequencing of instructional tasks; and (2) learning cycle lesson planning. We found that PETs appropriated aspects of the IPF and frequently used it to select and sequence instructional tasks. However, the PETs in our study sometimes appropriated the IPF in unintended ways, resulting in planned curricula that did not reflect authentic scientific practices. In these cases, PETs were limited by their science content knowledge and appropriated ideas about `exploratoryî lessons from our framework without understanding the role that conceptual knowledge should play in constraining and shaping those empirical experiences.

#### Jeffrey Carver, William Hunter

The Effects of Portfolio Assessment on Student Outcomes in Chemistry

Grading practices in science education have essentially followed two lines of thinking. The first approach is based on a total points system. A teacher will assign various point values to assignments and the student grade will be determined by calculating the amount correct out of the total possible points. The second approach utilizes a weighted average system where various assignments are grouped together. A percentage is determined for each category. Then each category is weighted with a percentage. The results of the calculations are then added together and represent a percentage for the course grade. This proposal involves a research project in which portfolio assessment was applied in a preparatory chemistry class. The portfolio assessment ties a standards-based approach to teaching together with authentic assessment in the form of a portfolio. This research examines the level of student understanding that results from the implementation of a portfolio design that puts more onus of control on the student. This study will focus on the level of student learning that is achieved as a result of completing the portfolio project. A pretest/posttest design with matched pair questions as well as interviews and surveys will be utilized to elicit conceptual competence.

#### Kefyn Catley, Laura Novick

Seeing the Wood for the Trees: An Analysis of Evolutionary Diagrams in Biology Textbooks

Graphical representations of evolutionary relationships among taxa have a long history in biology. Diagrams containing elements of various historic visualizations are unfortunately still found in contemporary biology textbooks. This study documents the type, frequency, and distribution of evolutionary diagrams in 31 well- established textbooks aimed at wide array of learners from middle school to undergraduate. A total of 701 diagrams were examined and placed one of three categories; cladograms (sensu stricto) in two forms, ladders and trees, and "other evolutionary diagrams". A coding scheme of 14 categories was developed to analyze the structure and content of the "other evolutionary diagrams" (n = 195). Of particular note are "tree of life" depictions, those showing anagenesis, and a very diverse group of diagrams showing hominid relationships. The data presented here are a first step in understanding how to better incorporate macroevolution into biology education, thus facilitating the tree thinking habit of mind. Scientifically-literate students should be as familiar with the patterns and processes of macroevolution as they are with the mechanisms of microevolution. Consistent exposure to authentic diagrams that clearly present the current consensus of scientific knowledge is a major part of such an education.

#### Janell Catlin

Student Voice Matters: Using Student Feedback to Evaluate Curriculum in an After School Science Program

This ethnographic study focused on using student feedback to evaluate the curriculum of an after school science program. Student reflection sheets and an interview were used to gather student comments on the activities they completed. The findings of this study suggest that student feedback gave insight on how teaching, student learning and assessment can be improved. The implications of this study suggest the power of student feedback to motivate students to learn and engage in science and the usefulness of the student feedback in classroom settings to enhance



the learning experience for students and teachers alike.

#### Andy Cavagnetto, Brian Hand, Lori Norton-Meier

The Nature of Student Discourse During the Generation of Argument

This study was conducted to determine the nature of student interactions in small groups. Fifth graders were audio recorded while working in small groups to generate claims and evidence after conducting student directed investigations. Audio recordings over four units of study were collected, transcribed, and analyzed using a multi-layered analysis. The layers of analysis ranged from analyzing turns of talk to identifying the functions of language and components of argument used during student talk. Results indicate that while the talk was dominated by the representational function of language and emphasized the claims and evidence components of argument, it was evident that students' discourse was focused on negotiation of their claims and evidence. The student dialogue is characterized as a process of information building both on an intrapersonal and interpersonal level as students oscillated between interpretation of their data and the language to represent their interpretations. The results would suggest that embedding argument within the curriculum appears to create a purpose for students to engage in meaningful discussions while the writing demands of the Science Writing Heuristic create student negotiation between the talk and the writing processes creating an environment that requires numerous layers of negotiation for students to participate in.

#### Robert Ceglie, John Settlage

Identity Conflicts in College Science Teaching

Our study explores the unique relationship and experiences that impact college level instruction through the experiences of an introductory biology professor. Specifically, we explore the type of growth and development occurring with a novice college biology instructor as he worked to improve student learning within his classes. We recorded shifts in his identity as he encountered opposition and conflict from peers within his department. The design of this study was a narrative phenomenology (Creswell, 2007). The phenomenon investigated was the decision-making involved in providing science instruction informed by science education reform (e.g., Project 2061) within a work environment that continued to hold to a philosophy of coursework being used to screen future science professionals from others who were less capable in science. The narrative was of a non-research science faculty member during a twelve month period in which data were gathered via a series of individual interviews as well as multiple observations of his science teaching.

#### Jeanne Century, Mollie Rudnick, Cassie Freeman, Debbie Leslie, Murat Kahveci, Andy Isaacs

A Framework for Measuring Fidelity of Implementation of Science Instructional Materials

This paper describes outcomes of the first strand of the "Applied Research on Science Materials Implementation: Bringing Measurement of Fidelity of Implementation (FOI) to Scale" project. This three-year, National Science Foundation-funded project is working measure the fidelity of implementation of standards-based science and mathematics instructional materials at the K-8 level in a large urban school district through the development and application of a suite of FOI instruments. This first strand focused on the development of a conceptual framework for describing FOI. We began with a thorough review of previous work on FOI, then engaged in an iterative process of theoretical review and framework development. We determined that the framework needed to comprise categories of critical components (the essential elements of the intended program model) and engaged in a process of science instructional materials review that focused on identifying of these critical components and placing them into framework categories. This paper will describe the application of the framework to the development of instruments, and the ways this framework will help to accurately describe teacher use of science instructional materials and support our ability to provide useful, meaningful information about FOI to the school district being served.



#### Jamie Chan, Kimberly Tanner

Understanding Middle School Students' Views of the Nature of Science: Perspectives from a Seventh Grade Classroom

Research into student and teacher conceptions of the Nature Of Science (NOS) has contributed a valuable framework to guide science teaching, curriculum development, and future science education research. However, few studies have investigated NOS views among adolescent students. In this study, we investigate seventh grade students' understandings of NOS. This research was performed with 74 seventh grade students at a diverse, urban public middle school in the United States, using questionnaire (n= 74) and videotaped interview methods with 14 of the 74 students, chosen to represent a range of cultural and religious backgrounds. The most articulate and divergent student responses centered around three major themes: 1) students' religious and cultural beliefs influencing their science views, 2) students' perceptions of the role of imagination and creativity in science and 3) students' self-identification with science and scientific careers. These students showed a diverse range of opinions and NOS views that are not dissimilar from those detected among older student populations. We believe this study contributes to extending our understanding of NOS views through investigation of these ideas among an urban American middle school student population.

#### Kim Charmatz

The Interplay Between Teachers' and Students' Personal Values and the Development of Environmental Action Projects Within Two Middle School Classrooms

This study investigated the development of environmental action projects within two middle school science classes from the framework of participatory action research: What are the experiences for students and teachers designing an environmental action project, in which students choose a specific action to complete? How do participants' prior experiences and values influence the development of these projects? How does the experience of developing action projects influence participants' existing values? Data sources included observations, student work, surveys, and journals. Findings indicated that tensions existed in the development of these projects: 1.) A teacher working with students on a project of their choice still maintains a type of authority and may guide students towards projects that more closely match her values. 2.) In this context, tensions also existed between the teacher's values and beliefs and those of the larger school community which had implications on the types of projects completed. 3.) Students' values influenced the type of project they developed, especially concerning whether or not completing the projects was something that was important to them, as well as their personal locus of control or belief that they could make a difference. Some students changed their initial values after completing the projects.

#### Jing Chen, Lindsey Mohan, Charles W. Anderson

Developing a K-12 Learning Progression for Carbon Cycling in Socio-Ecological Systems

We used assessment data from elementary, middle, and high school students to develop potential upper and lower anchors for a carbon cycle learning progression and to describe intermediate transitions between two anchor points. An upper anchor understanding of carbon cycling is characterized by principled reasoning about processes related to the generation, transformation, and oxidization of organic carbon in systems (e.g., commitment to tracing matter through processes such as photosynthesis, combustion, and cellular respiration). Students at this level reason about biogeochemical processes across scales, identify and consistently trace carbon and other elements in and out of various living and non-living systems. Students at the lower anchor explain processes such as growth, decay, and burning primarily through narratives of events at the macroscopic scale, showing little awareness of hidden mechanisms and little inclination to trace materials through changes. At intermediate levels, students' attempts to trace matter are often frustrated by their incomplete understanding of chemical identities of substances (particularly gases) and confusion about forms of matter and energy. Few students showed an understanding sufficient to account for mechanisms of environmental change, including global climate change. Implications of using the proposed carbon cycle learning progression to develop assessment items and curricula are discussed.



#### Sufen Chen, Wen-Ling Chen, Shu-Fen Lin, Sang-Chong Lieu, Wen-Hua Chang

Research and Development of Nature of Science-Explicit Curricular Materials for the Dissolving Unit

This paper reports an innovative way of researching and developing Nature of Science (NOS)-explicit curricular materials for elementary students. The NOS competency indicators in the Science Curriculum Framework were unpacked through focus group discussions followed by elementary science teachers designing the dissolving unit to teach targeted NOS tenets, including consistency, replicability, causality, durability, and agreement achieving process, through collaborative action research. The authors then explored possible ways of illustrating and exemplifying NOS explicitly in curricular materials. Moreover, embedded and add-on assessment tools were developed to evaluate the effectiveness of the curricular materials on students' understanding of NOS. In this article, we will present how we designed embedded assessment in the curriculum material to prepare and support elementary teachers for teaching NOS explicitly.

#### Jing Chen, Lindsey Mohan, Charles Anderson

Developing a K-12 Learning Progression for Carbon Cycling in Socio-Ecological Systems

We used assessment data from elementary, middle, and high school students to develop potential upper and lower anchors for a carbon cycle learning progression and to describe intermediate transitions between two anchor points. An upper anchor understanding of carbon cycling is characterized by principled reasoning about processes related to the generation, transformation, and oxidization of organic carbon in systems (e.g., commitment to tracing matter through processes such as photosynthesis, combustion, and cellular respiration). Students at this level reason about biogeochemical processes across scales, identify and consistently trace carbon and other elements in and out of various living and non-living systems. Students at the lower anchor explain processes such as growth, decay, and burning primarily through narratives of events at the macroscopic scale, showing little awareness of hidden mechanisms and little inclination to trace materials through changes. At intermediate levels, students' attempts to trace matter are often frustrated by their incomplete understanding of chemical identities of substances (particularly gases) and confusion about forms of matter and energy. Few students showed an understanding sufficient to account for mechanisms of environmental change, including global climate change. Implications of using the proposed carbon cycle learning progression to develop assessment items and curricula are discussed.

#### Jun-Yi Chen, Huey-Por Chang, Chorng-Jee Guo, Wen-Yu Chang

Infusing Inquiry Teaching into Classroom Practice: A Junior High School Science Teacher's Professional Development Experience

As a new educational initiative for a long-term and collaborative professional development project, this study was to help science teachers recognize the importance of inquiry teaching and investigate how to implement it in actual science classes. Meetings were held every two weeks from September 2004, where participants shared their teaching experiences, read inquiry teaching articles as well as designed and implemented lesson plans of inquiry teaching. The purpose of this article was to present one chemistry teacher's experience on constructing his understanding of inquiry teaching and infusing it into classroom practice. The data were collected by long-term observation, meeting and teaching practice recording, open-ended questionnaires, and interviews. It was found that the case teacher initially explained inquiry teaching based on literal meaning and his research experience in scientific laboratory. Participating the professional development project two years later, he obtained a thorough understanding on inquiry teaching. Furthermore, he considered various factors which may influence the effects of implementing inquiry teaching and formed feasible strategies of integrating inquiry teaching into classroom practice.

#### Kuei-Hsiang Chen, Hsiao-Lin Tuan, Chih-Chung Tsai, Jung-Chi Chang

Can Inquiry Teaching Enhance Motivation and Inquiry Abilities of Different Achievers?

The purpose of study was to investigate high achieving and low achieving 8th graders' motivation and inquiry



ability after experiencing shift in teaching context (traditional vs inquiry). Quantitative data were collected by surveying in pre, mid, and post-tests using ¡§students' motivation towards science learning;" (SMTSL, Tuan, Chin & Shieh, 2005) and self-developed ¡§Perception towards inquiring ability;" (PTIA, based on (NRC, 1996)) questionnaires. Analysis suggested that inquiry based teaching is capable of sustaining motivation and inquiring abilities of low achieving students. A slight but non-significant increase from mid to post-test indicates a promising outcome for the low achieving students by incorporating inquiry into teaching, if the inquiry-based teaching is conducted for a longer timeframe. The results revealed that traditional teaching significantly diminished students' (high achieving) motivation and inquiring abilities. Notably, the total motivation score for high achieving students' in traditional teaching environment was lower than that of low-achieving students in inquiry-based teaching environment. Keywords: inquiry teaching, inquiry ability, motivation, science teaching

#### Hsiu-Ling Chen, Sufen Chen

College Science Instructors' Views and Experiences of Curriculum Reform

The need for curriculum reform in higher education is urgent and universal. However, reform of undergraduate curricula is infrequently put into action because it requires a commitment of time and energy. In this study, college science instructors' perspectives and experiences of designing an interdisciplinary curriculum were investigated to understand the factors that promote reform, the impact of the reform on the faculty, and the ways in which educational beliefs are transferred into curricular decisions. The subjects were eleven scientists in the Department of Atomic Science at a research university. Data were collected from interviews with the scientists, faculty meetings, documents relevant to curriculum and instruction, students' feedback, and syllabi. This study found that a vital incentive for science faculty to carry out reform is a strong link between quality undergraduate education and the research workforce. The reform also fostered an unanticipated climate for improving pedagogical skills. However, the curriculum design failed to adequately address an evaluation plan, student involvement, and departmental core values. Recommendations are offered for early and full cooperation between scientists and science educators in providing a high quality undergraduate curriculum.

### Yeong-Jing Cheng, Ying-Shao Hsu, Wen-Hua Chang, Tsung-Hau Jen, Shu-Fen Lin, Che-Di Lee

Innovating Science Curricular Materials for Future Citizenship- 3C-AIMS Project

Agreed upon the critical role of curricular materials on science education reform and enlightened by the results of TIMSS survey, this 3C-Advancement of Instructional Materials in Science Project was initiated to achieve the goals of enhancing students' competence, cooperation and confidence through developing innovative science curricular materials and professional development programs, and supporting teachers' enactment of curricular materials. The project relies on the outcomes of serial research projects and now moves further to work with school teachers in developing innovative curriculum materials that better involving science education research and practice at a wide range. Five curricular materials development teams that emphasize difference approaches of developing science curriculum cooperate with one assessment team that emphasizes evaluating the effectiveness of each approach to create innovative curricular materials in this three-year project. This poster is to share the originality and progress of the study as well as future directions.

#### Jang-jeng Chern, Ming-jun Su, Ming-liang Lin, Shing-ho Chiang

A Comparison of the Teaching Strategies for Problem Solving in Senior High School Physics

An analysis of the score of the college entrance examination showed that difficulties exist for senior high school students studying problem-solving in physics. Hence, this study aimed to look for proper teaching strategies to improve the performance of physics problem-solving for senior high students. Subjects of this study were 108 eleventh grade students and three teachers who have been teaching physics for more than 22 years. We used URORA problem-solving model, which was developed by the authors based on Polya, as a tool to draw the "path chart of physics problem-solving" to analyze different teachers' teaching strategies based on their writings while they were



teaching. The analyses of teaching process and scoring of students' writing in problem-solving indicated two kinds of teaching strategies, analytic problem-solving (APS) and expert problem-solving (EPS), and two scoring strategies, scoring each step (SES) and scoring the result only (SRO). The result showed that the teaching strategy of APS is better than EPS. And the strategy of SES does influence students' will and confidence in physics problemsolving and creates a positive effect on student performances. We highly recommend the strategies of APS and SES to senior high physics teachers to improve their students' performances in problem-solving.

#### Jennifer Chidsey Pizzo, Rashmi Kumar, Wendy Green, Susan Yoon

SPARK! Igniting Student Interest in STEM Through Engineering Design

The SPARK! project targets a diverse population of youth in grades 4-8 from a small network of urban schools. The project provides sustained OST STEM activities focused on engineering design for students who are least represented in STEM careers. Project research addresses: 1) Do engineering design challenges represent an effective way to engage students  $\mathbb{A}^{\mathbb{M}}$  interest and motivation to participate in STEM activities, 2) What aspects of problembased, inquiry-oriented approaches transfer effectively from OST/ISE to IST settings and under what conditions? 3) Does a mentoring program that pairs women and minority STEM professionals with under-served, urban students influence students  $\mathbb{A}^{\mathbb{M}}$  self concept with respect to STEM disciplines and career aspirations? Preliminary findings indicate that students are interested in STEM activities and this translates into increased participation in the classroom. Students describe understanding science concepts and processes as a result of their involvement. Students identify themselves with STEM careers and take on career identities of their mentors and OST teachers. Teacher change occurred as a result of professional development and less structured participation in program activities. We have discovered and continue to track an emergent group of parents who have an impact on the participation and interest of their children in project activities.

#### Christine Chin, Kim-Chwee Daniel Tan, Thiam-Seng Koh

Science Education Reform in Singapore

With the advent of the digital age and increased globalization in recent years, science education in Singapore is facing a number of challenges. Although students from Singapore have done well in the Third International Mathematics and Science Study (TIMSS), past achievement is not necessarily a predictor of future success. The drive towards a knowledge-based economy requires us to implement new pedagogies to equip our students with new scientific and technological skills, as well as good habits of mind, to meet the challenges ahead. To help students achieve scientific literacy in the 21st century, we need to constantly review and make changes to the science education programs. The Ministry of Education has introduced several initiatives in recent years, and it works closely with the National Institute of Education and other organizations to implement these national policies. Some recent developments in science education include providing increased funding for science education programs and research, reforming the school science curriculum, advocating an inquiry approach to teaching and learning science, modifying science assessment practices, emphasizing the use of information and communication technologies in science education, encouraging students to pursue careers in science, enhancing the quality of teacher education programs, and providing increased opportunities for the professional development of science teachers. This paper describes how Singapore is responding to these challenges and discusses some issues related to this.

### Chi-Chin Chin, Wei-Cheng Yang, Hsiao-Lin Tuan

Infusing Guided TAPing with a Socioscientific Issue in Science Teaching

This study used guided TAPing, which integrating Toulmin's Argument Pattern [TAP] and a reading-writing activity focusing on a clone issue, one popular socioscientific issue [SSI], to teach sixth graders(n=28) argumentation. In the beginning of the study, the students were provided with reading-writing clone texts for experiencing an active scientific reading and writing process. Meanwhile, the test of reading comprehension and essay writing were used to assess students' performance. And then, all of them began to fill out the eight wbqr/WBQR ([war-



rant], [backing], [qualifier], [rebuttal]) cells of TAP to match already provided common data and claims such as doggy cloning in lab and doggy cloning pro and cons, respectively. The accuracy of all the wbqr/WBQR cells was assessed. This study found the significant correlation existed between clone reading-writing performance and quality of argumentation. We suggest that the guided TAPing is an applicable strategy in teaching elementary students argumentation and promoting their scientific literacy.

#### Christine Chin, Lay-Yen Teou

Using Concept Cartoons as a Formative Assessment and Learning Tool in Science

The purpose of this study was to explore how concept cartoons, together with other diagnostic and scaffolding tools, could be used in formative assessment to (a) stimulate talk among students in small groups, as part of peerassessment and self-assessment; and (b) identify misconceptions and provide diagnostic feedback to the teacher. Two classes of primary 5 and 6 students worked in small groups to discuss the opposing viewpoints posed by the cartoon characters, using "paper dialogues" and discussion templates to guide their discussions and to evaluate, challenge, and document each others' ideas. Students also used drawings to depict their ideas. The conversation from one group was audio-taped. These tools provided a record of students' thinking in a form that was accessible to the teacher for monitoring and feedback purposes. Findings showed dialogic talk and interactive argumentation among students where they made their reasoning visible. Students' assertions and questions had formative potential as they encouraged exploratory and reflective discourse by drawing upon each others' ideas. The teacher's discursive practices, as well as her role in designing scaffolding structures for supporting "assessment conversations" when using concept cartoons and in devising strategies that take into account students' conceptual and epistemic thinking, are emphasized.

#### Pauline Chinn

#### Na Pua O Maunalua: Transdisciplinary Literacies and Multiple Identities

If learning is socially situated, involving changes in identity, language, knowledge, and skills then evidence for these changes must be found. Discourse analysis of the transcript of a student–made video of a 24 hour culture-science immersion examined language, activities, actors and tools to detect Discourses and identities associated with home, culture, school, and science. Analysis of the transcript, based on students' journals suggests science done in the context of real world cultural and environmental issues is challenging work, but engaging and meaningful. Place-based, real world science learning communities that include indigenous Hawaiian knowledge, values and practices enable students who have traditionally been underrepresented in science to contribute in a variety of ways. Student writings reproduce and interweave cultural, science and school Discourses suggesting the simultaneous development and strengthening of multiple identities and literacies. This suggests situating student learning in place-based communities of practice that include indigenous, local and scientific experts enables students to benefit from role models and resources missing from conventional text and classroom-based science learning.

#### Mei-Hung Chiu, Saouma BouJaoude

Reforms in Science Education in Different Countries

This seminar discusses reforms in science education in four different countries: Australia, Israel, Singapore, and Costa Rica. David Treagust reflects problems and challenges on Australian science education. Israeli Uri Zoller contributes his reflections on whether or not the science education reforms, worldwide, are compatible with this paradigm shift. Christine Chin, Kim-Chwee Daniel Tan, and Thiam-Seng Koh elaborate their discussions on science education programs and policy changes currently in Singapore. Avi Hofstein discusses science education reform in Israel, as influenced by National Science Education Standards in the USA (NRC, 1996). Gilberto Alfaro-Varela from Costa Rica describes alternative ways of providing in-service teacher programs for promoting education.



#### Mei-Hung Chiu, Justin Dillon

A "Centre of Maths & Science Education" as a Specific Learning Site for Pupils, Pre- and In-service Teacher and the General Public

The centre was founded for university purposes highlighting hands-on science but has gradually expanded its audience. The specific learning topic mainly concentrates on hands-on lessons in gene-technology. (1) The school audience consists of 10th and 12th graders who in an outreach lab are learning a regular syllabus content; the regular visits provide the empirical basis for monitoring and enhancing the educational units; within the last years some scientific papers in international journals originated from these school visits. (2) The pre-service students learn, firstly about new relevant and innovative experiments, secondly how to transfer the topic to their pupils later-on and thirdly to shadow in small groups a real teacher enhancement course. (3) The in-service teachers refresh their content knowledge. However, they additionally learn about the empirical results, which is, the teacher enhancement courses consistently build upon scientific empirical grounds. Therefore, all teacher experience scientifically tested modules, both in terms of content and teaching approaches, thus, avoiding principal problems related their hands-on "teaching". (4) The general public, which very often is not aware about the scientific foundation of the specific topic but is affectively very much involved in it, may find at the educational centre specific offers to communicate the issue on scientific grounds.

#### Mei-Hung Chiu

Research And InstructioN-Based/Oriented Work (RAINBOW) for Conceptual Change in Science Learning---An Example of Students' Understanding of Gas Particles

The purpose of this study intends to delineate the importance of research in science education and instruction in schools that contribute to our understanding about the enterprise of learning and teaching in science, in particular, the mental representation and conceptual change processes while learning science. The author proposes a framework entitled ¡§Research And InstructioN-Based/Oriented Work (RAINBOW);<sup>¬</sup> that summarizes what her research lab has been working on in science learning for the past years. Also, the author introduces a recently completed research on understanding how students change their mental models about the behaviors of particles via the RAINBOW approach. The results revealed that the students in a multiple modeling activities group outperformed the students in the non-multiple modeling activities group in various perspectives, such as in epistemological, ontological, and affective perspectives. Educational implications will be discussed.

#### Moon-Heum Cho, Deanna Lankford, Daniel Wescott, Deborah Cunningham

Exploring the Relationships Between Epistemic Beliefs and Nature of Science in a College Biology Course

The purpose of this paper was to explore the relationship between epistemic beliefs and nature of science in a college biology course. 120 college students participated in the research. Exploratory factors analyses with 32 epistemic items yielded three aspects of epistemic beliefs: fixed ability, certain-simple knowledge, and simple knowledge. Exploratory factor analysis with 34 nature of science (NOS) items yielded three aspects of NOS: validation of new scientific knowledge, social and creative aspect of NOS, and relationship between scientific theories and laws. Multiple regression results suggested that students who have more sophisticated beliefs of knowledge or knowing in general are more likely to also have sophisticated beliefs of nature of science. For instance, individuals believing knowledge is simple and certain are less likely to understand the needs of empirical evidence for acceptance and validation of scientific knowledge. Also, students with simple and certain beliefs about knowledge or knowing are less likely to believe that the creative and social influence have an important role in science. The research is significant in that it provide empirical evidence explaining the relationship between students' beliefs of knowledge in general and science context specific beliefs, nature of science.



#### Soyoung Choi, Dan Shepardson, Dev Niyogi, Umarporn Charusombat

Earth and Environmental Science Textbooks' Coverage of Secondary Students' Concepts of Global Warming

This study analyzed 14 journal articles that researched students' concepts of global warming and 8 science textbooks for their global warming coverage. The findings from these two analyses were used to identify the conceptual mismatch between students' concepts of global warming and science textbook coverage of global warming. Implication to curriculum development, instructional design, and science textbooks are articulated.

#### Sanghee Choi, John Ramsey

Elementary Teachers' Beliefs and Practical Knowledge About Teaching Science as Inquiry: The Effect of an Inquiry-Based Elementary Science Course

This study examined inservice elementary teachers' beliefs and practical knowledge toward inquiry-based science instruction and the influence of an inquiry-based elementary science course on teachers' beliefs and practical knowledge regarding inquiry. The 14 elementary teachers completed a three-credit elementary science methods course that emphasizes teaching science as inquiry. Both quantitative and qualitative data were collected using pretest and posttest surveys, and a case study. The findings showed that the participant teachers' beliefs and practical knowledge about inquiry-based science instruction were clearly influenced by the course. The teachers constructed fairly positive beliefs and practical knowledge that promoted inquiry-instruction throughout this course. Moreover, they improved their knowledge and skills of conducting inquiry in their science teaching as they successfully practiced inquiry-instruction in their science teachings. From the results of this study, it is important to underlie that teachers' beliefs could be used to predict their practice of inquiry in their science teaching. This study suggests that a follow-up study is necessary to assess the participants' implementation of inquiry-instruction in their classrooms, and to examine whether the use of inquiry-instruction makes any significant difference in their students' science learning.

#### Aeran Choi, Brian Hand, Thomas Greenbowe

Examining Students' Scientific Arguments as a Consequence of Inquiry-Based Chemistry Experiences

This study was designed to investigate the quality of argument found in student science writings. The student writings evaluated were produced as part of inquiry-based college chemistry laboratory classes. Students used the template provided by the Science Writing Heuristic (SWH) approach in the process of constructing scientific argument. A framework for analyzing student argument in science writing through the SWH approach was developed in this study. The quality of student arguments was evaluated using the scoring matrix. Results indicate that using the SWH framework the students were able to construct a reasonable written argument which was generated from and embedded in an inquiry-based scientific investigation. Despite fluctuations, the weighted argument scores tended to improve over the course of the semester. In some labs, students obtained a higher Holistic Argument score than Total Argument score. The argument scores were higher for Year 1 students who had the original SWH template than Year 2 students who had the additional sections on the SWH template. The evidence and the claims-evidence relationship components were identified as the most important predictors of the Argument scores. Both Year 1 and Year 2 student argument scores were significantly correlated with the lab final grade.

#### Sung-Youn Choi, Sung-Won Kim

Exploration of Korean Preservice Elementary Teachers' Science Teaching-Anxiety and Science Teaching-Efficacy

Science teaching-anxiety and science teaching-efficacy are one of the most influential factors on teachers' teaching practice and behaviors. In order to encourage better teaching practice, therefore, this study identified sub-factors that caused teachers' science teaching-anxiety and investigated the relationship between science teaching-anxiety and science teaching- efficacy. And finally the authors attempted to suggest practical implications to enhance their confidence in science teaching. The guiding research questions were 1) which factors affect science teaching-anxie



ety level of the pre-service teachers, and 2) how each factor of science teaching-anxiety are related to science teaching-efficacy. 133 Korean pre-service elementary teachers (57.1% were female) in a large city participated in this study. The data sources included teachers' responses to three paper and pencil questionnaires: State-Trait Anxiety Inventory (STAI), Science Teaching-Anxiety Questionnaire (STAQ), and Science Teaching Efficacy Belief Instrument (STEBI-B). The results indicated that, first, among the 6 sub-factors, their level of anxiety on professional responsibility and science was relatively high. Second, there was a negative correlation between science teaching-anxiety and science teaching-efficacy. And third, science as teaching domain is the most influential factor for science teaching-efficacy and teaching science in classroom and professional responsibilities were followed.

#### Panwilai Chomchid, Norman Thomson

A Cross-Cultural Comparison in the Use of VAST-Models by Thai and United States High School Students for Learning Atomic Structure

In response to surveys of teachers and students in Thailand and the United States, VAST-Models were developed to facilitate learning atomic structure. The models are 3D hands-on analogs representing how concepts of atomic structure have changed historically, but we also believe they are the first hands-on models quantum mechanical models in which students are explicitly asked to compare and contrast two representations (teacher demonstration and student working models), along with textbook and video animation representations. In typical introductory chemistry lessons for atomic structure, students are expected to make visual transitions and transformations from expository text, 2D figures and drawings, and relate these abstract representations to changes in energy, for example, the light spectra observed in electron/photon interactions observed in laboratory flame tests. Such transformations require students to negotiate abstract, sub-microscopic, and macroscopic models. In this paper, we offer a cross-cultural comparison of the use of VAST-Models by Thai and United States high school students in learning atomic structure.

#### Hye-Eun Chu, David Treagust, A Chandrasegaran

The Context Dependency of Students' Conceptions of Basic Optics Concepts Using a Two-Tier Multiple-Choice Diagnostic Instrument

The Context Dependency of Students' Conceptions of Basic Optics Concepts Using a Two-Tier Multiple-Choice Diagnostic Instrument A large scale study involving 1,786 Years 7 -10 Korean students from three school districts in Seoul was undertaken to evaluate their understanding of basic optics concepts in different contexts using a two-tier multiple-choice diagnostic instrument. The instrument which proved to be reliable helped identify several alternative conceptions that varied according to context and were held by 10%-35% of students. The research identified unstable alternative conceptions that were context dependent and stable alternative conceptions that were in higher grades. However, the students' grade levels had limited influence on their understanding of basic concepts in optics as measured by the instrument. The importance of this study is that given current emphases on the development of context-based curricula, it is important to identify how these contexts influence students' conceptual understanding.

## Douglas Clark, Sharon Schleigh, Cynthia DAngelo, Gokhan Ozdemir, Helen Zhang, Edgar Corpuz

Cross-Cultural Analysis of Knowledge Structure Coherence and Understanding of Force

This study investigates and compares students' knowledge structure coherence, meanings, and understandings around the scientific concept of "force" in the Philippines, Turkey, China, Mexico, and the United States. This study applies the analytic frameworks of both Ioannides and Vosniadou (2002) and diSessa et al. (2004) to two hundred students from the five countries in order to map in greater detail the specific connections, regularities, and irregularities demonstrated within the students' understanding of force. The five countries have been chosen to allow comparisons across a range of language families and branches to clarify possible differences in students' understanding of force across different languages and cultures. The findings suggest that students from different



cultures develop different meanings of force and different degrees of knowledge structure coherence. This paper outlines the nature of these differences in terms of meanings and knowledge structure coherence.

#### Julia Clark

Research on K-12 Science and Math Education at the National Science Foundation

The Division on Research and Learning in Formal and Informal Settings (DRL) has been initiated a new program, Discovery Research K-12 (DRK-12), at the National Science Foundation to provide funding to support research, development, and evaluation activities through which new knowledge is generated and applied to improve K-12 learning and teaching. The program forges strong connections between curriculum, assessment and professional development. DRK-12 brings together science, technology, engineering, and mathematics (STEM) education faculty, scientists and mathematicians, cognitive scientists, teachers and administrators, and STEM education graduate students to conduct the research, develop resources and tools and build the nation's capacity to develop and test innovative solutions to improve K-12 teaching and learning. This session discusses DRK-12 program, the importance of the research generated from it, and its relevancy in addressing the goals and issues of the American Competitiveness Initiative and the initiative of No Child Left Behind.

#### Renee Clary, James Wandersee

Earth Science Teachers' Perceptions of Autonomous Informal Education Assignments in a Nationwide Online Paleontology Course

In nationwide graduate paleontology classes of Earth science teachers taught entirely online at a research university in the South, students (n = 36, n = 16) were required to apply their content knowledge in self-selected informal education sites through (a) collection and identification of a small number of fossil specimens, and (b) the investigation and analysis of displayed or in situ fossils at established informal education sites. Both groups subsequently developed paleoeducational activities for their own middle or secondary students through their research. Approximately 86% of students scored higher in the hands-on informal education activity than in previous course laboratory assignments. Content analysis of students' anonymous electronic survey revealed three stable findings: (a) the informal education assignments helped students synthesize course content material; (b) local site investigation identified the community's scientific relevance; and (c) practicing teachers perceived high value for informal education experiences within formal geoscience learning. Students stated that the application exercise was not more difficult when assigned in an online format. Our exploratory study results indicate that autonomous geoscience informal education activities are possible in an online graduate course setting.

#### John Clement

Six Strategy Levels for Model Based Teaching

This paper proposes six levels of organization for teaching strategies, using different time-scale levels. Strategies were collected from three successful model-based curricula in electricity, mechanics, and middle school biology. At the highest level, curriculum projects may have a strategy for making connections between month-long units. At the other extreme, teachers use strategies that operate over seconds for maintaining discussion. Intermediate strategies include small cognitive imovesî and larger model modification cycles. Understanding strategy levels may increase the coherence of planning at each level by showing how that level contributes to the one above it, i.e., its larger purpose. This could reduce the widespread phenomenon of finding sets of well-meaning activities used in classrooms but with no real connection between them. There has been insufficient work that deals with multiple levels of teaching strategies and that is grounded in case studies of actual curricula and of actual classroom interactions. Teacher educators and teachers could benefit from dividing the very complex act of science teaching into several basic sets of skills so that they can be learned/practiced one at a time, starting with the bottom level of fostering participation in discussion.


#### Carmit Cohen, Nir Orion

Design-Based Research of an Oceanography Course for High School Earth Sciences Students

Oceanography is an area of the earth sciences that focuses on the exploration and understanding of the oceans system and its interrelationships with the other earth systems. In this study the new unit in the program, "Oceanography and the earth systems", has been developed as a part of the environmental ñ based interdisciplinary of the earth science program. The development of this unit has been conducted as a design based research. The unit starts with the film "The day after tomorrow" which establishes the environmental context and the motivation for asking questions that leads to the next lab-based part that explores the scientific basis of the movie. Following the lab activities the students develop understanding of basic oceanography concepts and phenomena. In the last part of the unit each student has to select oceanography related phenomena such as hurricanes, El-Nino, tsunami, for a self study that later will be presented to the class through a power point presentation. The study included more then hundred 12th grade earth sciences students and was based on a mix of qualitative and quantitative research tools that helped to understand the student knowledge and attitudes in order to design the unit to its current version.

### Huseyin Colak, Khemmaadee Pongsanon

The Relationship Between the Development of Nature of Science Views and Personal Epistemologies of Upper Elementary and Middle School Students

This study explored the relationship between students' understanding of nature of science aspects (NOS) and their personal epistemologies before and after an explicit-reflective NOS instruction undertaken in the six-week Saturday Science program designed for elementary and middle school students. The aspects we targeted included the empirical, tentative, subjective, imaginative and creative, and social and cultural NOS. One additional aspect was the distinction between observation and inference. The personal epistemologies were measured along four dimensions with a 26-item instrument adapted from Elder's (2002) study. The four dimensions were source of knowledge, certainty of knowledge, development of knowledge, and justification. Participants were 12 upper elementary and middle school students who registered to the six-week Saturday Science program in a Midwest university. An open-ended NOS survey and a 26-item instrument were administered to all students at the beginning and at the end of the program. Postinstruction assessments indicated that participants made substantial gains in their views of some the target NOS aspects. Many students also improved their personal epistemologies toward more sophisticated parallel to the development of their NOS views. Although it was not strong, there was a clear relationship between NOS understanding and personal epistemologies.

#### Michelle Cook, Glenda Carter, Eric Wiebe

The Influence of Prior Knowledge and Cognitive Load Theory on Instructional Design Principles

Visual representations are essential for communicating ideas in the science classroom; however, the design of such representations is not always beneficial for learners. This paper presents instructional design considerations providing empirical evidence and integrating theoretical concepts related to cognitive load. Learners have a limited working memory and instructional representations should be designed with the goal of reducing unnecessary cognitive load. However, cognitive architecture alone is not the only factor to be considered; individual differences, especially prior knowledge, are critical in determining what impact a visual representation will have on learners' cognitive structures and processes. Prior knowledge can determine the ease with which learners can perceive and interpret visual representations in working memory. Although a long tradition of research has compared experts and novices, more research is necessary to fully explore the expert-novice continuum and maximize the potential of visual representations.



#### Michelle Cook, Eric Wiebe, Glenda Carter

A Comparison of Visual Representations of DNA Replication

This study is part of an ongoing research project examining middle school girls' perceptions and interpretations of visual representations of DNA replication. Eye movement measures were collected as participants viewed two different presentations of DNA replication. Gaze time and fixation count results, as well as a log-linear analysis indicated that the redesigned graphics were more effective at cueing participant attention to the relevant portions of the graphic. Interview responses supported eye-tracking findings, but also revealed that attention to relevant features did not necessarily result in understanding of the process in all cases. More research on how representations are interpreted by learners is necessary in order to offer insight into the design of visual representations.

#### James Cooper

Children's Practice of the Social Construction of Scientific Facts: Meta-Ethnographic Synthesis and Science Education Research

Science education researchers have attempted descriptions of the relationship between science studies and science education. Such descriptions have applied the aggregate logic of literature reviews to the interpretive works of sociologists and anthropologists. Meta-ethnography (Noblit & Hare, 1988) provides a framework for the synthesis of interpretive studies which may be more appropriate to describing the relationship between science education and science and technology studies. This project attempts to articulate that relationship further using Latour and Woolgar's (1986) Laboratory Life, a seminal work in science studies, and Barton's (2003) Teaching Science For Social Justice, a study of the scientific practices of youth who live in homeless shelters. The meta-ethnographic synthesis reveals that the relationship between each of the two communities of scientific practice and the knowledge they use and produce does much to determine the form of that practice.

#### Liesel Copeland, Kathleen Haynie

Using Preschool Science Activities to Impact Teaching Interactions and Learning Environments

Science literacy among the public is imperative and can be improved by ensuring that science, as play, is incorporated at the preschool level. High-quality science programs for children support exploratory and inquiry-based learning embedded in children's daily activities; such programs are based on an understanding of children's learning and of appropriate science content. Key factors related to learning are derived from the environment in which the learning takes place - including the steps teachers may take to facilitate an environment where science-inquiry may occur. This paper presents our findings on the relationships between resource utilization (e.g., of materials and of science activities), teaching practices, and learning gains. Our analyses addressed whether learning and behavioral outcomes were related to changes in science instruction and utilization. Importantly, a relationship was found between teaching practices and children's learning and behavioral gains. Providing preschool teachers with resources for carrying out inquiry-based science activities can contribute to more frequent and effective teaching practices, thereby improving children's learning of science content and skills. NARST members interested in preschool education can learn of new pre-k science resources, measures of instruction and learning, and how our findings generalize to a variety of preschool contexts.

## Edgar Corpuz, N. Sanjay Rebello

Scaffolding Activities to Facilitate Student Modeling of Microscopic Friction

In this paper we discuss the development and validation of hands-on and minds-on modeling activities geared towards improving students' understanding of microscopic friction. We will also present our investigation on the relative effectiveness of the use of the developed instructional material with two lecture formats - traditional and videotaped lectures. Results imply that through a series of carefully designed hands-on and minds-on modeling activities, it is possible to facilitate the refinement of students' ideas of microscopic friction.



#### Beth Covitt, Kristin Gunckel, Hasan Abdel-Kareem, Charles Anderson, Rebecca Dudek

A Learning Progression for Processes that Alter Water Quality in Socio-Ecological Systems

This poster addresses students' understanding of how substances combine with and are separated from water. These processes occur in human engineered systems (e.g., water pollution, water treatment) and natural systems (e.g., filtration through wetlands, materials moving into solution in groundwater). Results from assessments administered to grades 2-12 students show that students with a low level of understanding have difficulty keeping track of substances that mix with water. Such students equate dissolving with disappearing. Students at a slightly higher level of understanding recognize that substances can mix, but the nature of how is vague, or incorrect. For example, when asked if polluted lake water can turn into polluted rain, some students with intermediate understanding can successfully describe the distillation process. Very few students, however, provide atomic-molecular scale descriptions of substances, they have difficulty mastering atomic-molecular level explanations, and connecting atomic-molecular explanations with macroscopic observations. Connecting scientific explanations of mixtures and solutions with real world water contexts is an important skill for making informed decisions about water quality issues.

#### Beth Covitt, Christina Schwarz, Minjung Bae, Jamie Mikeska

#### Facilitating Preservice Teachers' Development of Professional Practice Through a Boundary Spanning Activity

Differences between preservice teachers' often intuitive visions and teacher educators' reform-based visions of science teaching can prove a challenge to developing reform science teaching knowledge and practices through methods courses. Here, we describe a task we have found useful for bridging preservice teachers' and teacher educators' Discourses to help preservice teachers integrate reform-based curriculum materials analysis into their teaching visions. Our Light & Shadows Curriculum Materials Analysis Task served as a boundary spanning experience to bridge Discourses. The task was enacted in four sections of an elementary science methods course at a Midwestern University. Analysis indicates that preservice teachers were engaged in significant, on-task work, and had extended conversations about reform science themes such as determining whether materials meet specific learning goals. Our review of task discussion indicates that the task served as an effective boundary spanning experience; preservice teachers drew on their own intuitive Discourses (and thus, found the task authentic and engaging), took on aspects of reform-based science Discourse, and participated in conversations that combined both Discourses together. Through engaging in boundary spanning tasks that are contextualized to be authentic, preservice teachers can begin to envision the importance of critical use of curriculum materials for effective science teaching.

#### Barbara Crawford, Carla Zembal-Saul, Sandi Abell, William Holliday, Julie Luft

Publications Advisory Committee-Sponsored Sympsosium: How Can We Translate and Communicate our Science Education Research to Practice (RTP)?

One of the initiatives of the NARST Publications Advisory Committee is to develop better ways to translate and communicate our research findings to practitioners and the general public. Some ideas include developing brief summaries of current research to share with classroom teachers, and to sponsor a booth at the upcoming NSTA conference in Boston and distribute publications. In this symposium we would like to exchange ideas about innovative and effective ways to move our research into practice (K-20) and to the general public, through practically-based publications, both electronic and paper. We refer to these as RTP (Research to Practice) briefs in the form of e-publications to be posted on the NARST website. We anticipate these briefs will include some combination of podcasts, blogs, wikis, and pdf files. We are eliciting ideas from the NARST membership regarding how we can better communicate our research on science education to K-20 teachers, as well as to informal learning centers. We anticipate this panel will generate useful and innovative strategies for how we can accomplish this goal, as well as address the challenges and roadblocks we need overcome. Panel members will present their ideas and experiences



during 5-10 minutes each, followed by interaction with the audience.

#### Barbara Crawford

Learning Science in Authentic Settings: Moving Students to the Inner Circle

Given support, guidance, and innovative materials, it is possible for teachers to engage students in authentic scientific settings, both in and out of classrooms, to support learning the nature of science, inquiry, and key science concepts. In these authentic settings students of various ages are situated in use of evidence and creating scientific explanations of what is happening in the natural world. Research indicates that authentic learning experiences may motivate all students in learning science, including underrepresented student groups. However, researchers have mixed views of what counts as iauthenticî. The author proposes a research-based model of how students are situated in settings in which they investigate authentic problems and increase their science understandings. The proposed model draws from several case studies conducted during the last several years.

### Brett Criswell, Scott McDonald

An Investigation of the "Dead End" Participant Structure: Examining How Student Cognitive Factors and Teacher Beliefs Impact Its Contribution to Progressive Discourse

This paper describes research into a participant structure known as a dead end. Initially, the goal was to characterize the features of this structure. More recently, it has evolved into an examination of why this structure becomes enacted in specific ways during particular instantiations. Testing of cognitive factors (e.g. need for cognition), pre-[lesson]interviews, and post-[lesson]interviews provided insights into the ways that students participated in these episodes. Questionnaires focusing on epistemic beliefs and beliefs about practices, pre-[lesson]interviews, and post-[lesson]interviews helped shed light on the teacher's role in these performances. Video analysis (conducted in StudiocodeÆ and through application of the framework developed by Mortimer and Scott) of the dead end episodes themselves indicated how the actors jointly constructed these experiences. The entire set of data was examined through a community-of-practice theoretical lens where the ëideal' practice was considered to be interactions that contributed to progressive [scientific] discourse. The data was first analyzed to identify which student / teacher actions enhanced this discourse and which inhibited it. These actions were then correlated with the cognitive factors (in the case of students) and the beliefs (in the case of teachers) to show how these impacted the way the different actors participated in these episodes.

## Shanna Daly, Lynn Bryan

Nanoscale Phenomena Models: Middle and High School Teachers' Conceptions of Their Use in Curricula

One of the big ideas in nanoscale science and engineering is the role of models and modeling. This big idea is particularly interesting because the role of models in nanoscale science and engineering education (NSEE) is two-fold: models are a scientific concept and a pedagogical tool. Teachers' views and understanding of models as educational tools as well as a concept of science and engineering will have an impact of the ways in which students learn nanoscale phenomena concepts. This study focused on understanding teacher conceptions of models through their written and oral reflections and the ways in which they utilized models in lesson plans they designed as part of the NCLT professional development experiences. Themes emerging from this data included teachers' ideas about the importance of models as tools in science education, how and when teachers use models, and the role of models of nanoscale phenomena as means for visualization and in inquiry and design contexts.

## **Robert Danielowich**

Engaging in Socioscientific Issues (SSI) Instruction: A Unique Resource for Science Teacher Reflection and Learning

Although many studies highlight the barriers teachers face in implementing socioscientific issues (SSI) instruction, we know very little about how teachers can use SSI pedagogies as resources for learning about and transforming



their teaching. In this multiple case study at a large, urban high school, four practicing science teachers designed, taught, and reflected about two videotaped SSI lessons and then shared their reflections in two cycles of peer group meetings. Cross-case analyses of their reflections about these lessons indicated that all four teachers recognized ways they should: (1) adjust their teaching to meet their students' explicit needs and (2) find more authentic ways to motivate their students to learn. As compared to an analysis of their reflections in two previous cycles of reflections about general "student-centered" lessons they taught, all teachers also explicitly questioned: (1) how they communicated with their students and (2) how they could encourage students to take intellectual and emotional risks while still protecting their safety. The findings indicate that these teachers made the contradictions in their teaching choices more explicit and available for change by reflecting about their attempts at SSI instruction, supporting its potential in transforming sustainable change in science teaching and learning.

#### Linda Darby

#### Describing and Comparing Mathematics and Science Teaching: Subject Culture Under the Microscope

The current teaching climate in Australia and the US supports both the close alignment of science and mathematics by teachers, educators and researchers, and a move towards generic descriptions of pedagogy. It is, therefore, important to understand how the subjects play a role in determining pedagogy. Is it possible to describe mathematics and science teaching without recognising their epistemological and methodological differences? This qualitative study used classroom observations and video, reflective interviews and a focus group discussion to investigate the relationship between subject culture and pedagogy. Through a thematic analysis I developed four themes that highlight similarities and differences between the subjects. These include: 1. the nature of curriculum organisation across the two subjects; 2. the epistemological, pedagogical and cultural demands associated with planning and running mathematical and science activities; 3. the translation of the rhetoric of "relevance" as a generic pedagogical imperative into teachers' practice and conceptions of the subject, teaching and learning; and 4. the role of the aesthetic in how science and mathematics teachers experience, situate themselves within, and negotiate boundaries between the two subject cultures. Implications for teacher development and for teachers who teach subjects for which they have limited background and training are discussed.

#### Kathleen Davis, Mary Mawn

#### Science Teacher Learning of Ecological Concepts in an Online Biology Course

This study explores elementary and middle school science teachers' understanding of ecological concepts in an online, project-based biology course. The course focused on topics such as populations, communities, and ecosystems. Qualitative methods were used. Data was collected through interviews, online discussions and journals and course documents to investigate for teachers' understanding of science content. Data indicates teacher understanding of 1) the characteristics of organisms and the interdependence that fosters the existence of an ecosystem, 2) the meaning of the concepts of community and populations, and 3) ecological change. Teachers demonstrated limited understanding of energy transfer via the food web. The limitations of online discussion boards and electronic journals to enable students to develop and convey their knowledge was evident.

#### Vaille Dawson, Grady Venville

Argumentation and Conceptual Understanding: Grade 10 Students' Learning about Genetics

The literature provides confounding information with regard to questions about whether students in high school can engage in meaningful argumentation about socio-scientific issues, whether this process improves their understanding of science content and, conversely, what degree of understanding is adequate for participation in the process of argumentation? The purpose of this research was to explore the interaction between high school students' argumentation skills and conceptual understanding of genetics and how these interactions change over the period of a unit on genetics specifically designed to involve them in argumentation. The research design was an instrumental case study of two Grade 10 classes (n=46) taught by one teacher in a suburban high school. Data



were generated through a written pre and post-instruction student survey, pre and post-instruction semi-structured student interviews, teacher interviews, and classroom observations. The findings demonstrated that, based on a multiple-choice style survey, students' understandings of genetics improved significantly. Their definitions of genetics terminology also improved but their understandings about the relationships between concepts only showed very limited improvement. The students' levels of argumentation improved, showing greater use of warrants, backings and qualifiers. There was a correlation between students' genetics knowledge and argumentation skills both before and after instruction.

### George DeBoer, Cari Herrmann Abell, Kristen Lennon, Natalie Dubois

Assessment Linked to Middle School Science Learning Goals: Development and Use

This symposium will address how we develop distractor-driven, multiple-choice test items in which common misconceptions are used as distractors (Sadler, 1998) and it will address various ways in which these items are being used. The work is part of a multi-year, NSF-funded project to develop assessment items aligned to middle school content standards for 16 topics in science, mathematics, and the nature of science from AAAS's Benchmarks for Science Literacy (AAAS, 1993) and the NRC's National Science Education Standards (NRC, 1996). In this symposium, we will focus on 1) how feedback obtained from students through pilot testing provides information about what students do and do not know about the targeted ideas and the appropriateness of those targeted ideas and 2) how the results of field testing on a large national sample are used to describe the current state of student thinking, their year-to-year progress from grade six through eight, and how field test results are being used to validate hypothesized learning trajectories for these topics.

### Isha DeCoito, Erminia Pedretti, Derek Hodson, Maurice DiGiuseppe, Larry Bencze, Lisa Serebrin

Professional Development: The Role of Principals in Supporting Action Research

The Science and Technology Action Research (STAR) Project, a three-year school district/university project, engaged seventy-five elementary and secondary teachers from an Ontario School Board in collaborative action research in science and technology education. It is our view that engaging teachers and principals in the STAR project is likely to be the most effective strategy for supporting and enabling them to meet the provincial Ministry demands while maintaining some sense of ownership and professionalism. Sources of data for this study include field notes, journals, interviews, questionnaires, repertory grids, and documentary materials. Results suggest that: 1) as elementary principals expand their understanding of effective teaching and learning practices in science and technology education, they are better able to encourage and support teachers in moving forward in implementation of the new curriculum; 2) principals came to foster the development of learning communities while providing opportunities to develop teachers as leaders in curriculum implementation, assessment and instruction; and 3) principals link action research to professional growth planning and they assume multiple roles in order to foster professional learning in their teachers.

## Cesar Delgado, Shawn Stevens, Namsoo Shin

Development of a Learning Progression for Students' Conceptions of Size and Scale

The concepts of size and scale are important tools in learning both traditional and emerging science disciplines such as nanoscale science. Yet recent research shows that most people do not have a firm grasp on size and scale. Efforts to improve curriculum, instruction, and assessment of size and scale can be guided by an empirical learning progression. In order to generate this progression, interviews were employed to examine middle school students' through undergraduates' knowledge about objects too small to see, the units with which to express their size, and four conceptions of size: ordering and grouping by size, the absolute sizes of key macroscopic and submacroscopic objects, and how many times bigger or smaller these objects are relative to each other. The tasks used objects ranging in size from the atom to the earth. The participants were from diverse, low SES Midwestern public middle and high schools, and from a public Midwestern research university. The findings, along with previous research



into the degree of connectedness or coherence between the conceptions of size, result in a learning progression for students' conceptions of size and scale.

### Dorita Demetriou, Constantinos Korfiatis

Tracking' Students' Process of Learning

In every discipline a variety of methods are used to collect, analyze and interpret data in order to answer to scientific questions. If we want students to understand the diversity of methods used in science we must give them the opportunity to involve in authentic inquiry. The design of new curriculum materials that support authentic inquiry tasks and help students overcome difficulties in conducting inquiry is still a challenging case. Many innovating approaches from different research teams using technology multimedia have been made to fill the gap. In our research we present a curriculum material supported by a web based learning environment. We are searching for 'the ways' in which inquiry is implemented in an environmental science classroom and investigate how an already existing web-based learning environment can be instructionally improved. We are looking for new ways of approaching the design and evaluation of curriculum materials using various methods of assessment. In this study we analyze the data collected from log files in order to inform the assessment of our curriculum material and discuss how we expected students to involve in authentic inquiry tasks and how they actually did it.

### Abdulkadir Demir, Sandra Abell

Context of Science Teachers' Learning: Inquiry-Based Teaching Practices' of Beginning Science Teachers

The purpose of this phenomenongraphic research study was to gain an understanding of how beginning science teachers from an ATCP implement inquiry-based instruction in their beginning years of teaching. As source of data collection, we used semi-structured interviews, classroom observations, field notes, and artifacts. We applied an iterative data analysis process and presented our findings in the form of profiles of the research participants. From all profiles, we constructed a set of assertions. Data analyses revealed that the excessive amount of inquiry-based teaching integrated in the science methods courses did not help ATCP interns to utilize inquiry-based teaching in their practices. Indeed, the science methods courses made ATCP interns to think inquiry was the only teaching method that they needed to employ in their teaching.

Abdulkadir Demir, Charlene M. Czerniak, Fouad Abd-El-Khalick, Laura Moin, Valerie Otero, Frances Lawrenz Recruitment of Science and Mathematics Teachers: National and International Perspectives on Issues and Policies

This symposium will consist of a panel of researchers involved in recruiting and overseeing research grants aiming to recruit mathematics and science teachers, an international science education researcher, and a policy researcher. The policy and international researcher will review what science educators shared with audiences and will provide a perspective on international and national issues and policies. The experiences that science educators have faced in recruiting science and mathematics teachers will be used to enlighten efforts and issues related to recruitment. We believe this symposium would be of interest to NARST members who are actively working on recruiting and retaining science and mathematics teachers. The session also has policy implications locally, nationally, and internationally in terms of teacher licensure and Federal and State allocation of funding for teacher recruitment. There will be time allocated to discussion among the panel members and with the audience about research issues related with recruitment.

## Perry den Brok, Ruurd Taconis, Darrell Fisher

A Comparison of Science and Mathematics Teachers' Interpersonal Behaviour With Teachers of Other Subjects

This study was an investigation of differences in students' and teachers' perceptions of teacher interpersonal behavior between science or mathematics classes and other subject classes in secondary education. Teacher interpersonal behavior was studied with the Questionnaire on Teacher Interaction (QTI), which maps behavior in terms of two



dimensions - influence (degree of teacher dominance) and proximity (degree of teacher- student cooperation). The study employed multilevel analyses of variance on an existing data set containing 44,353 students in 1,820 classes and 605 teachers. After correction for covariates it appeared that science/mathematics teachers were perceived as less dominant and cooperative, and that these teachers perceived themselves as less cooperative as well. Also, science or mathematics teachers had less often directive, authoritative or tolerant- authoritative profiles and more often tolerant or uncertain-tolerant interpersonal profiles.

### Victoria Deneroff

#### Professional Development in Practice

What is the role of professional development in the ways high school science teachers re-shape practice over the long term? What traces does it leave in class-room practice, and how might we find them? This paper reports an ethnographic study of one high school science teacher's daily life in an urban high school. Over three years, I listened to Marie Gonzales's stories about teaching, professional development and district politics. She reported "Reading Apprenticeship" (West-Ed, 2007) and the 5-E Learning Model (Bybee, 1997) to have been crucial in her learning to teach using inquiry. By triangulating with observations of her classroom practice, I was able to tease out ideas from professional development which made it into the classroom. Marie told me that traditional curriculum implementation workshops, while useful, did not help her develop a deeper understanding of inquiry. This study suggests areas for further research into the professional development experiences of science teachers.

#### Jennifer Dewitt

What Did You Learn at the Science Centre? Using Video in Stimulated Recall Interviews With Primary School Children

An issue of enduring interest to researchers in the field of learning in informal contexts is what visitors are learning from interactions with science center exhibits. While there is evidence that such experiences can lead to cognitive and affective outcomes, these gains seem to be relatively small and possibly short-lived. The present study aimed to achieve further insight into these outcomes, by using video to stimulate recall and reflection during interviews with students following their visits to an interactive science center. Students from seven upper primary classes participated in such interviews, which were transcribed and coded. A coding schema was developed encompassing statements that provided evidence for the value of the visit as a cognitive, social and affective experience. Analyses indicated that the visit was a positive social and affective experience, and the transcripts provided evidence for characteristics that contributed to this outcome. They also demonstrated that students were engaged cognitively by their interactions with the exhibits, although the extent to which they contributed to pupils' understanding of science was more variable. Analyses also reflected the possible benefits of using video clips of interactions to encourage student reflection on their visit experience.

#### Daniel Dickerson Dickerson, Craig Stewart, Daniel Cutshaw, Julie Lambert

Rhetorical Analysis of Global Warming and Other Socioscientific Issues in Popular News Media

This study investigates the educational and rhetorical outcomes of different frames for presenting global warming and other socioscientific issues to non-specialists in popular news media. A sample was identified and coded in a number of steps. The first was to identify the Semantic Actors in the texts as either Scientific or Non-Scientific, and as either Individual, Aggregate/Collective, Generic, or Object. Next, we used Diction 5.0, a word-count analysis system, to quantitatively compare the rhetorical features of this sample against norms drawn from news articles and science writing. The third was to qualitatively code for news frames as described above as well as for other rhetorical and argumentative appeals that appear in the texts. Our findings suggest that, the socioscientific controversies included necessarily implicate science and scientists, non-scientist actors are represented with much greater frequency than scientist actors, especially in the domains of global warming and stem-cell research. Also, when scientist actors appear in news discourse, it is as individual researchers rather than as groups working on common problems or as political entities. This may suggest that, contrary to what is sometimes assumed of socioscientific



controversies, science does not necessarily hold a discursive advantage over other ways of knowing.

#### **Daniel Dickerson Dickerson**

The Nature and Role of Evidence in Addressing Controversial Science Content

This study focuses on the relationship between science and religious faith. Specifically, we examine the ways preservice teachers (both science and language arts/social studies) think about the relationship between science and faith, with a specific emphasis on the application of evidence.

#### Emily Diefendorf, Gregory Kelly

Argumentation for the Future

The purpose of this study is to examine ways that students build arguments derived from inscriptions, expertise, and data. The setting for this study was an introductory oceanography course intended for non-science majors with an emphasis on writing. The students were expected to write evidence-based arguments regarding such issues as plate boundaries, monsoons of India, climate change, and health of ocean fisheries. A sample of fifteen students' papers for the four written arguments was analyzed to assess their construction of evidence and the overall quality of the arguments, which can be used to compare across students and assignments. Results suggest students were only partially able to write plausible arguments in the scientific genre. Students used inscriptions, data, and expertise to introduce lines of reasoning, but were often unable to engage in the theoretical aspects of constructing valid scientific arguments. Although writing to learn science provides students opportunities to engage in scientific reasoning.

#### Lynn Dierking, Dale McCreedy

The Impact of Free-Choice STEM Experiences on Girls' Interest, Engagement, and Participation in Science Communities, Hobbies and Careers: Results of Phase 1

This paper describes Phase 1 of a research project investigating roles of informal science, technology, engineering, and mathematics (STEM) experiences on girls' long-term interest, engagement, and participation in STEM. The goal is a model for documenting informal STEM learning with policy implications for designing informal gender-based programs and research. Four focused investigations provide increasingly in-depth insights into roles that informal STEM experiences play in girls' interest, engagement, and participation in science communities, hobbies, and careers. Phase 1 explored the ways in which young women discuss their early free-choice experiences. Participants were recruited from five successful informal STEM initiatives for girls. Data collection was two-fold and face to face: Personal Meaning Mapping (PMM) and in-depth qualitative interviews discussing PMMs created by each woman. Twelve women, ages 20 to 29, participated; most were in the program 10-15 years prior. The approach provided a useful context in which to discuss the roles of informal STEM in these women's lives. Findings suggested that such programs have a range of impacts, some STEM-related, but also outcomes like improving self-esteem or self-efficacy, as well as developing or reinforcing leadership skills. Investigation #2 will build on this phase and more fully explore and quantify program impacts.

## Jeff Dodick, Inbal Flash-Gvili

Challenges to Graduate Student Research in the Historical Based Sciences

The premise of inquiry-based pedagogy is that learning science in a manner similar to how scientists do science is more effective than learning science in a decontexualized fashion. Thus, developing inquiry-based materials depends on understanding how science is pursued. Until now, research about scientists in action has focused on experimental science. However, our study focuses on researchers in the historical sciences (specifically, integrative archeology) to better understand how the PhD students overcome the constraints of fieldwork. Our results show that students deal with two sets of constraints affecting their research. The first is associated with the philosophi-



cal understanding that each field site must be probed to identify relevant problems. This frustrates students who would rather concentrate on solving defined problems. The second is connected to methodological difficulties of fieldwork. Certainly, real time in the field contributes to increased competency in fieldwork. However, equally important is the support that a student receives from his colleagues, as well as the daily interaction he has with the multiple representations of a field site. Thus, developing inquiry based materials for high schools in historical science should incorporate group-based work emphasizing the ability to analyze multiple representations of the field.

#### Joel Donna

### Understanding the Affordances of an Online Induction Program for Beginning Science Teachers

Online induction programs can offer participants multiple sources of support and provide professional growth for beginning teachers. These models can help teachers to thrive and survive through interaction within an online community of learners. However, as in many online communities, sustainability of quality participation can be a challenge, especially as online induction programs compete for the limited time and energy of beginning teachers. This study examines the online dialogs, participation patterns, needs assessments, and evaluative questionnaire data of highly active participants in an online induction program. Through this exploration we hope to understand how to merge theoretical affordances of online induction with participant perceived and actual affordances. These understandings can be used to develop new models of blended induction programs that meet the immediate needs of individual science teachers while helping to foster professional growth.

#### Lisa Donnelly, Valarie Akerson

High School Biology Students' Evolution Learning Experiences

This study investigated how secondary biology students from six different high schools perceived their evolution learning experiences (ELE). The theoretical framework of border crossing was employed to interpret these results. Using daily classroom observations, interviews, and surveys, student's ideas about their ELE and acceptance of evolution were obtained. The findings suggest that student acceptance of evolution is related to having positive or negative ELE. Students experienced evolution learning in a variety of ways depending on the extent to which their home cultures embraced evolutionary theory and the extent to which students managed their border crossings using a variety of techniques.

#### Sharon Dotger, Lisa Johnson, Benjamin Dotger

The Applicability of Science to Decision Making: Moral & Reflective Factors

The development of scientific literacy among the citizenry assumes that individuals will be able to use their understandings of science content and its process to make decisions about socioscientific issues (SSI). A key component in understanding SSI is moral reasoning (Zeidler, Sadler, Simmons, & Howes, 2005). This article focuses on the types of moral reasoning used by participants as they consider the potential of science knowledge to influence decision-making. Their moral reasoning is compared to their reflective judgment and their evaluations of science. Findings suggest that postconventional thinkers are more likely to think reflectively and value science to some degree when making a complex decision. Implications for teaching will be discussed through applications of an instructional framework grounded in moral and reflective judgment.

## Denise Drane, Su Swarat, Eun-Jung Park, Kathy Chen, Thomas Mason

Enhancing Undergraduate Students' Nano-literacy Through an Instructional Module

Rapid developments in nanoscience will require both a nano-literate workforce and a population capable of grasping what nanoscience is and how nanotechnology is being applied in their everyday lives. In this proposal, we report a preliminary effort to help undergraduate students achieve nano-literacy through a 3 hour lecture-based nanotechnology module in a materials science course for non-majors. We define nano-literacy as the capacity



and readiness to approach, comprehend, and deal sensibly with phenomena involving nanoscience. Analysis of students' responses to a nano-literacy survey indicated that they made gains in nano-literacy during the course, reporting greater confidence their ability to explain what nanotechnology is, evaluate new applications of nano-technology and engage in discussions on nanotechnology. However, qualitative analyses of their responses to two open-ended items requiring them to explain how nanotechnology works in two nanotechnology applications covered in the class revealed that few students were able to explain a nanoscience application using scientific reasoning to support their explanations. These findings suggest that students may require more opportunity to develop their true ability in solving nano-related problems, not just their self-perception. Knowledge-application opportunities, and reflection moments could be incorporated into the class to help students gain a fair assessment of their knowledge.

#### Karen Draney, Jinnie Choi, Yong-Sang Lee, Mark Wilson

Developing Progress Variables for the Carbon Cycle

We discuss the development of progress variables to define our learning progression for students' conceptions of the generation, transformation, and oxidation of carbon in coupled human and natural systems.1A progress variable represents a cognitive theory of learning grounded in the principle that assessments be designed with a developmental view of student learning.1We want to describe a continuum of qualitatively different levels of knowledge from a relatively naïve to a more expert level. Our progress variables include "Tracing Matter" and "Tracing Energy."1We describe the tools and processes used to develop the hierarchies for our progress variables, including: 1) Analysis of student responses to individual items., 2) Selection of exemplar responses to represent each level of each progress variable. 3) Multiple scoring of selected response sets, and group discussion to resolve any scoring discrepancies. We display empirical maps developed through analyses of data from items relating to each progress variable, and administered to students at the upper elementary, middle school, and high school levels.1These analyses are conducted using item response modeling techniques.1We discuss how they relate to our theoretical progress variables, and what we learn from them.

#### Oliver Dreon Jr., Scott McDonald

The Development of Professional Identity Through Participation in a Community of Practice

Professional identity has emerged as a critical area of research for teacher educators. Instead of focusing solely on the acquisition of knowledge or skills, the professional identity construct allows researchers to investigate how teachers see themselves within larger communities of practice. A teacher's professional identity is a dynamic property, one that is constantly being renegotiated as an individual interacts with other community members and encounters new tools. This research focuses on the identity trajectories of two prospective science teachers as they participate in a community of practice of reform-minded science educators, the Invisible College for Inquiry Science Study (ICISS). The focus of ICISS is to use educational research to understand inquiry science as it is implemented in practice. Through the analysis of data collected through interviews and reflective web logs, this study examines the tensions that exist as prospective teachers' professional identities develop through their participation in the group. The introduction of inquiry pedagogy may influence how each prospective teacher sees herself and how she views teaching and learning.

#### Natalie Dubois, George DeBoer

Probing Middle School Students' Understanding of Ideas about Matter Transformations in Living Systems Through Content-Aligned Assessment

With funding from the National Science Foundation, we are developing an online collection of student assessment items for middle school science topics that are precisely aligned with national content standards. By rigorously applying a set of criteria to ensure the alignment of assessment items to specific learning goals and to identify features of the items that may obscure what students really know, our goal is to accurately assess student knowledge



of specific concepts and to enable educators to identify specific gaps in student understanding. In this poster, we focus on items specifically targeting ideas related to matter transformation in living systems. We were particularly interested in whether students see food as a source of molecules for growth and replacement of body structures or primarily as an energy source. The results indicate that, even though students may recognize that food is needed for organisms to grow, students usually think of food as providing energy for growth rather than being a source of matter for growth. This finding has important implications regarding students' ability to conceptualize the movement of matter in living systems.

### Reinders Duit, Thomas Koballa, Michael Beeth, Terry McCollum

Systematic Reform of Science and Mathematics Education: Results from a Decade of Collaborative Efforts in Ohio

Systemic reform of science and mathematics education occurs at the state level in the United States of America. Since 1991, the State of Ohio has engaged in systemic improvement of K-12 mathematics and science education statewide, first through Project Discovery (1991-1996), a teacher professional development institute, and later through Project SUSTAIN (1996-2002) and the Centers of Excellence (2002-2006), regional networks focused on K-16 systemic reform. Ohio's initial approach to statewide systemic reform, Discovery, focused on updating teachers' content knowledge and modelling learning thorough inquiry. Evaluations of student learning outcomes from Discovery were positive, especially in reducing achievement gaps between categories of learner, and in school building where more than half of the teachers received inquiry-based training through Discovery. The systemic reform efforts of SUSTAIN and the Centers of Excellence extended the reforms initiated through Discovery by disseminating inquiry-based instruction to all grade levels and incorporating inquiry into education programs at thirteen state-assisted colleges and universities. The focus of these collaborative reform efforts has shifted in recent years to include partnerships between two-year and private institutions preparing science and mathematics teachers. Insights from Ohio's systemic reform efforts can inform the design or implementation of large-scale efforts in other countries.

#### Reinders Duit, David Treagust

The Challenges Ahead for Research and Development on Conceptual Change in Science

Conceptual change views of teaching and learning processes in science, and also in various other content domains, have played a significant role in research on teaching and learning as well as in instructional design since the late 1970s. It is argued that this can be the case also in future so long as conceptual change views about research are further developed. In this paper, we present an overview of the different developments in conceptual change research since the introduction of this term in the early 1980s and discuss, using specific examples, three key challenges for future research and development activities in conceptual change in science.

## Jazlin Ebenezer, Osman Kaya, Dionysius Gnanakkan

Students Becoming Information Technology Fluent: Technology-Embedded Environmental Research Studies

This study developed high school students' fluency in information technology by engaging them in long-term scientific research projects on community-based environmental issues. Fluency in information technology in contrast to literacy (minimum level of familiarity) about information technology requires a deeper, more essential understanding and mastery of information technology for information processing, communication, and problem solving. A project-specific Likert-scale survey consisting of two-parts was administered to 45 students from Grades 9 to 12. On the average, 67.46% and 76.04% of the students reported that they were fluent in GIS/GPS and CBL2 interface with Datamate program, respectively. Students' experience was revealed by their responses to open-ended questions corresponding to each of the three components of the Likert-survey. Transcripts generated from focus group interview revealed the following categories of meaning: the role of the teacher; the functions and qualities of IT; and the students' self awareness of their ability to use IT. Evidence from various sources of data points to accepted level of student fluency in information technology. The study implied that high school students can achieve



accepted level of fluency in specific high-end information technology when teachers who have attained proficiency fully immerse students in meaningful science research projects that utilize these.

### Jennifer Eklund, Nonye Alozie

Activities to Promote Student Learning of the Role of Proteins in Modern Genetics

As the fields of molecular genetics and genomics have boomed and become increasingly important in the lives of the general public, traditional education methods have struggled to address the challenges in developing modern genetics literacy. To increase the understanding of the efficacy of tools designed to help students better understand fundamental concepts in modern genetics, we report on the development and use of materials as they relate to student learning about proteins and their role in modern genetics. Two activities, one using flexible 3-D models of proteins and another prompting students to draw comic strips to demonstrate protein activity, were particularly engaging for students and contributed to student learning. Students gains in understanding of proteins were found on many levels: 1) the role genes play in the structure of proteins 2) the relationship between protein structure and function, and 3) the role proteins play in manifesting traits. While challenges remain, students have made significant progress in their understanding of proteins. The improved understanding of proteins serves to help students further their understanding of genes and traits and the complex, multi-level relationship between them.

### Rowhea Elmesky, Gale Seiler, Christopher Emdin, Lisa Singletary, Wesley Pitts

Pathways to new possibilities: Creolized Science, Solidarity, and Hybrid Identities

Urban science classrooms have been and continue to remain sites of disconnect for many students of marginalized backgrounds as the teaching practices are distant from students' experiences and fail to tap into their ways of being. This symposium provides examples from studies conducted in different classrooms in large urban centers in the US and Canada showing how hybrid communities of creolized science emerge and the central role of identity hybridization in this process. By discussing the cultivation of science identities for teachers and students in these settings, we outline practical ways to ensure the inclusion and involvement of students in science across these various contexts. Through the symposium, we share some ways that a deep understanding of students' dispositions grounded in their localized knowledges can be supported and utilized as tools for learning science and for enacting responsive science pedagogy. Finally, involving researchers who share a theoretical framework, yet work in different cities and are at different places in their research careers, we explore the collaborative evolution of a sociocultural theoretical framework and growth of individual and collaborative research programs.

#### Doris Elster

"Biology in Context": Teachers' Professional Development in Learning Communities

Biology in Context (bik) is a German-wide program funded by the Federal Ministry of Education and Research (BMBF) to promote students' competencies in context-based biology education and to support teachers' professional development (Bayrhuber et al., 2007a). Based on a framework that was derived from the German national educational standards (KMK, 2004) and theories of context-based teaching and learning of science (Gilbert, 2006; Bennett et al., 2005), science education researchers and teachers (N=150) work together in learning communities (Brown, 1997) to transform this framework in teaching and learning practice. The accompanying qualitative evaluation of the Biology in Context (bik) project reflects teachers' and researchers' development and co-operation in ten different bik learning communities. Therefore, thirty-seven teachers and sixteen science education researchers from ten different bik sets all over Germany were asked twice for interviews: at the initial part of the bik-project and one year after working together in learning communities. The goal of the research is to acquire teachers' attitudes about context-based and competency-advanced teaching and learning, their approach, their hopes and fears in connection with the national educational standards and the project bik and their first experiences with networking in the bik learning communities.



#### Eva Erdosne Toth, Peter Hewson, Jan Van Driel, Elizabeth Davis, Michele Nelson, Carrie Beyer

Pedagogical Content Knowledge Development as Conceptual Change: Perspectives From Multiple Approaches

There has been a call for studies that clearly inform teacher education practice via a research-based isignature pedagogyî. Despite much effort however, teachers' experiences during their formal training often deviate from the innovative pedagogies we anticipate them to implement in their own teaching. The argument of this symposium is that if we wish teachers to fundamentally change the teaching methodologies they are accustomed to, we should employ a research-based methodology for teacher education that supports the conceptual change that is necessary to do so. The symposium is designed to integrate existing data on teachers' Pedagogical Content Knowledge and evaluate these processes with theories and methodologies developed to study Conceptual Change and Conceptual Change have been the focus of prior research it is proposed that an integrative framework with consideration of these two lines of studies can significantly improve our approach to teacher education. Our symposium will generate a discussion to assist in the fusion of these theories, methods and findings. The participants of the symposium bring a variety of experiences from multiple research settings and methodologies and the discussant is an esteemed member of the teacher education community.

#### Eva Erdosne Toth

Representational Tools for Teaching Science: Designing a Research-Based Approach

The purpose of this study is to develop a research-based instructional methodology that employs representational tools (pictures, images and graphs). A pre- and post-instruction test was used in combination with two forms of a worksheet: a treatment worksheet with a matrix-based representation and a control worksheet without the application of a specific representation. Results indicated the benefits of representational guidance on students' ability to design scientifically controlled experiments. Data indicated the effectiveness of instruction in combination with the treatment but not instruction alone. The findings are significant for NARST members as they document an effective method to improve the experimental design performance of inner-city high school students, specifically in cases when they previously performed below their peers.

#### Mehmet Erkol, Murat Gunel, Mustafa Kisoglu, Erdogan Buyukkasap, Brain Hand

Impact of the Science Writing Heuristic as a Tool for Learning in Introductory Physics Laboratory

This study aimed to evaluate the effect implementing the Science Writing Heuristic (SWH) approach in the introductory physics laboratory. Such implementation and investigation was conducted on electricity unit by measuring students' conceptual understanding of subjects and attitudes towards implementation. The study was carried out with 80 freshman students who were admitted to science education department in a university at Eastern Turkey. There were two classrooms and each classroom had two sections. Half of the four sections randomly assigned as control and the other half as treatment groups. Laboratory activities in the treatment group were conducted by using the SWH approach and students prepared their laboratory reports according to the SWH student template, and in the control group, the laboratory activities were conducted by following the lab book and the traditional approach and students prepared their laboratory reports in traditional format. Unit achievement test was applied as pre-test and post-test. Also an attitude survey was applied to investigate students' attitudes towards laboratory and the SWH. Semi-structured interviews were conducted with randomly chosen students both groups. Results indicated that the SWH approach and the reporting format significantly increased students' electricity unit achievement, conceptual understanding of the unit and attitudes towards laboratory.



#### Susan Everett, Gail Luera, Charlotte Otto

Investigating the Pedagogical Content Knowledge of Pre-Service Elementary Teachers Concerning Models

While much research has been conducted on students' conceptions of models, limited assessments have been created to assess teachers' pedagogical content knowledge (PCK) of models and modeling in science. We began the process of developing a measure to assess the PCK of pre-service elementary teachers in a science capstone course focusing on the unifying theme of models. We piloted two versions of questionnaires with open-ended questions. Following analysis of the responses, the questionnaire was revised to include ten open-ended questions and two pictorial models. A rubric was developed for scoring the responses using three broad levels of PCK development: limited, basic and proficient. A pre- and post-test design was conducted with 25 pre-service elementary teachers participating in the study. The results were analyzed using a paired sample t test and showed a significant increase in total PCK (p=.000) as well as in each component of PCK: subject matter knowledge (p=.007), pedagogical knowledge (p=.005) and contextual knowledge (p=.001).

#### Cathy Ezrailson, Cathleen Loving, Peter McIntyre, Teruki Kamon

Visual Physics: Using a Case Correlation Study to Inform Introductory Physics Course Design

This study correlates the effect(s) of Introductory Calculus-based Physics course reform. Case correlations are made between 1) the instructors, TAs and their students in the treatment group with 2) instructors, TAs and their students in the control group. Examined were instructor instructional preferences, including methods of problemsolving in recitation and lab measured with the Reformed Teaching Observation Protocol, video analysis, interviews and surveys. Also examined were attitudes about teaching and beliefs about the nature of physics and physics teaching using the MPEX2, interviews, video analysis and other quantitative and qualitative assessments applied periodically. Student learning was measured tracking the solution of context-rich problems with a CIPS (Coordination in Problem Solving) tool. Results seem to indicate that students learned best when the instructor interacted consistently and explicitly with individual students and small groups, and when cooperative groups were "healthy" interacting consistently and fruitfully. Course redesign also appears to work best with all elements of the introductory course "reformed."

#### Kathleen Falconer, Joseph Zawicki

The Pedagogical Beliefs and Values of Physics Alternative Certification Teacher Candidates

While alternative certification appears to increase and diversify the pool of teachers (Stevens & Dial, 1993), not a lot is known about alternative certification candidates' beliefs, attitudes and values towards their subject discipline content and the teaching of the content, notably in physics. This is a report of a grounded theory study of the perceptions of physics alternative certification candidates – people holding bachelors degrees in engineering or science who originally prepared for a technical career, but are now changing careers to become secondary school physics teachers. Approximately half of the candidates in a physics alternative certification program were interviewed regarding their understandings of their content knowledge, attitudes and beliefs about physics and physics teaching. Results indicated that the candidates felt that the program helped them develop a better understanding of their physics content through self-reflectively focusing on their own learning and upon unfamiliar teaching methods. Candidates viewed their prior experiences as poor. Candidates felt that science, especially physics, was a way of making sense and understanding the world, so science and physics courses were very important and so everybody could and should participate in physics courses. Candidates constructed a new understanding of the science teacher's role as very different from the traditional teacher- centric role.

## John Falk, Martin Storksdieck

Science Learning in a Leisure Setting

A large and growing literature has documented that the public learns science as a consequence of visiting informal



institutions like science centers. Given the leisure nature of most science center experiences is science learning the most likely outcome? Holmes (2000) suggested that learning is typically motivated for two purposes – either to build skills and competency or to support identity. According to Holmes there is an inverse relationship between learning for practice and learning for identity-building. Holmes' model suggests that in the extrinsically motivated learning world of schooling and the workplace, where there is a high demand for learning mastery to be demonstrated, identity-driven learning is depressed. By contrast the model would imply that free-choice learning at a science center visitors revealed that the learning that occurred was primarily identity-driven, as predicted. However, since the leisure context was a science-rich environment highly conducive to learning, much of the identity-driven learning was science oriented. In addition, there was also evidence that some of what visitors learned was situational rather than identity-motivated; learning was driven by compelling exhibit experiences. These findings have implications for research and practice.

#### Donna Farlland, William McComas

Correlating Students' Drawings of Scientists with Interview Data: Further Validation of E-DAST

The Draw-A-Scientist Test (DAST), used in many research studies, was designed to gauge students' views on the nature of scientists. Unfortunately, the DAST is suspect in terms of validity and reliability. The E-DAST is a more valid and reliable instrument; it includes three drawings and an interpretive rubric examining the scientists' appearance, location and activity. To further validate E-DAST, the researchers have correlated data provided by E-DAST with results gleaned from interviews. An interview protocol and scoring rubric were developed, with results compared with data derived from E-DAST data from 29 4-8th grade students. Each category (appearance, location and activity) received two scores; one based on the drawing and one based on the interview. Scores were compared showing that students' drawings of scientists were an accurate indicator of what interviews revealed 46% of the time. This conclusion, while tentative due to the small sample size, leads researchers to conclude that students hold a range of perceptions, some conflicting, of scientists that become evident only in interviews. When children draw more than one scientist and participate in interviews they reveal a depth and range of perceptions that may be a more accurate assessment of students' perceptions of scientists from drawing alone.

## Xavier Fazio, Wayne Melville, Anthony Bartley

The Role of the Practicum Experience in Supporting Secondary Pre-Service Teachers Implementing Inquiry Based Science

The purpose of this paper presentation is to disseminate some findings from a current study regarding perceptions that pre-service secondary science teachers have toward inquiry- based science teaching, and the extent to which the explicit teaching of inquiry-based science in science curriculum and instruction courses may influence those perceptions. While findings indicate that pre-service teachers did improve their understanding of scientific inquiry and increased their efficacy towards their future teaching of inquiry-based science, the role of the practicum in supporting their newly developed perceptions was problematic. Issues ranging from associate teacher subjugation, availability of scientific inquiry resources, time constraints, and the need to cover the mandated curriculum standards, were the most commonly cited reasons for teachers being unable to create an inquiry-based environment during their practicum teaching experience. Implications for the role and limitation of practicum experiences in supporting pre-service science teachers' newly formed practices are presented.

## Sabine Fechner, Marion Haugwitz, Angela Sandmann, Elke Sumfleth

Context-Oriented Learning and Its Effects on Students' Achievement Levels in Chemistry Education

After the weak performance of German students in large-scale assessments like TIMSS and PISA the demand for better educational quality in the field of science education has risen. Especially context-based approaches to learning science have been focused on. In practice, however, teachers often doubt that the actual content structure of the field is adequately acquired by students in context-based instruction. Therefore, the presented study investi-



gates whether a context-oriented learning environment enhances interest and has a positive effect on achievement in chemistry education. In addition, it also examines whether concept mapping as a learning strategy is able to support the integration of new conceptual knowledge into prior knowledge in a cooperative and context-oriented learning environment. The experimental study takes into account the two variables context and concept mapping and assesses their effects on students' achievement by means of a two-factorial control-group design. The results of the pilot study support the hypothesis that students achieve better in a context-oriented learning environment. However, achievement levels could not significantly be raised by the additional introduction of concept mapping. Results of this study may offer practical advice to teachers how to modify cooperative learning environments in order to improve students' learning.

#### Lisa Felix, Bruce Johnson

Back in the Classroom: Teacher Influence on Students' Environmental Understandings, Perceptions, and Actions Following an Earth Education Program

Teacher follow through in the classroom following participation in the Earthkeepers program was examined in this mixed methods study. Individual semi-structured interviews were conducted with seven teachers, four who did a great deal of follow through following the program and three who did little. Analysis revealed rich descriptions of the follow through as well as comparisons of the characteristics of the teachers who did much and little and reasons that account for the differences. Student surveys before and after the program as well as during the following school year showed that while all students gained new understandings and increased environmental perceptions following the program, those gains were greater and more persistent to those who had teachers who did a great deal of follow through. In addition, those students undertook more positive environmental actions following the program and continued those actions at a higher rate during the next school year.

#### Peter Fensham

#### Science Education Research and Science Education Policy: A Too Often Overlooked Link

Closing the gap between Research and Policy in Science Education Innovations in science education are suggested and research in science education occurs as if science education takes place in a political vacuum. Policy decisions about the practice of science education are made without regard for the relevant findings from researchâ Cases and examples that illustrate these two expressions of the gap between policy and research in science education will be discussed. Contrary examples that bridged this gap will then be considered to develop some bases for the research community to be more actively and effectively involved in shaping policy and practice in science education. What such involvement would mean will then be explored with respect to several major issues facing science education internationally at the present time.

#### Marcia Fetters, Paul Hickman

Teacher-in-Residence Programs: Supporting Physics Teacher Education at the University and Beyond

This paper highlights the work of Teachers-in- Residence as part of The Physics Teacher Education Coalition (PhysTEC). PhysTEC is a national coalition of colleges and universities designed to improve the quality and quantity of physics and physical science teachers. This study describes the work of these Teachers-in- Residence across 5 years of this grant. Using three project element categories to frame the study, the following questions are explored across the PhysTEC sites: • Bridges - How do TIRs help their sites utilize the expertise of K-12 teachers to inform educational directions with realities of the classroom and to connect physics departments with K-12 classrooms? What is their role is setting up and supporting Teacher Advisory Groups? • Engagement - How can they raise awareness of college and university faculty of their role in recruiting, training, and mentoring future physics and physical science teachers? • Continuum - What role do TIRs have in the development and promotion of programs that recognize that a continuum of efforts that include recruitment, training, induction, and mentoring are necessary to successfully empower students to become engaging physics and physical science teachers?



#### Cory Forbes, Elizabeth Davis

Beginning Elementary Teachers' Learning to Use Questions and Questioning in Inquiry-Oriented Science Teaching: A Longitudinal Study

Current science education reform efforts highlight the importance of engaging students in scientifically-oriented questions as a central dimension of scientific inquiry. To better support beginning elementary teachers' learning to engage students in inquiry-oriented science teaching, particularly supporting students to ask and answer scientifically-oriented questions, it is necessary to learn more about how they negotiate the use of questions and questioning at this crucial stage of the teacher professional continuum. Four beginning elementary teachers were studied longitudinally over their first three years of professional teaching. Results show that they differentiated between a variety of types of questions in science instruction, including driving questions, investigation questions, and interactive, activity-specific questions with students. While each teacher cited the importance of driving questions and investigation questioning to support student investigations. The teachers suggested numerous reasons for using interactive questioning to support student investigations though, over time, came to prioritize this strategy to support students' sense-making. These findings have important implications for our understanding of teacher learning along the teacher professional continuum and help inform research on teachers and teaching, as well as teacher education and science curriculum development.

#### Danielle Ford, Steve Fifield, Xiaoyu Qian, Deborah Allen, Richard Donham, Yovita Gwekwerere

Preservice K-8 Teachers' Developing Pedagogical Context Knowledge within an Integrated Science and Education Continuum

In this symposium we examine the beliefs, knowledges, and experiences of preservice K-8 teachers enrolled in reform-based science and science education courses in their first two years of our teacher education program. Our team reports on preservice K-8 teachers' (1) self-efficacy, achievement, and the reliability of the Science Teaching Efficacy Beliefs Instrument (STEBI-B), (2) emerging, formal understandings of targeted content (energy and matter interactions in ecosystems), (3) performances and practices within courses to ensure success as they (perhaps not their instructors) define it, (4) exertion of power in resistance to reform that challenges their expectations for science teaching and learning, and (5) understandings of pedagogy, inquiry, and science that change and remain the same over a two-year period. We examine longitudinal and cross-sectional data across our reform-based continuum to gain insights into a critical dimension of teacher education ñ the ways in which preservice teachers accept, resist, and modify dimensions of the undergraduate teacher preparation experience to align with their goals for their own college experience as well as their future teaching careers.

#### Jennifer Forrester, Gail Jones

Growing A Scientist: Scientists' Experiences, Relationships, and Identity Formation

There is a shortage of students choosing STEM (science, technology, engineering, and mathematics) in college as well as a decline in people pursuing a career in a science and engineering field. This study was conducted to determine if common experiences exist across scientists in different science disciplines that are influential in an individual's decision to select science as a career. Thirty-seven scientists participated in the study. Participants indicated that experiences with science in and out-of-school, nontraditional out-of-school experiences and relationships with peers, teachers, and family members were factors that had the most influence on their decisions to become scientists. These experiences and relationships contributed to participants' ongoing process of trying to make sense of themselves as science learners. These experiences illustrate the intersection between participants' personal histories and of their cultural histories; components that comprise their communities of practice allowing their evolution from student to scientist.

#### Brian Fortney, Laura Henriques, Julie Grady

Membership and Elections Committee-Sponsored Session: Mentor Mentee Nexus

This is an informal discussion session sponsored by the Membership and Elections Committee that enables early career members to meet like-minded educators and scholars to enhance their professional networks. The Mentor Mentee Nexus meets on the first evening of the conference and matches new members with mentors who share similar interests. The Nexus helps members launch or expand their professional networks and explore different perspective on their research. You will provide a summary of your science education knowledge and interests and we will try to match you with a like-minded mentor who will help you meet and greet scholars of interest.

#### Brian Fortney, James Barufaldi

Conceptual Change in Pre-service Teacher Belief Structures-Through Japanese Lesson Study

This 15 week mixed methods study presents the belief structures of six pre-service teachers (PSTs) as they progress through their first experiences in teaching science at the elementary level-through the use of Japanese Lesson Study. Initial evaluation of the baseline/pre/post time samples of the six participants indicates the following changes exhibited by participants: evolutionary cognitive change; belief structure change by the accretion of knowledge; no significant change in the structure of beliefs about teaching and student learning in science classrooms. This paper utilizes a multidimensional interpretive framework to interpret learning situations from different theoretical perspectives, resulting in the construction of Cognitive Maps representing the belief structures held by PSTs about teaching and student learning in science classrooms. Additionally, Differential Cognitive Map techniques are described and used to determine conceptual change in the belief structures of six PSTs by evaluating baseline/ pre/post time samples.

#### David Fortus, Ayelet Weizman, Yael Shwartz, Joi Merritt, Christina Schwarz

Incorporating Modeling Practices Into Middle School Project-Based Science

IQWST is an NSF-funded project developing a comprehensive and coordinated middle school inquiry-based science curriculum. Four studies, conducted in the context of pilot enactments of two 6th grade units, one in physics and the other in chemistry, investigated the ability of students to engage in different aspects of scientific modeling, their understanding of meta-modeling knowledge, the contribution of modeling to the student's learning of science content, and the role whole-class discussions played in supporting students' construction and evaluation of, and communication about models. The results corroborate previous studies that demonstrated the power of modeling in helping develop content knowledge. Engagement with modeling supported students in constructing their content knowledge, but some initial content knowledge was required to engage in advanced levels of modeling. Different students take different paths in developing their content knowledge. While students were engaged in multiple aspects of the practice, their meta-modeling knowledge seems to be limited. Students were able to engage in more advanced modeling practices in later lessons of the same units and can apply the same practices to new content and new situations. These findings are helping guide the revisions being made to the teacher guides and informing the development of the learning progression.

#### Wendy Frazier, Donna Sterling, Mollianne Logerwell

An Examination of the Process of Supporting Uncertified Science Teachers: What New Teachers Need to Succeed

The purpose of this study was to analyze the complex process of supporting uncertified, inservice science teachers. With the current shortage of science teachers, school systems are forced to hire teachers with science degrees, but little training in education or experience teaching. The New Science Teachers' Support Network (NSTSN) was designed to help uncertified, inservice science teachers teach successfully and remain in the profession via university-school district partnerships. With a record of success based on treatment-control group comparisons,



this study seeks to move beyond merely reporting the influence of the program on increased student grades and test scores. Components of the NSTSN included in- class instructional support by retired science teachers, science methods courses, mentoring by fellow teachers and science professors, and a support website. Support provided by the NSTSN had a positive impact on teachers' classroom management, planning, and instruction as evidenced by over 400 in-class observation reports from 34 uncertified science teachers' classrooms. Qualitative analysis is used to identify WHY the NSTSN works by chronicling the specific needs of new teachers and the ways in which university-school district partnerships support new teachers' effectiveness at teaching.

#### Kelley Friden, Sara Morrison, Nikki Hanegan

Teacher/Student Questioning Interactions

Questioning behaviors between teachers and students serve to build and develop problem solving skills, formulate and test hypotheses, and improve overall cognitive ability. The interchange of questioning between teacher and student is incredibly valuable in strengthening and sustaining questioning skills. The purpose of this study is to analyze the relationship between teacher-initiated questioning and student-initiated questioning in the development of questioning skills. This study used mixed methods with an interview and observational dataset. A treatment in the form of professional development was applied to 47 teachers. Classroom observations were analyzed and coded for teaching and learning behaviors. Instances of questioning. Teacher-initiated and student- initiated questioning rates were determined and examined in terms of correlation. Teacher- initiated/student-initiated behaviors with regard to open-ended questioning were found to be positively correlated. No correlation was found regarding the teacher-initiated/student- initiated relationship of yes/no questioning, factual-based questioning, or general questioning. As teachers ask questions which cause students to explore and examine the world around them, students in turn pose open-ended questions back to their teachers, as both are engaged in the conversation of learning.

#### Rebecca Fulop, Kimberly Tanner

Understanding Novices' Versus Experts' Conceptions About the Biological Basis of Learning and Memory

From mental health disorders to new consumer products to articles in the news, neuroscience – the study of the brain and the nervous system – is everywhere. How prepared are today's students to understand and critically evaluate the claims made by advertisers, the media, and health care professionals? In this study, we begin by investigating the conceptions of high school students (novices) – those individuals that have most recently completed mandatory high school biology in the United States – around the biological basis of learning and memory. Next we examine a likely origin of many high school student conceptions – the knowledge held by high school biology teachers. Finally, we compare students' and teachers' ideas with those of neuroscientists (experts). This study uses a mixed-methods design with qualitative data collection in the form of written assessments and semi-structured, video-taped interviews. Preliminary results indicate that at least one-third of high school students are confused about neuroscience concepts that are considered to be the basis of learning and basic tenets within the field, including the concept that changes take place inside the body when a person learns.

#### Erin Furtak, Tina Seidel

Recent Experimental Studies of Inquiry-Based Teaching: A Meta-Analysis and Review

In the ten years following the publication of the National Science Education Standards in 1996, the science education community explored how inquiry-based teaching could facilitate student learning of science. During this time, the Department of Education placed a new emphasis on so-called 'gold-standard' research designs in educational research; that is, experimental studies that determine the effects of teaching interventions on student learning. To address the need for the science education community to have an informed perspective of how recent experimental studies characterize inquiry teaching interventions and their impact on student learning, this paper presents a new framework for conceptualizing inquiry-based science teaching, applies the framework to experi-



mental studies published after the Standards. Twenty-two studies published between 1996 and 2006 were coded according to a framework of inquiry consisting of methodological, epistemological, conceptual, and social facets. Results revealed an overall moderate effect size of 0.77; higher effect sizes were observed for those studies that focused on all four facets of scientific inquiry. The paper helps the science education community to better understand how reforms are being conceptualized in the research reports that have the most potential, given the current political climate, to influence changes in educational policy.

#### Martha Galganski, Tommie Turner

Lesson Study in Elementary School Science: Steps to Investigative Culture

Lesson study (LS), a multi-step professional development(PD) model, has historically been utilized by teachers to improve their classroom mathematics instruction. Using LS, we designed and revised a single content research lesson based on anticipated student responses. Our LS teams were comprised of K2 urban elementary teachers and informal science institution educators (ISIEs). The teachers on the LS teams wanted to improve their science content knowledge and the ISIEs wanted to enhance science inquiry so that the teachers would make more effective conceptual connections between activities and concepts. Our research was framed on the literature results of the Local Systemic Change (LSC) that distinguished investigative practices and student-centered or investigating the effects that LS has on science teaching practice, especially the self-perceived changes and actual changes in the classroom when teachers received less than 80 hours of PD. Team meetings and classroom instruction were observed via field notes and videotapes. Participating teachers self-reported their teaching beliefs and practices through questionnaires and interviews. We report the changes in teachers' investigative practices and the steps used toward an investigative culture in their classrooms.

## Alejandro Gallard Mart'nez, Sherry Southerland

Teachers' Self-Identity and Conceptual Hurdles to "Science For All"

Teachers' Self-Identity and Conceptual Hurdles to "Science For All" In this research, we focus on what science teacher educators need to know to be able to facilitate teachers' professional development regarding inclusive science teaching. The goal of this research is to identify science teachers' beliefs/conceptions that play a significant role in shaping their understandings of and attempts to enact inclusive science teaching practices. We examined the work products for 34 teachers enrolled in two graduate courses. One of the courses had as a main focus diversity in science teaching and learning and the other it was implied in the assignments. We checked our emerging understandings via a series of interviews with a subset of teachers. As we analyzed these data, we noted the superficial difficulties the teachers' understanding and enacting of equitable science instruction. Themes emerging from the data include: the view of science learning as a strictly cognitive endeavor, teachers' own ethnocentrism, deficit mentality about non mainstream students, their families and their communities, and the rejection of equitable science instruction in favor of equal science instruction, a conception that was closely tied to teachers' belief in schooling as a meritocracy. The implications of these conceptual hurdles for science teacher education are discussed.

## Athena Ganchorre, Debra Tomanek

Prospective STEM Teachers' Early Schooling Experiences and Exposures as Drivers to Teach in High Needs Schools

One way to increase talented Science, Technology, Engineering and Mathematics (STEM) teachers to high minority schools is to fund institutions through the Robert Noyce program to provide training and scholarships for pre-service STEM teachers. Upon award, recipients commit to teach in high needs school districts. High needs school districts have schools with a high percentage of students qualifying for free or reduced priced lunches, or have a high percent of teachers teaching out of their major field of study, or have a high teacher attrition rate. This exploratory study sought to gain an understanding of what motivates Noyce-supported teachers in preparation at a



Southwest research one university to teach math and science in high needs school districts. A qualitative approach using an interpretive coding method revealed subjects are motivated by their experience with or awareness of the educational challenges encountered by high needs students; and their beliefs that teaching in high needs schools is more satisfying than teaching in low needs schools. This study adds to the limited body of work on what motivates pre-service STEM teachers particularly, to teach in math and science in high needs school districts. Implications for recruitment and retention of STEM teachers are discussed.

### Anne Gatling, Katherine McNeill, Dean Martin, Michael Barnett

A Comparison of Field and University Based Science Methods Courses Impact on Preservice Teachers' View of How Students Learn Science

Preparing preservice teachers to be more effective at teaching science once in their elementary classroom is a great concern for our field. This study explored two different approaches to elementary methods for preparing preservice teachers to teach elementary science, a university based and a field based methods course. The purpose of this study is to determine the strengths and weaknesses that both courses have on preservice teachers' preparedness for teaching science in a diverse elementary classroom. We investigated whether preservice teachers' beliefs about science instruction and student learning changed over the semester and whether or not that growth varied depending on which methods section they were in. We collected multiple data sources to assess the impact of the two different types of methods courses including: pre and post surveys, pre and post-interviews and various assignments collected throughout the semester. Analyses of the survey data suggest that preservice teachers in the field based section developed a more inquiry view of science, yet smaller growth in confidence to teach a range of science content. The university based preservice teachers finished the course with less inquiry based views but more confidence in other science content areas.

### Andrea Gay

Capitalizing on Teacher Expertise: Contemplating Transfer From Professional Development to the Classroom Through Effective Use of Pedagogical Contexts

Of primary concern in professional development (PD) are the ways in which teachers transfer knowledge from PD to the classroom. This qualitative case study of a chemistry PD course for elementary teachers examines how using pedagogical contexts in PD can both encourage and reveal teachers' thinking about transfer. Teacher learning of chemistry concepts, activities, and pedagogical strategies were motivating factors for considering transfer. Teachers appropriated and adapted PD materials based on the specific learning needs of their own students, the constraints of their teaching contexts, and their desired outcomes, including making science learning relevant for students. Use of pedagogical contexts to illuminate teacher thinking allows PD providers insight into how to structure PD to better facilitate transfer to the classroom. Furthermore, teachers' active consideration of appropriations and adaptation highlights how pedagogical contexts enhance teachers' leveraging of their expertise in shaping their PD experiences.

## Yun-Ping Ge, Huey-Por Chang, Kuo-Hua Wang

Under Cultural Conflict: Change of the Teacher Discourses About Taiwanese Curriculum Reform

Drawing on socio-cultural perspectives, this study extended the previous 3-year survey to have further in-depth realization how local teachers adjusted teaching under cultural conflict. A cultural sensitive methodology was adopted to have both grouped interview and individual interview to collect data. Resulted from large sample survey in a big city, this longitudinal study can offer solid reference to realize the curriculum implementation and shed light on the further curriculum reform. Coded by two-tier scheme, the qualitative data were transformed into quantitative clues to provide an overview of the teacher discourses. The findings are: First, the change of local teacher discourses was mild. The most concerned issue remained as teaching practice. However, trapped by cultural myths, the teachers could not practice the true meaning of the new curriculum. Secondly, most local teachers tended to



adjust teaching towards traditional examination-driven curriculum in echoing parental demand. It was concluded that the tension between cultural myths and the goals of new curriculum produced cultural conflict. That impeded the curriculum reform. Thirdly, we were optimistic to propose some possibilities, revealed by our local teachers, to be released from the cultural myths. Implications and suggestions for in-service teacher education and future reform were made.

#### Coral Gehrke, Shawn Rowe

Examining the Role of Affect in Visitor Engagement with Touch Tanks

Many acknowledge the importance of the affective domain in learning and meaning making experiences in informal and free-choice learning settings. However, a characterization of the role of affect, especially in terms of content learning, is largely missing from the literature. Previous research has shown that touch tanks engage people emotionally, yet few studies have attempted to understand the characteristics of this engagement, or examine what factors might improve these experiences. In order to address this gap, we developed an observational rubric to characterize the role of affect in visitor learning though observations and focused interviews at the Pattern Garden exhibit at Hatfield Marine Science Visitor Center in Newport, Oregon. This rubric provides researchers and evaluators with a new practical tool that may be used to effectively evaluate affect and learning at other touch tanks and in any setting where visitors interact with live animals. In addition, the findings of this study provide research-supported ideas that inform the development and design of both interactive exhibits featuring live animals and staff mediated interpretation at these exhibits, facilitating an increase in the educational value of these interactions by deepening visitor engagement.

#### Hadas Gelbart, Anat Yarden

#### Generating Knowledge in Genetics Through a Simulation of a Research in Genetics and Bioinformatics

We previously reported on the development of a learning environment, which enables learners to participate in a simulation of a research in genetics with the aim of identifying a gene in the genome, using bioinformatics tools and genetics practices. The environment is giving the learners an opportunity to apply their prior knowledge in the context of current genetics research. Here we report on a case study in which we examined high-school students' generation of knowledge in genetics while learning through the environment. Using a qualitative research approach we analyzed the learning processes of two high-school biology students who coped with the learning environment. Our results indicate that learning through the environment promotes the generation of a link between classical genetic models and the molecular mechanisms involved, and encourages students' examination of knowledge. We therefore suggest that the physical basis for patterns in the transmission of genetic material be integrated with the recognition of the affordances of genetics research. Thus, recognizing the scientists' basic heuristic of comparing between normal and affected individuals at the molecular level.

#### Libby Gerard, Jane Bowyer, Ronald Marx

Building Leadership to Support Teachers' Integration of Technology-Enhanced Science Instruction

Extensive research documents the effectiveness of technology-enhanced curricula to help students learn science concepts, yet teachers are using these curricula minimally. Research suggests that active involvement of the principal promotes scaling or integration of technology-enhanced science in the school system. This three-year study examines a professional development program that supported the principal as the key leverage point for creating a school environment that nurtures teachers' implementation of a particular technology-enhanced science curriculum (TELS). Nineteen principals participated; seven participated in the professional development and twelve provided a comparison group. Results describe: (a) shifts in principals' understanding of the leadership necessary to support teachers' integration of technology-enhanced science and (b) changes in the number of teachers integrating TELS modules in their science classrooms. Research-based heuristics for supporting principals to foster



teachers' use of technology-enhanced science reform are recommended.

## Julie Gess-Newsome, Janet Carlsen Powell, Joseph Taylor, April Gardner

Impacting Teacher Knowledge, Teacher Practice, and Student Achievement: The role of Educative Curriculum Materials and Professional Development

Educative curriculum materials integrate a coherent organization of the content with research-based pedagogy and make explicit students learning goals and provide the teacher with instruction and insight into how to appropriately implement the materials and address student misconceptions. Two sets of biology curriculum were ranked the most educative of materials submitted for review by biology textbook publishers. Twenty teachers spent five days using the Analysis of Instructional Materials rubrics to select one of the two curricula for use during the two year study. Following selection, teachers received extensive professional development on half of the units from their selected curriculum. All units were to be taught during the academic year with fidelity. Pre and post test measures of teacher content knowledge, pedagogical knowledge, and pedagogical content knowledge were analyzed to compare units for which professional development was provided against units without professional development. Student pre and post content knowledge scores were similarly compared and correlated to teacher scores. Within-teacher analyses show a strong positive correlation between a teacher's gain score on concept- specific PCK measures and his/her participation in professional development relevant to that concept. The strongest of the student score-teacher score correlations were for those concepts where teachers received professional development.

### Cynthia Ghent, William Holliday

Embedded Science Textbook Questions Used to Increase Comprehension

Most science textbooks used in classrooms are filled with dense technical prose, which students are poorly trained to read and comprehend, according to reading strategy research. Students answering embedded questions of the general type investigated in this study theoretically engaged students in relatively more information processing by activating and retrieving their relevant prior knowledge and thus theoretically enabling them to comprehend a read science text. The 146 participants were randomly assigned to either an experimental group where students answered a form of "why" question while reading about animal behavior; or to one of two control groups: a) rereading-control where students read the same experimental text without questions, or b) a just-read (once) control, where students read an unrelated science text without questions. Why questions may ask students to answer why statements pulled from a text are true or why falsified statements based on a text are indeed false. The results (p< .01) supported the hypothesis that using the questioning strategy improved comprehension of science text compared separately to the two control groups. The comprehension posttest asked 50 questions that required students to transfer what they remembered from reading their text and applying it when answering the posttest questions.

## Penny J. Gilmer, Mohammed Al-humiari, Donald Bratton III

Cogenerative Dialogue: Improving Undergraduate Biochemistry Teaching and Learning

In the fall of 2006, we asked students enrolled in a second-semester, undergraduate-level biochemistry course at a major southeastern US university to participate in 12 cogenerative dialogue (cogen) sessions aimed at improving the course. The cogen group consisted of the course instructor and five students of diverse backgrounds, programs of study, goals, and levels of prior education. We held informal sessions weekly at lunchtime, discussing topics such as classroom facilities, assessment techniques and content delivery. We recorded the cogen sessions via audio and videotape and transcribed and compiled the data, initially as one students' undergraduate research project. The major topics of discussion were class learning environment, biochemistry content, teaching methods, teacher learning, and other effects. From the students generally gave a positive response to the instructors novel and recent teaching methods. Two cogen students contributed more insights after the class ended. A major benefit was for the instructor to meet with some of her students and use the cogenerative dialogue to improve the learning environment.



ment in her classroom. The instructor improved as she progressed and saw the outcome develop during the semester.

### Claudette Giscombe

Negotiating Pathways to Successful Science Careers: The Life Experiences of African-American Women

In this qualitative study, the life experiences of five African-American women who navigated pathways to successful careers in science were investigated. The data was primarily obtained from the in-depth phenomenological interviewing method (Seidman, 1991). The women articulated four major themes as critical determinants to their achievements. The major findings were: (1) "Black Intentional Communities" (Delpit, 2003) acted as social agencies for the positive development of the participants; (2) "My World"-- acceptance of their segregated worlds, not being victims of inequities and injustices Early academic successes were identified as precursors and external motivational stimuli to their interests and achievements in science; (3) Experiences of "Tensions and Double Consciousness" from race and gender negative images and career stereotypes, required the women to make "intracultural deviations" from stereotypic career roles and to develop "pragmatic coping strategies" to achieve in science careers and; 4) "Meaning-making"--Significant to the meaning of their journey was the fact that the participants grounded their experiences and achievements in a social context. Implications for future research and the need for a deeper understanding of Black women's experiences in science education and science careers are discussed from a social historic context.

#### George Glasson, Micahael Evans

Connecting Community Elders with Primary Schools in Africa Using Mobile Phones and Web 2.0 Technologies

In this project, we investigate the facilitation of connections among community elders, primary school teachers, and science teacher educators using mobile phone Web 2.0 technologies (e.g. blogs and wikis, instant and text messaging) to learn about sustainable agriculture in Africa. The development aspect of this project focuses on mobile devices (handheld computers and smart phones) as a primary data collection and delivery platform. Initial interviews focuses on the culture context for connecting community elders to schools. Currently, curricular and structural barriers pose severe limits to the building and exchange of knowledge: indigenous knowledge is absent in schools, community elders are displaced from curriculum, and resources are outdated and scarce. From this analysis, we are iteratively designing, implementing, and evaluating mobile and Web 2.0 technologies in a participatory manner. A participatory design approach creates a living archive of traditional and scientific knowledge related to sustainable agriculture.

#### Nicole Glen, Sharon Dotger

Exploring the Intersection of Writing and Science in Elementary Classrooms

This qualitative study examined three upper elementary teachers' purposes for using writing in science lessons and their expectations of students' products. Analysis of interviews, classroom observations, and artifacts revealed that teachers lacked confidence about what writing in science meant, writing opportunities were grounded in teachers' perceptions of students' abilities, and writing was used mainly as a knowledge-telling task. One purpose for science writing was to have students convey their knowledge to the teacher, which is consistent with knowledge-telling tasks. Another purpose, however, was to enhance students' general literacy abilities with little attention paid to the science content in the writing. Teachers also believed that students' writing abilities should influence the type of writing that students do. Implications for science educators include using this knowledge of teachers' concerns and expectations of writing to help them develop writing-to-learn strategies that also increase their students' conceptual knowledge gains in science.



#### Ravit Golan Duncan, John Ruppert, Andrew Bausch, Hava Freidenreich

Promoting Middle School Student's Understandings of Molecular Genetics

Genetics is the cornerstone of modern biology and understanding genetics is a critical aspect of scientific literacy. Research has shown, however, that many high school graduates lack fundamental understandings in genetics necessary to make informed decisions or to participate in public debates over emerging technologies in molecular genetics. Currently, much of genetics instruction occurs at the high school level. However, recent policy reports suggest that we may need to begin introducing aspects of core concepts in earlier grades and to successively develop students' understandings of these concepts in subsequent grades. Given the paucity of research about genetics learning at the middle school level we know very little about what students in earlier grades are capable of reasoning about in this domain. We also know little about the ways in which we can help younger students develop deeper understandings of genetics. In this paper, we discuss a research study aimed at fostering deeper understandings of molecular genetics at the middle school level. As part of the research we designed a three-week modelingbased inquiry unit implemented in two 7th grade classrooms. We describe our instructional design and report results based on analysis of pre/post assessments and written artifacts of the unit.

#### Susan Gomez-Zwiep, Shawn Holmes

#### Using a Concept Map to Guide Instruction: The Impact on Teachers' Understanding of Evolution

This descriptive study explores teachers' conceptual understanding of evolution, specifically the lines of evidence supporting evolution and the genetic mechanisms that drive it. During an in-service for elementary and middle school teachers, a type of concept map was used to link concepts, organize activities and drive instruction. This "conceptual flow" organizes concepts and facts into a comprehensible storyline using backwards mapping. Sixteen teachers from two urban school districts participated in the weeklong institute. Teacher content growth was examined using 1) pre- and posttest scores, journal entries, and daily written evaluations. Scores on the pretest ranged from 39% to 80% correct. Post-test scores ranged from 64% to 93%. Journal entries and evaluations were analyzed and common themes are discussed in the paper. The results suggest that the use of a specific concept map, a conceptual flow, in a teacher in-service not only lead to an increase in teacher content knowledge, but also allowed teachers to make new content connections for themselves. In addition, journal and evaluation data suggest that teachers also began to consider how the content story presented could be used to create meaningful connections for their own students.

#### Karen Goodnough

Generating "Knowledge of Practice" in the Context of Science Education: Case Studies in Teacher Learning

This study reports on science teacher learning that occurred in the context of a three-year teacher development/action research project. The main purpose of this paper is to report on how conceptions of teacher knowledge and learning (knowledge-for-practice, knowledge-in- practice, and knowledge-of-practice) emerged within this project. Qualitative case study was adopted as a means to explore how school-based action research teams developed their personal and professional knowledge in the context of K-12 science education. Audio taped planning meetings, teacher electronic journal entries, semi-structured interviews, and teacher and students documents were used as data collection methods and sources. The themes of teaching-as-praxis, the role of collaboration, and the context of teaching and learning reflect how professional learning occurred in this action research project.

#### Karleen Goubeaud

College Science Faculty's Assessment Practices: Trends From the National Study of Postsecondary Faculty

The role of assessment in teaching and learning has been elevated in importance recently by the advances of education and cognitive science research that shed light on how students learn. In the present study, the types of assessments used by college faculty in various areas of science disciplines are discussed from the perspective of current



assessment reform efforts. The purpose of the study was to (a) describe the assessment practices of biology, chemistry, and physics faculty at the college level; (b) compare the assessment practices of faculty from various science disciplines; and (c) examine the recent trends in college faculty assessment practices to determine whether they implement traditional or performance- based assessment strategies. The results of the study indicated that there were statistically significant differences between the types of assessments used by science faculty in the subject areas of biology, chemistry, and physics. There appears to be a slight increase over the last decade in the proportion of faculty who used assessments that could be considered to be consistent with constructivist strategies.

### Wolfgang Graeber, Claus Bolte, Jack Holbrook, Avi Hofstein, Martin Lindner, Claus Michelsen

Popularity and Relevance of Science Education and Scientific Literacy - The PARSEL Project in Europe

A consortium of researchers from 8 European nations has successfully applied to the EU commission for funding the PARSEL (Popularity and Relevance in Science Education and Literacy) project, which aims at raising the popularity and relevance of science teaching and enhancing students' scientific and technological literacy, through identification of suitable teachingñlearning materials based on relevant context-based educational approaches. These approaches, identifiable within the teachingñlearning materials, are expected to focus on socio-scientific issues, promote the acquisition of a range of personal and social skills (including cognitive skills associated with investigatory scientific problem solving and socio-scientific decision making) and clarify the relevancy of science education for the 21st century. This symposium will introduce and discuss the project PARSEL ideas within a framework of related studies that helped shape the current vision of PARSEL. We will present the theoretical background and an empirical base derived from the OECD PISA study and the German Curricular Delphi Study in Chemistry. An important goal of the symposium is the further development of the PARSEL profile, including more innovative approaches and hoping to expand the existing network over the boarders of Europe.

### Andre Green, Phillip Feldman

21st Century Community Learning Science Education Camp

It is no secret that there is a teacher shortage across the nation and Alabama is no different in this regard. Many teachers are retiring and others are leaving the profession altogether because of a multifaceted set of reasons. Some teachers feel they have no support, some feel that they are required to teach to a state test, while other teachers feel that neither they or the profession are appreciated. Whatever the reasons, the fact remains that it is becoming increasingly difficult each to attract and retain teachers. Embedded within the problem of a general teacher shortage is a greater teacher shortage in the area of science. Nationally and locally science teachers are a valuable commodity to any school district because fewer teachers are certified to teach within the STEM fields. Additionally, finding African Americans with the credentials to teach in these fields is often times more difficult. To address the problem a science summer camp for thirty African American high school students was hosted by the local university. The summer camp used science and mathematics avenues to encourage these young persons to consider careers in education and science. This proposal focuses on the experiences of those that participated.

#### David Grueber

Teacher Commitments and Resources to Facilitating Evidence-Based Reasoning in an Inquiry-Based Curriculum

Curriculum materials sometimes require teachers to enact new social roles associated with norms of scientific inquiry practices. Curriculum materials designed to include an emphasis on scientific inquiry give teachers the responsibility of making sure that a priority is given to evidence. A priority on evidence requires teachers and students to learn new social roles in the classroom. This leads to the following research questions: 1) What were the enacted inquiry events and practices? and 2) How do the teachers' commitments and resources toward inquiry-based teaching influence teacher-student interactions when reasoning with evidence? Three teachers enacted an inquiry-based curriculum in three schools. Data sources included transcripts of video and audio recordings and stimulated recall interviews of enacted lessons. In general, analyses across the three classrooms show a continuing



tension between the implicit curriculum intent and teacher knowledge and beliefs. The traditional classroom participation structures place the teacher in a position of both intellectual and social authority. Shifting to a structure of participation where the teacher maintains social control while intellectual authority shifts to students' reasoning with evidence is a complex process that the teachers accomplished only rarely.

#### Pascal Guderian, Burkhard Priemer

The Impact of Multiple Visits to an Informal Learning Facility on the Development of Interest in Science

Visits to informal learning facilities such as museums, science labs, zoos etc. are quite popular in school practice. With regard to students' interest in science positive effects are ascribed to these settings although systematic research in this field is rare. A study was conducted which assessed the influence of three visits to an informal learning setting on students' situational interest in physics. In addition, for a part of the sample the instruction at the informal learning facility was connected to their school curriculum. The results of the group without a curricular integration give rise to the notion that only short-term effects can be obtained by stand-alone visits. However, the group with integration showed a constant development of interest indicating a medium-term stabilization of situational interest. The study shows that it is required to complement visits to informal learning settings with suitable preparation and follow-up activities in school to ensure longer lasting effects on students' interest in science.

#### Kristin Gunckel, Beth Covitt, Hasan Abdel-Kareem, Charles Anderson, Rebecca Dudek

A Learning Progression for Processes that Move Water through Socio-Ecological Systems

Processes that move water through socio-ecological systems include evaporation, precipitation, condensation, surface run-off, infiltration, and gravity flow. Results from assessments administered to students in grades 2-12 show that students with lower level reasoning recognize some natural systems and can trace where water goes in those systems. However, they do not recognize the need for a mechanism to explain how water moves. Students with higher level reasoning trace water along several possible pathways through connected systems and provide explanations for the processes at the molecular level. Spatial visualization is also important as students at higher levels become better able to interpret maps and cross-sections to analyze systems and explain processes that move water through those systems. Analysis shows that by high school, few students are able to use model-based reasoning to describe water moving through connected systems. This finding suggests that while students may be learning about some processes in detail in science courses (i.e. phase changes in physical science), there are aspects of water movement that receive inadequate treatment (i.e. ground water and surface water flow) or are taught in contexts divorced from environmental systems, resulting in incomplete student reasoning about the movement of water.

#### Kristin Gunckel

Preservice Elementary Teachers Learning to Use Science Curriculum Materials

New teachers rely heavily on curriculum materials, but available science curriculum materials do not often support teachers in meeting specified learning goals or teaching culturally responsive, inquiry-oriented science lessons. One approach to supporting new elementary teachers in using available science curriculum materials is to provide frameworks to scaffold preservice teachers' developing lesson planning and teaching practices. The Inquiry-Application Instructional Model and Critical Analysis and Planning frameworks were designed for this purpose. This study examined the meanings that three intern teachers made of these frameworks. Only one of the interns was able to plan and enact a unit that fit the intent of the frameworks. Unlike the other two interns, she focused on providing students with many examples of key patterns that she had identified as important to understanding her assigned learning goals. These results suggest that using the frameworks as intended is fundamentally different from some preservice teachers' perceptions of planning and teaching science lessons. These perceptions mediate how the preservice teachers use the frameworks. While these tools show promise, in order to be helpful, they must carry meanings that are similar for both the teacher educators and the preservice teachers who use them.



#### Mark Guy, Tim Young

A Longitudinal Study of Elementary Students' Understandings of Lunar Concepts Related to Moon Phases

This paper reports on a longitudinal study of 14 elementary students' conceptions of the cause of lunar phases 11 months after classroom instruction. Videotaped interviews of the students revealed conceptual stability and growth among some, but a majority of the students experienced "conceptual decay" and reverted to previously held alternative conceptions. Despite exposure to a rigorous inquiry environment for learning, conceptual understanding was more unstable than anticipated.

### Minsu Ha, Heeyoung Cha

Suggestion of a New Strategy to Teach Evolution

We have designed a new instructional strategy and instructional materials to help students understand evolution as a scientifically acceptable theory from various alternative frameworks. Usually biology teachers teach evolutionary mechanism by means of comparing Lamarckism with national selection. In this study, we suggest a new instructional strategy in which Lamarckian explanation is first excluded and then the theory of mutation is replaced in it because Lamarckism has been subsumed in learner's cognitive structure as a strong misunderstanding about evolution. Darwinism including natural selection is set in next class hour independently. The scientific evidences of human evolution published in recent journal concerning science are used as instructional because the use of scientific evidences of human evolution improves students' concerns about and believes in evolution positively. The newly designed instructional strategy and instructional materials had made students' conceptions of, concerns about, and believes in evolution improve. We expect that the new instructional strategy researched in this study can make science teachers who have concerns with constructivist teaching.

#### Mark Hackling, Vaughan Prain, Shelley Peers

Reforming Science Teaching and Learning in Australia Primary Schools: An Innovative, Low Cost and Successful Model

Primary Connections is an Australian initiative comprising a primary science professional learning program that supports teachers with curriculum resources and professional learning workshops designed to reform the teaching and learning of science. Curriculum units are based on an innovative teaching and learning model which links science with literacy, integrates assessment with teaching and learning, and follows an inquiry process. A cadre of professional learning facilitators have been trained to facilitate professional learning workshops at schools throughout Australia. Workshops have also been provided for science educators from all Australian faculties of education to support them implement the Primary Connections approach to teaching science in pre-service teacher education programs. The program was trialled in 56 schools across Australia in 2005 to evaluate its impact on teachers, students and schools. Research has demonstrated that the program improves teachers' confidence, self-efficacy and practice, students' learning, and the status of science within schools. The project is an initiative of the Australian Academy of Science and is funded by the Australian Government's Department of Education, Science and Training. Primary Connections represents a very successful and cost effective model for reforming science teaching and learning in primary schools.

## Demetra Hadjichambi, Konstantinos Korfiatis, Andreas Hadjichambis

Children's Ideas About Rare and Threatened Species: Implications for Teaching

This study explores upper elementary children's ideas about organisms in danger. It focused on the biological concepts which are related to children's definition, designation and alteration of population status of rare animals and rare and threatened plants. Data were obtained through the use of structured, individual, oral interviews with 60 students. The majority of criteria used by children to explain the term "rare" were marked by ideas lying to the fields of ecology and distribution while the term "threatened" was considered with criteria related to human impacts. The study revealed that children even though correctly defined "rare species" they do not realize that most of



them are in that situation due to anthropogenic pressures, while are unfamiliar with the term "threatened". In all explanations ecological reasoning and detection of threats were extremely poor. Cutting and killing are the main threats mentioned and are the main actions that according to children should be interrupted to ensure conservation. However, these are only fragmentary, species-based actions and are not actually the most prominent regarding rescuing species from the danger of extinction. Children showed greater difficulty to argue about plant in relation to animal issues. Implications for curriculum inform and teaching are given.

### Leigh Haefner, Timothy Slekar

Giving Priority to Evidence in Science .....and History? How Preservice Elementary Teachers Make Sense of Evidence in Science and Social Studies Methods Courses

Current initiatives in many subject areas emphasize inquiry and supporting students' learning both substantive and syntactic aspects of the disciplines. Having robust understandings of the subject matter you are expected to teach is important, but do preservice elementary teachers, who are prepared as generalists, understand how the rules of the disciplines are different? This study examined 17 preservice elementary teachers' emerging understandings of evidence in the context of science and social studies methods courses that explicitly attended to the nature of inquiry and the role of evidence in science and history. Primary data sources included written responses to course activities, journals, and essays. In each discipline, preservice elementary teachers recognized that claims must be supported by evidence that is derived through the analysis and interpretation of data. In addition, evidence may be interpreted differently and claims disputed by other scientists or historians. However, when asked to differentiate between nature of evidence in science and history, their understandings were revealed as fragile. Scientific claims were described as proof, with all notions of interpretation and dispute of evidence gone. Conversely, historical claims were unverifiable because the interpretation of evidence was merely opinion.

#### Stephen Hale, Eleanor Abrams, Karen Graham, Barrett Rock

Attracting Undeclared College Students into STEM Majors Through Their Immersion into a Scientific Community of Practice

In the U.S., federal efforts to promote increased participation of underrepresented groups in science, technology, engineering and mathematics (STEM) disciplines within higher education have been in effect for the last three decades with modest results. This case study focuses on Watershed Watch (WW), a program designed to give undeclared undergraduates minorities the opportunity to be immersed in a scientific community of practice to encourage them to declare a STEM major or minor. Students participate in a two week summer institute where they learn the process of science and a follow-on academic year seminar designed to support them in their own research projects under the guidance of a mentor. Pre- and post-surveys along with Discourse Analysis of WW documents and observations showed that the students favored the experiential hands-on, inquiry-based approach. Four themes arose from the Discourse Analysis as being important in the development of the students' scientific identities: Acting like a scientist, Community, Preparation of Faculty, and the Field-Based Environment. Potential pitfalls and success stories will be shared during the presentation

## Kristy Halverson, J Pires, Sandra Abell

Undergraduates' Abilities to Use Representations in Biology: Interpreting Phylogenetic Tree Thinking

College students struggle with abstract reasoning and problem solving skills, especially in biological sciences (where visual representations have not been well studied). In order to be efficient problem solvers in plant systematics, students must develop expertise in tree thinking. Ideally, having scientifically correct content knowledge should help students chunk visual information represented by phylogenetic trees, allowing them to make sense of new species and develop the skills necessary to build hypothetical, testable trees. In this study, we used pre/post tests and interviews of college biology students to learn how students interpreted and used phylogenetic trees. Using observations and document analysis as supporting data, we identified multiple misconceptions within students' content knowledge of plant systematics. By relying upon these misconceptions, students developed alternative



types of reasoning that prevented them from interpreting and using phylogenetic trees. The types of reasoning we identified were: inconsistent, ecological, morphological, tree influenced, branch influenced, perceived common ancestry, reliance upon expert knowledge, quasi-scientific, and phylogenetic. These findings have implications for identifying students' misconceptions and developing instructional methods to help college biology students become more effective problem solvers.

#### Karim Hamza, Per-Olof Wickman

How Do Misconceptions of Electrochemistry Identified in Interviews Enter Into Students' Reasoning in a More Authentic Setting?

Despite repeated demonstration of students' nonscientific ideas, the central import for learning ascribed to such misconceptions has been questioned in the literature. In this study, we investigate what role encounters with misconceptions of electrochemistry identified in interviews play for the development of students' reasoning in an authentic school setting. We audio-recorded talk between eight pairs of upper secondary students during a practical on electrochemistry. To study the role of misconceptions during the learning process, we used an approach that operationalizes learning on a discursive level as a description of what students do and say as part of an activity. We analyzed how encounters with known misconceptions entered into the students' reasoning, and how these encounters influenced the directions students' reasoning took. None of the encounters with known misconceptions constrained students' reasoning or made it go in unwanted directions. In some cases, encountering the misconceptions worked as a resource for students' reasoning. Furthermore, the misconceptions appeared as tentative alternatives or as questions rather than being actively maintained and defended. The results indicate that misconceptions recorded in interviews may have different roles in other settings. This may have consequences for how we interpret difficulties in learning science in authentic learning situations.

#### Brian Hand, Arean Choi, Thomas Greenbowe, Jacob Schroeder William Bennett, Stephen Norris

Examining the Impact of Student Use of Multiple-Mode Representations on Argument Construction

Past studies have established the value of student writing for learning in science, but there has been less focus on its value when students engage with multiple-mode representation in the context of developing scientific reasoning. This study aimed to identify the role of multiple-mode representation in the development of quality argument in the context of tertiary Chemistry laboratory classes. Quantitative analyses of student work indicated that more the students were able to embed multimodal representations throughout their argument the higher score they obtained. The paper concludes by considering teaching nd learning implications

#### Vicente Handa, Deborah Tippins, Norman Thomson

Crafting a Community-centered and Culturally Relevant Pedagogy in Preservice Science Teacher Education: A Collaborative Action Ethnography

This paper describes our attempt in crafting a community-centered and culturally relevant pedagogy in the preparation of prospective science teachers. Using the collaborative action ethnography as a research methodology, we examined our research participants' notions of community, their beliefs about and learning through community immersion, and the process of drawing community funds of knowledge and transforming them into relevant practices in preservice science teacher preparation. Two faculty members and ten prospective chemistry teachers formed the research team (primary participants). Together with 31 other preservice science teachers, they participated in the lifeworlds of rural coastal village people through community immersion. Using the dialectic of narrative analysis and analysis of narratives, we made sense of our research participants' experiences from huge data sets such as transcripts of interviews and focus group discussions, journal entries, observation notes, portfolios, memory banks, lesson plans, pictures, and other archival information. Findings of our study revealed the multiple conceptualizations and utilization of "community" in teacher preparation; the multi-dimensional, contextual aspects of learning through community immersion; and the use of memory banking in the development of culturally relevant science lessons.



#### Nikki Hanegan, C Nelson

Improving Science Through Authentic Inquiry

To perform the diverse and complex roles of the teacher-facilitator, teachers need science learning experiences of their own in which authentic scientific inquiry is the norm and not the exception. This study examined inquiry used in professional development and how different types of inquiry create higher level cognitive activities and questioning skills with both teachers and students. We used the following criteria to investigate the two programs: 1) questioning skills of teachers and students, 2) teacher-to-student interaction, 3) teachers' pedagogical practices, and 4) teachers' understanding of inquiry. Two professional development (PD) programs, one focused on authentic inquiry (inquiry with real-time science investigations) and the other used computers and other curriculum materials to simulate scientific investigations. We found two statistically significant differences in: 1) Cognitive Activities and 2) Questioning Levels of Both Students and Teachers. Additionally, our study indicates that classroom-driven instruction is promoted by authentic inquiry and curriculum-driven instruction is promoted by simulated inquiry. In classroom-driven teaching (promoted by authentic inquiry), student's questions and attitudes are the basis for classroom activities. Teachers must become facilitators in the classroom so students can uncover their own learning.

#### Meytal Hans, Yael Kali, Yoav Yair

Promoting Middle-School Spatial Perception of the Moon Phases with a Web-Based Module

Understanding of basic astronomical phenomena requires spatial perception. Research indicates, that students hold alternative conceptions about these phenomena. Several physical and computerized aids have been developed in the past decades. Although research indicates specific affordances of such tools, some questions require more research. This research explores the spatial abilities that middle-school students develop with regards to the moon-phases, via interaction with a web-based module designed based on socio- constructivist design principles found in the Design-Principles-Database (http://www.design- principles.org). Outcomes from enactment with 35 students indicated that students significantly improved their spatial perception of the moon-phases phenomenon. The simultaneous use of both physical and computerized models, together with scaffolds, peer learning, and the teacher as a guide, were critical factors in supporting student learning. Implications include: a) contribution to the body of knowledge regarding spatial abilities, b) contribution of design knowledge to the public Design-Principles-Database, and c) development of the module which can serve students and teachers around the world via WISE.

## Deborah Hanuscin, Michele Lee, Valarie Akerson

Pedagogical Content Knowledge for Teaching the Nature of Science: A Study of Teachers Effective in Impacting Students' Views

Within research related to the teaching and learning of NOS, there is a need to focus on experienced classroom teachers who have demonstrated effectiveness in teaching NOS. Such "expert" perspectives can inform our understanding of how to support novice teachers in learning to teach NOS, as well as provide insight into the nature, source, and development of teachers' pedagogical content knowledge (PCK) for NOS. In this study, we use PCK as a lens to examine the practices of three experienced elementary teachers who have successfully utilized explicit-and-reflective instruction to improve their students' views of NOS. Using qualitative data sources, we characterize the way in which these teachers transform their understanding of NOS into forms accessible to elementary learners. Additionally, we examine the various components of their PCK for NOS, including their orientations toward science teaching and their knowledge of learners, curriculum, instructional strategies, and assessment. Results indicate a need for professional development that provides opportunities for teachers to implement, adapt, and develop new activities to teach NOS. Additionally, there is a need for teachers to develop competence in assessing their students' ideas about NOS and use those assessments to further guide their instruction.



#### Danielle Harlow, Valerie Otero

Learning Physics by Listening to Children

We investigated how prospective teachers use physics content knowledge when analyzing the talk of elementary children during special activities in a physics content course for teachers. We found that prospective teachers used content knowledge in three different ways: (1) restating children's ideas, (2) reflecting on their own learning, and (3) discussing the content involved in the elementary student videos directly. We present examples of events included in the restating children's ideas category which illustrate that the prospective teachers were able to use physics content knowledge to make reasonable inferences about the scientific meaning of children's ideas through videos can provide a meaningful context for applying conceptual physics knowledge in physics courses. Activities that are embedded within a physics curriculum, such as those studied here may help prospective teachers learn to use physics knowledge in exactly the type of activity in which their content knowledge will be most useful: listening to and interpreting children's science ideas.

#### Danielle Harlow

From Learning Science to Teaching Science: What Transfers?

Elementary teachers who teach science with methods consistent with inquiry are required to use their science knowledge in new ways - such as when responding to student comments that cannot be scripted or fully planned for. Compared to traditional courses, PER-influenced inquiry-based physics curricula appear to improve learning gains on tests of conceptual understanding. Less is understood about what teachers actually transfer from such courses into their teaching practices. I present the results of an investigation of how a professional development course based on the Physics and Everyday Thinking (PET) curriculum affected the teaching practices of five case study teachers. The findings of this study show that the each teacher transferred different content and pedagogical aspects of the course into their science teaching. The range of transfer is explained by considering how the individual interacted with the learning context and their initial ideas about teaching science.

#### Daniel Harris, William Holliday

Does Computer-Based Animation Sequence Impact Student Understanding of the Model of Global Atmospheric Circulation?

Computer animations in introductory science texts intend to support both textual descriptions and diagrammatic representations of complex, inter-related processes. However, research examining the benefit of these animations to learners has generated mixed results. Moreover, the question of when the animation sequence is employed relative to additional information sources has not been examined. This study sought to determine whether the animation presentation sequence impacted student learning related to an introductory earth science topic, global atmospheric circulation. Twelve undergraduate college students were randomly assigned to three treatment groups (animation first, animation last, and user determined animation) and one control group (no animation) to assess the impact of animation viewership on their understanding of the topic. Results indicated that animation presentation produced qualitative differences between the control and treatment groups. Treatment students' mental models often possessed greater process complexity as compared to their control group peers. This study's results indicate that animation viewership improves the level of detail observed in students' understanding of the general model of global circulation.

#### Diane Harris, Julian Williams

Sociocultural Influences on Primary Science Pedagogy: A Multilevel Analysis of the Effect of Questions/Questioning

UK science educationalists assert that teachers should ask 'open' questions to elicit pupils' ideas relevant to the science being taught. In contrast, some educational psychologists believe that young children can be confused by open questions and argue that children's cognitive potential can thereby be seriously under-estimated. Alter-



natively, a sociocultural perspective suggests the importance of background social factors in evaluating discursive interactions. This paper analyses teachers' questioning practices in twenty primary schools which serve very diverse communities in England: patterns of questioning in regard to age and subject are explained by an 'acculturation' model. However, discourse microanalyses of some anomalous cases reveal that 'context' (exophoric and anaphoric) of utterance is more relevant than its 'internal grammar' (i.e. 'open' versus 'closed') in explaining its function, and so the pedagogic 'code' (Bernstein). To test this hypothesis, multilevel modelling will be used to analyse the survey data set of questions and responses (N=5000 Q-R pairs in 102 classroom-activities) in science versus literacy activities with children aged from three to nine years. The resulting models will reveal the effect of the 'subject', age-level and the socio-economic status of the school on the patterns of Q-R interaction: and hence of 'class' on Bernstein's 'pedagogic code'.

#### Julie Haun-Frank, Sue Kimmel, Heidi Carlone, Margaret Vaughn

Doing the Work of Reform: Teachers' Narratives of Hard-Won Accomplishments

For over a decade, science educators have been reminded about the difficulty of reform. Missing from the literature on science education's problem of reform are the narratives of teachers who have successfully embraced standardsbased science practices. In this qualitative study, we sought to understand how in-service, elementary teachers manage to do the work of reform within and against the prevailing meanings of school. Informed by practice theory we were able to maintain a dual focus on the teachers and the context of their everyday practice. We collected ethnographic interview data from thirteen teachers working in various public school settings (urban, rural, and suburban) represented by diverse classroom populations. Through their narrative stories, we examined how their critical experiences enabled them to create new meanings of science and schooling. A puzzling aspect of our data was the "outsider" identity taken up by our participants. Across all cases, we found manifestations of these teachers' agency. These manifestations were an attempt to bridge their school-based colleagues' meanings of science and schooling with their own. While these stories offer hope to ongoing reform efforts, they provide a telling account of the larger social, historical, and political structures that those committed to reform must contest.

#### Amanda Heffner-Wong, Tina Grotzer, Lucy Morris

The Nature of Scientific Thinking: Assessing How Students Respond to Lessons Designed to Develop Understanding of the Nature of Science and Modeling

The national science standards call for students of all ages to develop an understanding of the nature of science (NOS). Yet ideas that students hold about the nature of science are typically at odds with the ideas held by scientists, philosophers, and sociologists. It may be helpful to frame the learning of NOS in terms of conceptual change in which students' misconceptions about NOS must be shifted towards alternative ideas. In this study, a set of lessons were prepared to teach aspects of NOS. A qualitative study looked at two classes of the same teacher and documented students' ideas about NOS before, during, and after their learning using the lessons. General findings include improvements in students' understanding of aspects of NOS, as well as additional gains that include making connections to science in current events.

#### Ronald Hermann

Student Predispositions Toward Understanding Evolutionary Concepts

Individuals may be predisposed to understanding evolution based on their early childhood experiences. The present study explores the interaction between the strength of scientific and religious worldview perspectives and understanding of evolution. In addition, it was hypothesized that greater exposure to factors influencing a strong scientific worldview perspective should result in a greater understanding of evolution. Sixty-seven high school students completed a 103-item survey. Extreme group analysis was conducted such that participants were grouped by exposure to scientific factors and also to religious factors. This exploratory research indicated participants with greater exposure to scientific factors had a better understanding of natural selection than those with less exposure



(t=2.37, p=.02) and those with stronger religious worldview perspectives had a poorer understanding of natural selection (t=1.99, p=.05). The strongest correlation was between scientific and religious worldview perspectives (t=-7.24, p=0.00), indicating that participants held a conflict view of science and religion. The findings presented here, along with recent research, suggest that science educators must address the nature of science, and evolution-ary concepts, prior to secondary school. Clarifying the relationship between science and religion, and providing alternatives to a conflict model, may result in a better understanding of evolution for all students.

#### Cari Herrmann Abell, George DeBoer

An Analysis of Field Test Results for Assessment Items Aligned to the Topic of Atoms, Molecules, and States of Matter

We report the results of a field test of assessment items aligned to the middle school chemistry topic of atoms, molecules, and states of matter administered to 3750 6th, 7th, and 8th grade students of diverse backgrounds in the spring of 2007. Our focus here is on the misconceptions that students reveal and their grade-to-grade growth in understanding of these science ideas. This work is part of a larger multi-year project funded by the National Science Foundation to develop an online collection of items that are precisely aligned with national content standards in middle school science. Each item is developed using a procedure designed to evaluate an item's match to important science ideas and its overall effectiveness as an accurate measure of what students do and do not know about those ideas. During item development, pilot testing is used to obtain feedback from students about the items. Then scientists and science education experts review the items using a set of criteria to ensure content alignment and construct validity. After revisions are made based on the reviews, the items are field tested on a large national sample to determine the psychometric properties of the items and clusters of items.

#### Peter Hewson, Maureen Robinson

Teaching Argumentation to Pre-Service Science and Technology Teachers: The Critical Thinking Group

Argumentation – using evidence in reasoning – plays a key role in scientific thinking, students' reasoning about science, and scientific literacy. As such, it is a significant form of critical thinking. While even young students, given the opportunity, have shown their ability to reason, few teachers have the skills or dispositions to teach argumentation. This paper reports on the design and implementation of a module designed to teach pre-service high school science and technology teachers how to teach argumentation as one form of critical thinking in an undergraduate teacher education program in Cape Town, South Africa. It locates this module within the huge policy changes that followed the election of South Africa's first democratically-elected government in 1994. A new curriculum requires learner-centred teaching and critical thinking outcomes. This places demands on prospective teachers to practice in ways they have not experienced as learners. Thus the paper also considers the significant role of the Critical Thinking Group – a team of science and technology teacher educators who taught the argumentation module – in creating a research-oriented, professional development environment that fosters their own community, the production of relevant teaching materials, and the development of innovative teaching modules.

#### Per Högström, Christina Ottander, Sylvia Benckert

Implementation of Objectives for Laboratory Work in Secondary School Science

The purpose of this case study of three laboratory exercises in biology, chemistry and physics is to show how secondary school science teachers' objectives for labwork are carried out in practice. What objectives do teachers put forward for specific laboratory exercises, what objectives appear in supporting laboratory manuals and how do objectives appear in teacher and student interactions during laboratory work? In three cases, pre-interviews with teachers about their objectives took place, laboratory instruction manuals were collected, video recordings of the actual laboratory exercises were made and post-interviews with teachers about these video-recordings took place. The teachers' expressed objectives and objectives identified in manuals were compared with objectives identified in teacher actions and teacher-student interactions. The results show that the introduction of the laboratory exercise and its laboratory manual is very important. In order for teachers' objectives to be implemented, results in this



study put forward that a correlation between objectives, laboratory manual and actual labwork is favourable. This study also puts forward that objectives need to be explicit to the teacher and that teachers' awareness of the need to pursue objectives is crucial.

### Gary Holliday, Norman Lederman, Judith Lederman

### Using Personal Meaning Mapping to Assess Learning at a Natural History Museum

It is the intent of this investigation to further the knowledge about learning in an informal setting and how an individual's ideas and concepts may change as a result of a visit to a museum exhibit. It is also the author's intent to validate an assessment method that can provide quantifiable data about these unique learning experiences, Personal Meaning Mapping (PMM). The sample consists of 54 9th-grade biology students, in five classes, at a Chicago Public School (CPS). As part of the biology curriculum, the classes had a focused field trip to a natural history museum to study energy flow within an ecosystem. Students were asked to fill out the PMM before and after the field trip experience; this along with interviews and observations provided the data. The results indicated that students showed an increased use of appropriate words and sentences. However, understanding of overall concepts about how energy flows through an ecosystem seemed weak and few students were seen to have a mastery level above level two (apprentice) out of four. Ultimately, Personal Meaning Mapping did seem to capture this minimal improvement and these results are reinforced by the interviews and observations of the students.

#### Michele Hollingsworth Koomen

Science for All and Inclusion: Learning From Dion

This paper reports on a case study of one special education student as he studied insect biology and ecology in an inclusive seventh grade life science class. Three fundamental data collection methods of qualitative research (student observations, interviews and artifact analysis) framed the data collection of this study. The primary method of investigating and analyzing the experiences of the student participant was grounded theory. Findings from the data analysis include: classroom constructs that position Dion to learn and challenges of learning in an inclusive science classroom. Implications and insights for science educators and researchers as to the meaning of science for all are discussed in the final sections of the paper.

## Sheryl Honig

#### Primary Grade Writers of Scientific Discourse: Two Case Studies From Integrated Science/Literacy Instruction

Primary Grade Writers of Scientific Discourse: Two Case Studies from Integrated Science/Literacy Instruction Abstract This paper is part of a larger two-year study whose purpose was to examine the development of informational writing of students as they moved through 2nd and 3rd grade in classrooms that featured integrated science- literacy instruction (which included the use of (1) hands-on exploration and small-group and whole-class discussions around them; (2) reading of informational science trade books; and (3) various teacher-led science writing). The primary purpose of the present paper is to report on the ways in which two children were scaffolded in their writing by a particular instructional context. Using Hasan's (1985, 1994) Systemic Functional Linguistics (SFL) approach, I describe the ways in which Jason and Rose represented scientific ideas within the genres of their classroom. While both Jason and Rose appropriated a generalized, sometimes theoretical academic scientific discourse by the end of two years, each showed unique paths of development. From the beginning, Jason attended to the analytical, generalized discourse of science. Rose relied on a personal, social orientation to science writing as her way in to scientific discourse. Both were scaffolded by aspects of classroom instruction.

## Larry Horvath, Cynthia Passmore

Prospective Science Teachers' Construction of Inquiry in the Context of Planning and Teaching Inquiry Based Lessons

This study focused on three prospective science teachers' own perspectives on inquiry and how those perspec-
tives changed in the context of being required to engage their students in inquiry-based science in fulfillment of the Performance Assessment for California Teachers (PACT) a high stakes assessment of teaching competency. Data sources included semi- structured interviews and access to PACT artifacts - written reflective commentaries and self-selected video clips of inquiry teaching. The questions guiding the research were 1) What effect does the implementation of inquiry have on prospective science teachers' perspectives on inquiry? 2) What are the factors that prospective science teachers identify as influencing their perspectives on inquiry? Two distinct perspectives on inquiry emerged out of the data, a procedure-dependent perspective and a procedure-independent perspective. Analyses framed through these perspectives indicate that all three prospective teachers likely constructed a more robust view of inquiry. Yet each prospective teacher also described experiencing and engaging with inquiry in relation to her own unique set of contexts. Evidence suggest that requiring prospective science teachers to plan, implement and reflect on inquiry-based teaching could create a rich space for science teacher educators to engage with prospective teachers around their developing understandings of inquiry.

#### Meredith Houle, Michael Barnett, Peter Piazza, Eric Strauss

Preparing Teachers to Support Students in Conducting a Field-Based, Technology-Rich Scientific Investigation

It is well known that urban minority students fall behind their suburban peers in both their knowledge and use of science and technology. While additional technological resources are necessary, teachers also need access to high quality curriculum materials and professional development. To this end we have designed three curriculum modules and a month-long summer professional development experience, which focus on conducting scientific investigations into issues of urban ecology. This summer institute is attended by both teachers and students, providing teachers with an opportunity to "practice" enactment with a small group of students. Results of our analysis of a validated survey instrument showed that students' significantly increased both their interest in science (t=4.90, P

#### Elaine Howes

#### Students' Learning about Plants in Elementary Science Methods: Journal Writing and the Uncertainties of Assessment

This paper is an effort toward addressing Roth's (2007) challenge to develop teacher research studies of reform-oriented instructional approaches. I use a teacher-research methodology to examine my preservice elementary students' learning from a long-term plant study. The data are from students' journal writing, at the beginning and the end of the plant study, in response to the question: How do seeds grow into plants that then produce more seeds? The qualitative analysis focuses on students' understandings of the concepts of plant growth and reproduction. I utilized statements of these concepts as codes throughout the analysis to unearth students' incoming and final conceptions as illustrated through their journal writing. The findings section indicates benefits and drawbacks of journal writing as an assessment, and also summarizes what I learned about students' learning through their journal writing. In sum, there were strong indications that several students developed a deeper understanding of plant reproduction, and indications that others either did not develop these understandings or did not write about them in their journals. However, the ambiguities, subtleties, and surprises revealed through open-ended journal writing make it an intriguing form of assessment of the effectiveness of reform-oriented instruction in teacher education courses.

#### Christine Howitt, Grady Venville

Dual Vision: A method for Capturing the Learning Journey of Pre-Service Primary Teachers of Science

This research extends an existing qualitative research method, based upon critical incidents, to capture the details of how pre-service primary teachers learn about science and how to teach science. This paper outlines the trial and evaluation of the method, called 'dual vision'. Dual vision is constructed through the combined lenses of the pre-service teacher and the researcher, allowing both voices to be heard, and providing the researcher with an opportunity to move into the reality of the pre-service teacher. The trial consisted of the description and interpretation of the science learning journey of one pre-service primary teacher over a 10-week science methods course. Advantages



and limitations associated with using this new method are also discussed.

## Tung-Hsing Hsiung, Wen-Hua Chang, Chao-Ti Hsiung, Ricy Chang

Subject Mentors' Professional Development in a School-Based Mentor Training Program

Internship is a critical phase in teacher education programs. Whether interns can build contextualized understanding of subject teaching, the mentors play an important facilitating role. From the literatures and field experiences, stakeholders raised issues of enhancing quality of subject mentoring programs, particularly in terms of what perspectives should be mentored and to what extend a mentor training program can achieve in preparing better subject mentor teachers. This case study was aimed to evaluate the mentors' professional development when they participated in a school-based mentor training program. Three elementary science mentors teamed with two university professors and three interns, and went through three Plan-Teaching-Reflection cycles to facilitate professional development of mentors and interns. 10 teaching stories were written based on real teaching events. The mentors were interviewed about how they would counsel the interns in the stories to probe their growth in terms of competences of subject mentoring. The interview transcripts, classroom teaching observation logs, meeting observation logs, and transcription of mentor meetings videotapes were analyzed by the constant comparative method to generate findings. The results indicated that the mentors appreciated the mentor training program and both their subject teaching as well as subject mentoring performances were enhanced.

## Ying-Shao Hsu, Fang-Ying Yang, Meng-Jung Tsai

Scaffolded Inquiry Curriculum for Science Learning

Working with school teachers, the researchers developed scaffolded inquiry lessons in order to improve students' inquiry learning, promote students' understanding about inquiry, and influence teachers' perspectives about the nature of inquiry. This project attempts to examine how students' inquiry competences, epistemology, and online searching strategies develop, and correlate to each other in scaffolded inquiry learning environments. Two pilot studies have been conducted after a training workshop for 3 participating teachers. One pilot study is using visualization as scaffoldings (the VS group) including Lesson Earthquake and Lesson Stars, and another is searching external resources as scaffoldings (the ERS group) including Lesson Weather Observation and Lesson Tide. Multiple methods (activity sheets, reports, tests, questionnaires, interviews, video tapes and computer logs) were used to examine students' inquiry processes, reasoning, and online searching strategies in a scaffolded inquiry learning environment. The findings will be used to revise these scientific inquiry lessons, and inform professional development program.

#### Hui-Ju Huang

Learning and Teaching Science as Inquiry

Two faculties who taught physics and science methods courses collaborated together to redesign and integrate both courses for prospective elementary teachers. The current study reports the implementation of the collaboration, analysis of prospective teachers' reflection reports, and elementary students' learning outcome. About half of the elementary students answered correctly on the concept of controlling variables. Although many students did not answer correctly, they enjoyed and appreciated this learning experience. The reflections content contained a range of topics, and most focused on management issues. The implication of the study calls for in-depth study of teachers' thoughts and actions about their teaching practice. It also suggests the development of a support system to help teachers deliberately examine their practices and effectiveness.

## Chun-Chieh Huang, Chun-Yen Chang, Tsai-Yen Li, Hao-Chuan Wang

A Collaborative Support Tool for Problem-Solving Ability: Idea Storming Cube

Problem-solving ability plays an important role in many science learning activities. In this paper, we propose a



game-based collaborative learning support system called Idea Storming Cube to support problem-solving ability and help a user form a perspective-shift thinking habit. The system analyzes the knowledge acquired from the history of user inputs and compares it with the ideas possessed by the domain expert and other users in the current brainstorming group. The system is designed to provide user-, goal- and context-sensitive supports with this mechanism that stimulates more divergent thinking. We have implemented the tool with a magic-cube-like game for collaborative idea generation. A preliminary evaluation of the system is also re-ported in this paper.

#### Shwu-yong Huang

Investigating the University Learning Environment, Student Engagement and Satisfaction among Science Majors

This study investigates college of science students' perceptions of their university learning environments and the association of these perceptions with students' academic engagement and satisfaction. Using data collected for 920 juniors majoring in science and mathematics, the research attests to the validity and reliability of the instrument: College and University Environment Inventory for Student (CUIE-S). The results reveal science students' diverse views of various environmental aspects and identify key aspects associated with the outcome measures, after controlling for student background and institutional characteristics. Faculty-student relation was the aspect most strongly related to both science students' academic engagement and learning satisfaction. These students' perceived adequacy of library resources, student services, relations with faculty, and development of language abilities and emotional growth were positively related to their overall satisfaction with universities. By identifying important relationships among variables, the study informs higher education policy makers the impact of university learning environment conducive to learning.

#### Wanchu Huang, Huei-Huei Lin

A Study of Sixth Graders: Creativity and Problem-solving Ability Through Othello Games

This research aimed to (1) investigate the relationships among the Othello Contest Scores (OCS) and the middlegraders' Reasoning Ability (RA), Creativity Ability (CA), and Problem- Solving Ability (PSA); (2) investigate the different thinking strategy between Higher-Scored Group (HSG) and Lower-Scored Group (LSG). The research was designed in both quantitative and qualitative methods. In the quantitative aspect, researcher proceeded the Pearson's product-moment correlation by OCS, Raven's Standard Progressive Matrices (SPM), Williams Creative Thinking Abilities Measurement (CTAM), and Problem-Solving Measurement (PSM). In the qualitative aspect, researchers used <sub>i</sub>Sthe test for chess players' PSA<sub>i</sub><sup>¬</sup> and <sub>i</sub>Sthe puzzles of Othello<sub>i</sub><sup>¬</sup> as tools to analyze the differences in the path of problem-solving between the HSG and LSG. Thirty-two subjects were chosen from the elementary school at Shulin city, and each student took 31 contests. The findings summarized as follows: (1) There was significant correlation between OCS and SPM (r =.532, p)

#### Peter Hubber, Maria Haslam, Russell Tytler

Teaching and Learning From a Representational Perspective: Insights From a Classroom Video Study

An enormous amount of research in the conceptual change tradition has shown the difficulty of learning fundamental science concepts, yet conceptual change schemes have failed to convincingly demonstrate improvements in supporting significant student learning. Recent work in cognitive science has challenged this purely conceptual view of learning, emphasising the role of languages, and the importance of personal and contextual aspects of understanding science. The research described in this paper is designed around the notion that learning involves the recognition and development of students' representational resources. In particular, we argue that difficulties with the concept of force are fundamentally representational in nature. The paper describes the planning and implementation of a classroom sequence in force that focuses on representations and their negotiation, and reports on the effectiveness of this perspective in guiding teaching and learning. Classroom sequences involving three teachers



were videotaped using a combined focus on the teacher and groups of students. Video analysis software was used to code the variety of representations used, and sequences of representational negotiation. Stimulated recall interviews were conducted with teachers and students. The paper will report on the effect of this approach on teacher knowledge and pedagogy, and on student learning of force.

#### Barbara Hug, Lisa Kenyon, Elizabeth Davis, Michele Nelson

Promoting Preservice Teachers' Understanding and Use of Scientific Modeling in Teaching and Learning

In this paper, we describe a series of instructional activities aligned for use in science teacher education for preservice teachers at the elementary and middle school levels aimed at increasing teacher understanding and use of scientific models in their own teaching and learning. We believe that by including such instructional activities aligned with key modeling learning performances in a methods classroom, we can help teachers be positioned to both engage their students in scientific modeling and to learn about associated modeling practices and metamodeling knowledge. We present findings that suggest that preservice teachers' knowledge about modeling practices and metamodeling are impacted by these instructional activities. We discuss how teacher educators and curriculum developers can overcome challenges to design supports for promoting teacher learning related to scientific modeling.

#### Robert Humphrey, Lynn Vaccaro, Barbara Crawford

Towards Independent and Critical Thinking: Learning about Evolutionary Concepts through Inquiry in a Rural High School

Many children, as well as teachers, lack a basic understanding of inquiry, the nature of science, and concepts of evolution. Science teachers need support in developing strategies and gaining access to interesting and authentic resources and interactive materials related to evolution, inquiry, and the nature of science. The purpose of this study is to determine the extent to which high school students developed understandings of evolutionary concepts and the nature of science, when engaged in an authentic, inquiry-based unit. A preservice teacher in rural New York State planned an authentic learning environment focused on the use of evidence in developing scientific explanations. The study was collaboratively designed and carried out by a team composed of a doctoral student who also served as a university supervisor (first author), a preservice high school biology teacher (second author), and a university professor (third author), The research design involved a mixed methods approach, using both a qualitative approach (Creswell, 1998) involving developing a case (Merriam, 1988) combined with quantitative data of student assessments. Research questions included: 1) to what extent did this preservice teacher engage her students in use of data and developing explanations? 2) What science understandings did the students develop?

#### Kelly Hutchinson, George Bodner, Lynn Bryan

A Qualitative Analysis of Factors Influencing Students' Interests in Nanoscale Science

Research has shown that increasing students' interests in science has a positive effect on their science achievement (Schwartz-Bloom & Haplin, 2003; Neathery, 1997). However, there is little research as to what topics increase students' interests in science (Schwartz- Bloom & Haplin, 2003). Nanoscale science is one topic currently being investigated as a way to increase students' interest in science, due to its integrated nature and increasing popularity in society. This paper reports on a qualitative study of 23 in-depth student interviews of rural and suburban students. A phenomenographical analysis of interviews identified eight characteristics of topics that students reported as influencing their interest in nanoscience: general curiosity, personal interests, relation to everyday life, novel, prior knowledge, prior experience, hands-on/ experimentation, and visual. Of the eight characteristics identified, general curiosity, personal interests, relation to everyday life, and hands-on/ experimentation were found to increase interests. The remaining four components ñ novel, prior knowledge, prior experience, and visual ñ showed both positive and negative influences on students' interests. These results contribute to the efforts of teachers working on K-12 curriculum development, creating experiences for students that increase student interest, and in turn could increase learning and understanding of nanoscale science, as well as science in general.



#### Jenny Ingber, Nick Stroud, Megan Roberts, Katherine Brown, Emily Noto

Designing Curricula to Bridge Informal and Formal Learning Environments

A new informal science education learning center was established by a large urban school district. Much of the inaugural year of this center was spent developing a curriculum in collaboration with a local natural history museum. The curriculum that was developed is intended to bridge a formal Earth Science course with the informal resources available at both the informal learning center and the natural history museum. The creation of a curriculum that bridges the formal and informal environment can serve as a tool for integrating these resources seamlessly into a course and providing a mechanism for teachers and guides to communicate about student learning experiences. With this curriculum, teachers and informal educators will be able to maintain a shared tool and guideline to assist in students' attainment of learning goals for a particular course. This paper is intended to describe how some of the curricula at the center have been developed and includes highlights of some of the guidelines we have generated as a result of our work creating a curriculum to bridge formal and informal learning environments are provided. The guidelines can be used as a framework for a standards-based science curriculum that integrates purposeful trips to informal sites.

#### Karen Irving, Vehbi Sanalan, Melissa Shirley

The Connected Classroom: Physical Science Case Studies

Archer's social theory provides a framework to interpret changes in classroom practice for physical science teachers who have completed their first year of a multi-year study of connected physical science classrooms. Connected classroom technology refers to a networked system of handheld devices combined with software specifically designed for use in the classroom. From the perspective of Archer's social theory, initially teachers adapted the new technology to their prior use patterns. The flexibility of the connected classroom system allowed teachers to implement the system slowly, building confidence and testing the limits and capabilities of the technology. Teachers faced additional challenges as the connected classroom required changes to existing classroom structures and procedures. As their proficiency developed, teachers used the connected classroom to facilitate both interactive and preplanned classroom formative assessment. Teachers gathered information about student learning, aggregated the information gathered, and attempted to interpret that information to inform their daily practice. Technology-assisted assessment provided teachers with informed knowledge of student conceptual understanding of science concepts. Detailed case-study descriptions of secondary and middle school classrooms in a variety of school contexts provide explicit examples of how teachers implement connected classroom technology to facilitate formative assessment in physical science instruction.

#### May Jadallah Jadallah, Brian Miller, Richard Anderson, Kim Nguyen-Jahiel

Promoting Children's Reasoned Argumentation on a Complex Socioscientific Issue

This study investigates the effectiveness of a pedagogical approach aimed at promoting children's development of argumentation skills and knowledge acquisition of a socioscientific issue (SSI). A 10-lesson unit on wolf reintroduction and management was developed to teach children concepts of ecological balance and economic considerations. 82 fourth-grade children participated in a 3-week study during which they had 2 small-group discussions and wrote end-of-the-unit essays to express their final opinions about the SSI. Different groups of children learned information about the impact of wolves on ecology, economy, or animal husbandry; then, they shared this information with other children by giving whole-classroom presentations and participating in a mixed-group discussion. Transcribed discussions were analyzed for theme development. Results indicate that children talked significantly more about ecology and economics in the final discussion as compared to the first, and talked significantly less about a simplistic solution. Preliminary analysis also suggests that children applied a "systems thinking" approach to make a decision about wolf reintroduction and management policy. Children's opinion letters point out that group-specific information was disseminated among other children. This finding suggests that giving presentations and participating in mixed-group discussions are effective classroom activities to share and acquire knowledge among children.



#### Mark James, Federica Barbieri, Paula Garcia

What are they talking about? Lessons Learned From a Study of Peer Instruction Discourse

Electronic classroom response systems (CRS) have been in use in large college lectures for over three decades. Such systems are designed to provide instructors and students with immediate statistical analyses of student electronic responses to multiple-choice lecture questions. Early research on the efficacy of these devices found no significant correlation between the use of CRS and student learning when implemented in a traditional mode where students entered responses to lecture questions passively. However, more recent studies have found significant gains in learning when CRS is utilized as a tool to facilitate a more active role for students in the context of constructivist-oriented classrooms. In this manuscript, we report on a study that investigated recorded peer CRS conversations collected in three introductory Astronomy classes. Analyses indicate that there is a relationship between the quality of student discourse and grading incentives associated with CRS responses. Our analyses of conversation transcripts also point to several mechanisms that could be responsible for learning gains which have been reported in the literature as well as highlighting areas where the technique could be improved. We also present a simpler method for studying Peer Instruction discourse that could be valuable to other researchers.

#### Dorian Janney, William Holliday

Unpacking Sixth Grade Students' Mental Models of Popular Astronomy Concepts

We were interested in unpacking some of the mental models that sixth grade students (all 11 years old) specifically had about the relative and absolute distances and sizes of objects in the universe; including Earth, the sun, and other objects both in and beyond our solar system. Because children create their own intuitive understanding of the physical world based on their direct experiences, (Vosnidou, & Brewer, 1992; Sharp, & Kuerbis, 2005), difficulties arise when natural phenomena cannot be directly observed and thus must be conceptualized in an abstract fashion. Many researchers, including Sharp and Kuerbis (2005) and Vosniadou, Skopeliti, and Ikospentaki (2003) describe studies in which young children are able to effectively comprehend astronomical concepts. We created three separate tasks to construct, by triangulating observations, mental models of 10 students' conceptualizations. We administered these using on a one-on-one approach: a) an oral interview consisting of 12 semi-structured questions with follow-up questions focusing on distances, b) a scaling task requiring students to estimate relative sizes, and c) a multiple-choice test designed to assess students' knowledge of astronomy. The results showed significant amounts of qualitative variation. The findings also supported the linkage between the assessed factors and students' performances on the test.

#### Bruno Jayme, Giuliano Reis, Wolff-Michael Roth

Egomorphism, a Teacher's Discursive Pedagogical Artifact in/for Science Education

The objective of this study is to expand the concept of egomorphism to the field of science education. Initially used in anthropology, it offers a rather innovative way of looking at science instruction. In the classroom context, egomorphism is the language that instructors and students use to articulate their selves or ego to describe their human understandings of non-human entities (e.g., animals and plants). We conclude that egomorphism is a discursive resource that mediates learning by constructing a hybrid language that is appropriate to the context (people and events) in which science instruction takes place—thus running counter to a faulty understanding of non-scientific school language use (misconceptions).

#### Bruno Jayme

Don't Say Yuk, Say Hum. The Role of 1 Interjections in Students' Engagement During Science Fieldtrips

Drawing on ethnography and discourse analysis, in this study we present evidence for and discuss the role of interjections in the context of science field trips where students from an elementary public school in British Co-



lumbia (Canada) have the chance to learn about the local environment. Our analysis reveals that, contrary to the common approach to interjections found in the literature, interjections are complete communicative acts, which reify student's cognitive engagement and participation in the instructional activities. Moreover, these interjections provide teachers and analysts with concrete evidence of students' attentiveness to the tasks at hand, thus presenting educational potential, both for instruction design and interaction between students and teachers, and for assessment purposes as well.

### Hunkoog Jho, Miran Chun, Jinwoong Song

Science Teachers' Conflicts and Practices in Relationship Between Science and Religion: A Life-Historical Approach to Two Realms

The purpose of this study is to investigate how religious science teachers have formed beliefs about the relationship between science and religion and how those ideas lead them to practice in their classes. It has been accomplished by examining the lives of four Christian science teachers in terms of life history, based on various sources of information including interviews. As a result, it has been found that science teachers tend to avoid conflict by separating science from religion. And the science teachers who went through significant religious experiences during their adulthood are more active in practicing their beliefs than those who did during their childhood. The reason is that teachers have little opportunity to be trained or to share their opinions on how to deal with socio-scientific issues. This context could be applied to many science teachers in other countries although these findings are from the Korean context.

#### Hui Jin, Charles Anderson

Developing a Learning Progression for Energy in Environmental Systems

We developed a learning progression focusing on how elementary, middle, and high school students use the scientific concept of energy to account for events in environmental systems, based on data from written assessments administrated to 579 elementary, middle, and high school students and from clinical interviews with 17 high school students. Students at lower levels (Level 1 and Level 2) accounted for environmental events in terms of human intentions, function of materials, or needs of organisms. Students at intermediate levels (Level 3 and Level 4) tended to see energy as a ubiquitous resource that causes events. Level 4 students could not account for events that require tracing energy and matter separately or tracing energy with degradation.1Level 5 students successfully used principles of energy conservation and energy degradation. Our data show that less than 5% of high school students achieved Level 5. This indicates that current K-12 teaching, probably due to its incoherent way of presenting energy in different disciplines, fails to provide effective facilitation. We argue that with appropriate instruction, Level 5 is achievable for high school students and that it is necessary for understanding environmental issues, including global climate change.

#### Hui Jin, Gail Richmond

An Analytical and Interpretive Framework for Examining Social Interactions in Professional Learning Communities

This research focuses on how social interactions within a professional learning community affect teacher learning. Study participants are 7th grade science teachers who have been involved in a professional development (PD) project for four to five years. We developed a framework to interpret teachers' social interactions and learning at two levels. At the community level, knowledge, meaning, or norms are continually negotiated through social interactions among members of the community. At the individual level, learning occurs when the interpersonal social interactions are transformed into intrapersonal intelligence. We examined teachers' social interactions in the professional learning community meetings over a three-year period. The major findings that emerged from our analyses resulted in the development of a new interpretive framework that provides a powerful way to better understand social interactions within professional learning communities. Our findings also support the following recommendations. First, PD projects should develop a "supportive community", which provides pedagogical and emotional support. Second, we propose "teacher as experience-broker" as a valuable idea to promote meaningful



learning in professional learning communities. Our study indicates that ongoing negotiation of that norm is necessary to foster learning at both levels. Third, PD projects should take into account specific influences outside the community.

#### Carla Johnson, Jane Kahle, Jamison Fargo

Does Change From Professional Development Programs Last? A Longitudinal Study of Sustained and Increased Science Teacher Improvement

The longitudinal study described here investigated the sustainability of improved practice for teachers who participated in a whole-school, professional development program for three years. All teachers in the program experienced improvement in their teaching during the program (Author, et al., 2007b), and students of teachers in the program outperformed their counterparts at the control school (Author, et al., 2007b). The results of this longitudinal study of sustained teacher growth suggest that not only do statistically significant gains occur during a program, but also that they may be retained for years after the program ends. These findings have strong implications for stakeholders in science education who design and implement professional development programs targeting teacher effectiveness and student learning. Previously research has demonstrated that whole school professional development for science teachers positively impacts student learning (Author, et al., 2007b). In addition, this study has suggests that this type of professional development program promotes a community of learners. Teachers in this study continued their collaboration and continued to grow professionally as more effective teachers three years after the professional development experience ended.

#### Bruce Johnson, Constantinos Manoli

Using the Model of Ecological Values to Examine Stability of and Changes in Children's Environmental Perceptions Over Time

The purpose of this study was to examine changes in the environmental perceptions of 9-12 year old children over a two-year period. Wiseman & Bogner's Model of Ecological Values was used to see 1) how stable the children's perceptions were over the two years and 2) how the perceptions were affected by participation in the programs. The perceptions were stable, starting out as pro-environmental and changing little during the first year or between the first and second year. Students' perceptions were, however, affected by an educational program in the second year, after which there were statistically significant changes toward even more pro-environmental views.

#### Angela Johnson, Sybol Anderson, Terrell Lasane, Katherine Norlock, Katherine Socha, Linda Coughlin

Why our students stay: Strategies for retention and teaching of women of color in STEM disciplines

We are an interdisciplinary group of scholars at an undergraduate institution, working together to address two related concerns: the underachievement of academically well-prepared women of color in science, and the rate of their retention in STEM disciplines. We trace one source of gaps in achievement and retention to educators' misrecognition of the identities of women of color. We explore the philosophical and psychological dangers of this misrecognition and propose strategies at the undergraduate level that more effectively recognize the experiences, motivations, and achievements of our students; we suggest that solutions to issues of retention are also solutions to issues in teaching. The disciplines we represent include anthropology, philosophy, psychology, mathematics and biology, and our group includes scholar- administrators, junior and senior scholars of color, and junior and senior scholars who are white. This symposium will include results of a longitudinal study of women of color who majored in science and are now in scientific careers; philosophical and psychological insights into the individual and societal costs of these women's difficulties in science; feminist arguments for altering institutions to improve science teaching to retain able women of color; and our own institution's attempts to do this, at the departmental and institutional level.



#### Heather Johnson, Kirsten Mawyer, Daniel Edelson

Practice-Based Professional Development: Design Considerations for New and Experienced Users of Curriculum Materials

Because of the potentially significant role of curriculum materials in changing teacher practice, supports are needed to encourage teachers to learn to enact the curriculum with congruence to the learning or pedagogical goals of the curriculum materials. This paper examines how practice-based professional development needs differ for new and experienced users of a high school environmental science curriculum. It focuses on such domains as curricular content and structure, curricular modifications to address enactment contexts, and anticipation of future professional development. It observes that new users required expertise in the curriculum's science content and structure, the underlying pedagogy necessary for effective enactment, and they tended to modify using a small scope, looking at individual activities. More experienced users needed support in developing pedagogical content knowledge and modified with a broader scope that included the chapter or unit level and secondary learning goals. While both new and experienced users of curriculum materials need support in their curricular modifications, those needs differ along a trajectory of experience. Findings from this research serve as a foundation for the design of practicebased professional development that targets the types of intervention and guidance needed by different kinds of users.

#### Carla Johnson, Sherry Marx

Urban School Reform Enabled by Transformative Professional Development: Impact on Teacher Change and Student Learning of Science

This longitudinal study of middle school science teachers explored if a teacher participation in the TPD program resulted in change in instructional practice, as well as a significant increase in student learning. Four participating schools were matched and randomly assigned to intervention and control groups. Teacher and student outcomes were compared. Eight teachers from Bryce and Zion Middle Schools participated in the two-week summer institute, followed by monthly release day professional development sessions focused on implementing instruction outlined in the National Science Education Standards. Student achievement was assessed using the pre/post instruments. Students of teachers at treatment schools experienced significantly larger gains than students at the control schools. TPD intervention teachers experienced increase in teaching effectiveness. Findings in this study revealed the positive impact that whole-school, sustained, collaborative, professional development programs have on improving teacher practice and student achievement at the school level.

#### Deborah Johnson, Kathryn Smith, Erin Dolan

The Impact of Undergraduate Research Experiences on the Graduate Student /Postdoctoral Fellow Mentor

At research universities, science undergraduate research experiences (UREs) take place in communities of scientists with different levels of expertise. In addition to faculty, scientists- in-training such as graduate students and postdoctoral researchers serve as mentors to undergraduate learners. How does the experience of mentoring undergraduates impact the scientific apprenticeship of graduate students and postdoctoral fellows? To begin to answer this question, a qualitative study was conducted with eight past and present graduate student / postdoctoral mentors from a plant molecular biology laboratory with a long history of involving undergraduates in research. Semi-structured interviews followed by a constant comparative method of data analysis were used to identify participants' perceptions of the impacts of mentoring an undergraduate student on their graduate / postdoctoral experience. Findings suggest that the gains these apprentice scientists made from mentoring undergraduates outnumber the challenges they faced. Perceived gains include a deeper understanding of their scientific work, a more enjoyable working life, and an improved ability to communicate science to non-specialists. This exploratory work serves as the groundwork for a larger study investigating the extent to which mentoring UREs contributes to the overall science education and training of future scientists.



#### Angela Johnson

The Motivation and Perseverance of Women Science Students of Color

How does being a woman of color affect the experiences of majoring in science? How do women science students of color build intrinsic motivation? What strategies do they use to persevere? This is an analysis of the experiences of three women of color (one African American, one Latina and one American Indian) who each encountered particularly discouraging experiences while majoring in science, and yet who have completed graduate degrees and now work in science-based fields. Each of these women were motivated to persist in science for its intrinsic interest to them and its potential to further their altruistic goals, and also saw science as a refuge from other difficult situations in their lives (situations often related to their status as women of color). However, they also felt that some of their professors did not see them as belonging in science due to their race and gender. Strategies for persevering consisted of finding places and people who accepted them as legitimate science students and, when this was not possible, simply tolerating the discomfort of feeling marginalized.

## Philip Johnson, Peter Tymms, Shaun Roberts

A Computer-Based Instrument to Assess Understanding of the Concept of a Substance: Evidence from Rasch Analysis for Unidimensionality.

This paper describes a computer-based instrument to assess students' concept of a substance. With reference to the literature, a case for such an instrument is argued on two fronts. One, that there is a need to assess an individual student's understanding across a range of basic phenomena involving matter and that the concept of a substance is an organising idea around which this can be usefully structured. Two, that there is a need to assess a large representative sample of students and that a computerised-based instrument (delivered over school networks) offers opportunities. The theoretical basis of the instrument and how research into students' thinking informed the construction of items is explained. Data from a total sample of 531 secondary students involving 9 schools (of very different types) are presented. Overall, the findings suggest understanding is limited. Patterns of option choices for individual items give specific insights into students' thinking of direct relevance to teachers. Important examples are given. The results of Rasch analysis which suggest the existence of a scale of difficulty relating to the concept of a substance are also presented. Significant implications for curriculum design are discussed.

## Adam Johnston, John Settlage, David Moss, Heidi Carlone

Perspectives of Scholar Activism, Pragmatism, and Orchestration in Science Education

This symposium ventures to propose three different layers towards action in science education, each represented as its own piece. First, a layer that proposes a model for how we work as individuals, scholar activism, is introduced and suggests that our standard separation of research, teaching, and service in the academy is stagnating. Second, the philosophical stance of pragmatism gives us a foundation that allows for the possibility of scholar activism at the individual level. Third, various examples of orchestration are introduced as ways by which the collective can work together to effect change in our field and beyond. Finally, these pieces are synthesized and put into application by a symposium discussant. This symposium offers an opportunity for us to critically analyze what we do in science education, how we do it, and towards which goals we honestly strive. If we do not explicitly address these questions, then we have little hope of accomplishing all that we as educators and researchers should be striving to achieve.

## Carol Johnston, Jeanne Grier

STEM Career-changers Transition to Teaching: I Have to Become a Student Again?

One obstacle to recruiting STEM professionals to teaching credential programs is the reluctance of many adults to become a student again (Haberman, 2005; authors, 2007). While many are eager to become teachers, they do not perceive traditional university credentialing programs as fitting their needs. In this study, we identify the concerns



of STEM career changers to better inform teacher education programs on how to be more mindful of the needs of this population as they return to the life of a student again on their path to a new career.

### Leslie Sandra Jones, Deborah Allen, Kathleen Fisher, Ellen Granger, Kim Sadler

Is Post-Secondary Biological Education Addressing the Evolution/Creation Controversy?

The stubborn persistence of the evolution/creationism controversy is evidence that K-12 teachers need much more support from the scientific community. Even though a number of scientific organizations have published formal statements, and a few individuals have participated in legal cases supporting the teaching of evolution, it remains unclear whether college biologists are taking an active role by attempting to diminish the furor that surrounds this important scientific theory. This symposium team is comprised of academic biologists who will critically examine the presentation of evolution in college science education with an emphasis on how this directly impacts teacher education and K-12 science teaching. Panelists will address a series of questions such as: How much formal training in evolution do college students, including biology majors receive? How do college biologists present evolution in various courses, given the fact that there is so much controversy surrounding the topic? Is a science classroom the appropriate place to address the social controversy? Where do elementary, middle, and secondary education majors receive formal training about the theory? How can university faculty members play a greater role in reducing widespread misunderstanding of the theory of evolution?

## Gail Jones, Tom Tretter, Amy Taylor, Tom Oppewal

Experienced and Novice Teachers' Concepts of Scale

Scale is one of the thematic threads that runs through nearly all of the sciences and is considered one of the major prevailing ideas of science. This study explored novice and experienced teachers' concepts of spatial scale with a focus on linear sizes from very small (nanoscale) to very large (cosmic scale). Novice teachers included undergraduates in science teacher education and students enrolled in a Masters of Arts in science teaching program. Experienced teachers included students enrolled in a Master of Science Program. Participants' knowledge of conceptual categories of size, scale accuracy, and experiences learning scale were assessed. Results showed both experienced and novice teachers were most accurate in their knowledge of human scale (1 meter or body length) and both groups were more accurate with large scale than small scale. Experienced teachers held more accurate concepts of small-scale measurements such as nanometer than novice teachers. Teachers' reports of in-school and out-of-school experiences suggested that being able to directly experience objects and distances influenced concepts of size and scale.

#### Esra Kabatas, Murat Gunel, Erdogan Buyukkasap, Mustafa Uzoglu, Brian Hand

Effects of the Implementation of Science Writing Heuristic on Students' Understanding of Electricity Unit in 6th Grade Setting in Turkey

The purpose of this study was to explore the impact on students' science achievement of implementing inquiry based laboratory activities using the Science Writing Heuristic (SWH) approach. A quasi-experimental pre-post test design with semi-structured interviews was used. The study involved one teacher and three 6th grade classes with total of 108 students in a large city at Eastern part of Turkey. One class was randomly selected as a control group with the other two classes selected as the treatment group. The control group used traditional didactic approaches used in the previous semesters and years. The treatment groups engaged in inquiry based laboratory activities using the SWH approach. Analysis of pre-post tests indicated significant difference between the control group and treatment group on the conception questions total and multiple-choice questions total.



#### Ajda Kahveci

Enactment Indicators of Reform Outcomes in Science Textbooks: An Holistic Look

Science and technology have come to be central endeavors for economic growth on global level. Most evident in current United States reform documents, science education reform initiatives have targeted scientific literacy through inquiry experiences and skills "for all" (AAAS, 1990, 1993; NRC, 1996). To succeed in large-scale reform initiatives commitment from all stakeholders is needed. Curriculum materials need to be designed in ways that promote learning through and about inquiry, develop deep understanding of science concepts, and address diverse student populations. Thus, to transform curricula a revision and transformation of textbooks as part of curriculum materials in accordance with reform outcomes is critical. In this study, I suggest the aggregation of evaluation techniques found in the science education literature to function as a set of criteria for evaluating the effectiveness of science textbooks in terms of reflecting current science education reform principles. By using this set of criteria, I evaluate Turkish middle school science and high school chemistry textbooks to provide an example and a ground for more informed discourse regarding evaluation criteria of science textbooks in terms of their match with reform efforts.

## Spartak Kalita, Dean Zollman

Group Interaction in Hands-On Activities Related to Medical Image Reconstruction

Based on our research on pre-med students' models of X-rays we designed a hands-on lab using semi-transparent Lego bricks to model computer assisted tomography. Without "surgery" (i.e. without intrusion into the Lego "body") students determined the shape of an object, which was built out of opaque and translucent Lego bricks and hidden from view. A source of light and a detector were provided upon request. Using a learning cycle format, we introduced CT scans after students successfully have completed this task. By comparing students' ideas before and after teaching interviews with the groups of 2 or 3 participants, we have investigated transfer of learning from basic physics and everyday experience to a complex medical technology and how their peer interactions triggers and facilitates this process.

## Justine Kane, Maria Varelas, Christine Pappas, Jennifer Hankes

How Urban Classes Develop, Transform, and Appropriate Scientific Ideas: The Ebb and Flow of Concept Development

We explore the ways young children developed the concepts of evaporation and condensation and we trace how certain concepts are constructed and realized linguistically throughout whole-class discussions in various curriculum genres. We make sense of the development of these ideas within classroom communities (1st-3rd grade classrooms in urban schools) where teachers and children offered ideas, took some of them up, came back to particular ideas, revised them, used different words for them, and came to understandings of them. We argue that it is important to learn about students' conceptions as they unfold and emerge, and are shaped with and by the ideas of other students and the teacher within classroom settings, especially settings that are dialogically oriented. In this way we can understand how children's ideas about evaporation and condensation developed over time in natural settings, and across communication activities (reading, writing, talking, drawing) as children constructed scientific ideas that were meaningful to them in the company of others. We discuss how children's understandings of the ideas of the ideas iebbed and flowedî over time, how children's ideas became more complex as the unit progressed, and how the verbs children used were related to the particular activity in which they were engaged.

## Nam-Hwa Kang

Intended, Taught and Learned Curriculum: Student Learning Through a Problem-Based Environmental Health Science Curriculum

The purpose of this study was to examine how the intended curricular goals were interpreted and actualized by the teacher and learned by students. Data on one teacher's curriculum teaching and 25 focus group students were



collected through interviews and video records. The teacher targeted two major goals including collaboration skills and scientific argumentation skills. The teacher's emphasis on the two goals in teaching practices was evident in the video records. Students perceived specific contents, collaboration skills, or awareness of the environmental effect as curricular goals, and most students stated awareness and contents as their learning outcomes. The findings indicate that the intended curriculum shaped by curriculum developers and the enacted curriculum shaped by teacher's perceptions both are relevant to students' learning outcomes. Therefore, both aspects of curriculum need to be attended for successful curriculum implementation.

## Hosun Kang, Charles Anderson, Steven Tuckey, Kelly Merritt, Mark Conley

Understanding Science Teacher Candidates' Views of Problems of Practice: Scientific Literacy and Students

This study investigated science teacher candidates' views about two problems of practice in science teaching: understanding scientific literacy as a goal for teaching science and making sense of students' ideas. We explored secondary science teacher candidates' interpretations of three video cases of science teaching and learning. The findings showed that teacher candidates often saw science as a factual narrative and used phenomena as motivators for students' engagement or "illustrations" for factual narratives. Though the teacher candidates shared a focus on the material world as the most important "text" for a science classroom with their methods course instructors, the material world experiences were interpreted as a motivator that made the facts in curricula and textbooks more real and relevant to their students. Teacher candidates' interpreting student language. As a result they sometimes misinterpreted students' motivation and understanding, especially when the students' backgrounds were significantly different from the candidates'. The candidates appropriated language and ideas from their methods classes while continuing to rely primarily on their personal experience mostly as successful science learners.

#### Nam-Hwa Kang, Daniel Balls

Student Learning in Problem-based Inquiry: From the Perspectives of Teachers

The purpose of this study was to understand teachers' conceptions of student learning from science inquiry experience during their implementation of environmental health science curriculum. Twenty teachers who taught a 12 week-long problem-based inquiry science curriculum unit were interviewed about their implementation practices, their professional learning, and learning outcomes of their students. The data were analyzed through constant comparison methods. Most teachers perceived learning outcomes in four different aspects including capabilities of work in teams, awareness and knowledge of the topic, capabilities of conducting scientific inquiry, and achievement. However, the teachers who taught different groups of students focused on different aspects of learning and produced different conceptions of learning. The types of evidence used by the teachers included students' reflection on their activities and evaluation of their peers, teachers' classroom observations of student actions, and feedback from outsiders including principals and colleagues. The teachers who taught low achieving students or students in alternative programs described learning as transformation of mode of participation in class activities whereas teachers who taught college-prep students described learning as achieving knowledge and skills prescribed in the National Standards. In relation to the findings, the notion of learning promoted in the current science education reform and research literature is discussed.

#### David Kanter, Kimberly Tester, Jack Gallagher, Spyros Konstantopolous

Project-Based Science Curricula Impact Minority Students' Achievement, Attitudes, and Plans Via Teacher Knowledge and Enactment

We studied how much Project-based Science (PBS) curricula could improve middle school minority students' science achievement and attitudes and ultimately their science college and career plans. Teachers' lack of science content knowledge (CK) and pedagogical content knowledge (PCK) impacts their ability to use PBS as designed, so we also provided professional development. Minority students of teachers using PBS improved in science achieve-



ment compared to a control, but science attitudes and plans did not change significantly. Teachers' CK and PCK improved with professional development but correlated only with improved student achievement. Teachers' use of inquiry activities correlated with improved student attitudes and plans. The success of PBS with minority students appears to rely on elements of both teacher knowledge and practice.

## Yilmaz Kara

Educational Software Evaluation Scale: the Study of Validity and Reliability

The purpose of the study was to develop an educational software evaluation form to provide an evaluation and selection instrument of educational software that met the requirements of some balance between mechanics, content and pedagogy that is user friendly. The subjects for the study comprised a group of 32 biology teachers working in secondary schools in the central part of the Erzurum province in Turkey. The biology teachers were asked to evaluate three educational software packages for their classes, schools, students, and individual use. The data from biology teachers were analyzed by the SPSS, using the frequency, reliability and factor routines. The body of the form covers 40 evaluation criteria in four major categories: Content, Student Involvement, Ease of Use, and Design, Esthetics. Key Words: Educational Software Evaluation; Educational Software Selection; Evaluation Criteria.

## Douglas Karrow, Xavier Fazio

A Case Study of NatureWatch within an Elementary School: Schools, Teachers, Students, and Community Based Monitoring (CBM)

NatureWatch, under the purview of The Ecological Monitoring and Assessment Network (EMAN), provides ecological monitoring protocol for citizens to examine simple ecological indicators as evidence of ecological health. Piloting of a NatureWatch program—WormWatch—within an elementary school to ascertain to what degree such programs may contribute to community based monitoring (CBM), teachers' professional learning outcomes, and students' ecological literacy is important as it contributes first to children's local knowledge about ecological issues, and provides a moral dimension to notions of scientific and ecological literacy (Hodson, 2003; Roth & Lee, 2004; and Fien & Greenall Gough, 1996). Through a qualitative research methodology, teacher's views prior to and after WormWatch inservice and implementation indicate that such ecological monitoring and assessment programs contribute to CBM, when adequate inservice is provided, sufficient implementation time is considered, "user-friendliness" is optimized, and curriculum standards are reflected in the program. Critical to the adoption of this NatureWatch program by teachers was data validity. When data is believed to be valid support for the program was optimized. Preliminary data analysis suggest that WormWatch supports EMAN's priority and future planning objectives, contributes, with qualification, to CBM, partly realizes teachers' professional development outcomes, and superficially clarified teachers' notions of ecological literacy.

## Lutz Kasper, Helmut Mikelskis

Christopher Columbus Discovers ... Magnetic Declination Changes! Improving Metaconceptual Knowledge With Learning About Change of Models and Historical Mistakes in Science

This paper reports on a study aimed at investigating how students react to narratively styled science content.Our multimedial environment consists of radio plays, animation and includes discourse and narration. A fictitious dispute about scientific questions develops between historically experts and a girl from the present. "scientific dead ends", which are not found in most current textbooks, are discussed. Students are unaware of the historical and tentative character of science. For knowledge restructuring knowledge about the tentative and social character of science seems to be a moderating factor. Main questions of our study: Does narratively arranged texts influence students' views about the nature of science? What conceptions about geomagnetism do students have? We could find significant pre-post differences concerning NOS and the knowledge about (geo-) magnetism. We also identified typical alternative frameworks concerning students' views about geomagnetism that are published not yet. To sum it up it can be said that the work with narratively styled science content offers the chance to effect positively



students' views about the NOS. The dialogues provided useful contexts to offer arguments and they can serve to confirm students' adequate views and to change their inadequate views that theories are absolute true.

## Claudia Kastens, Reinders Duit, Manfred Lehrke

Studies on Videobased Physics Teacher Professional Development

Developing teachers' ways of thinking about 'good' instruction and their views of the teaching and learning process are generally seen as essential for teacher professional development. The aim of the study presented is to evaluate video-based interventions that attempt to develop both teachers' ways of thinking about teaching and learning and their teaching behaviour. Evaluation draws on three sources: (a) Questionnaires measuring teachers' views about teaching and learning as well as their perception of their own teaching, (b) a video-test, asking teachers to comment on short video-sequences and (c) audio-recordings of teacher talk in the plenary sessions. The results support the widely held assumption that video-analyses may be efficient means for teacher professional development. Teachers' talk about instruction, for instance, developed significantly during the video-analysis sessions ñ from arguing on the grounds of personal experiences and views towards arguing on the grounds of recent theoretical positions on teaching and learning science. Teachers generally were of the opinion that their way of thinking about instruction as well as their teaching behaviour developed considerably by analysing videos of their own lessons and lessons of the other colleagues participating.

## Claudine Kavanagh, Esther Zirbel, Cary Sneider

Learning to Think about Gravity I: From Aristotle to Newton

Although Newton's three laws have been discussed in some depth in the science education literature, the concept of gravity has attracted less attention. This is surprising since gravity has fascinated many prominent figures, such as Aristotle, Newton, and Einstein. Nevertheless, a recent literature review (Kavanagh & Sneider, 2007a&b) indicated that most people tend to have non-scientific operational definitions of gravity that often resemble those held by medieval philosophers. We propose to build on that paper, administer targeted semi-structured interviews, and describe, categorize, and interpret students' understanding of gravity. During these interviews, students will be asked to perform experiments and answer questions concerning their interpretation of the results. An additional, but not insignificant goal will be to develop a Gravity Concept Diagnostic Tool that can then be used to test student's emergent understanding of Newton's Universal Law of Gravity. The transition of students' naïve beliefs to the full Newtonian notion will also be categorized according to the skill levels in Fischer's Dynamic Skill Theory (Fischer & Bidell 1998, 2006). Finally, recommendations of how to teach about gravity and induce conceptual change will be presented along with suggestions of how to guide and inspire students to enhance their naïve understandings of gravity.

## Ebru Kaya, Ali Yildirim

Science Anxiety Among Failing Students

The main purpose of this study is to investigate the reasons of students' science anxiety. It was used purposeful and typical case sampling methods. The sample was composed of six ninth grade students who failed in chemistry course. In this study, the data gathered from only two students were analyzed and their results were presented. Gathering and analyzing the data from the other students have been going on. Their results will be presented later. To determine the reasons of students' science anxiety, semi-structured interview was made with the students. The interview questions are related to the activities in class, students' experiences, attitude of teachers, relationships between students in class, the feelings of the students during chemistry courses, homework given to students, attitude of students' parents. During the interviews, a tape recorder was used in order to gather and record the data. The data were transcribed, and then the codes and themes were formed based on these data. Based on the result of the study, it was concluded that the students' science anxiety is result from activities performed in the class, test anxiety of the students, the students' perceptions of chemistry and other science courses, attitude of teacher, at-



titude of parents.

## Loretta Kelley, Kimberly Tanner, Allison Busch

Investigating the Short-Term and Longitudinal Impact of Scientist-Teacher Partnerships on Middle and High School Science Teachers

This study examines the short-term and long-term effects of participating in a scientist-teacher partnership program on a group of middle and high school science teachers. This study explores the questions: (1) What are the short-term impacts of scientist-teacher partnerships on secondary science teachers?; (2) What are the enduring, long-term impacts of scientist-teacher partnerships on these teachers?; and (3) What are the conditions that enable the short-term impacts to persist or the constraints that prevent continued impact? This study uses both qualitative and quantitative data. Short-term effects of participation were based on data collected from 23 teachers participating in the partnership over three years. Long-term effects were based on interview and observational data collected from a subset of these teachers after they had not been participants in the program for at least one year. These long-term effects on their teaching were analyzed according to the areas of collaboration, student assessment and questioning, inquiry-based science, science content knowledge, and pedagogical content knowledge. This study has implications for professional development for science teachers and making lasting change in their thinking about science and science teaching.

#### Sybil Kelley, William Becker, Dalton Miller-Jones

Theory to Practice – Challenges and Successes Implementing an Inquiry-Based Science Curriculum with Diverse Learners and Its Impacts on Student Learning and Engagement

This paper outlines the research emerging from a partnership between the science education department of a local, state university and a struggling, urban middle school. Through this partnership, graduate students provided support for teachers and students as they integrated science, inquiry and technology into the curriculum. Circumstances provided an opportunity for direct co-teaching of 6th grade science, which has become the focus of this study. This study explores the socio-cultural setting of this highly diverse science classroom, and will specifically investigate the impacts that an inquiry-based science curriculum, contextualized in the local environment has on student engagement and learning in science. Findings and implications from the first year will be discussed.

#### Angela Kelly, Keith Sheppard

Construction of a Latent Variable to Predict Physics Access in U.S. Urban High Schools

High school physics is a gateway course for post-secondary study in science, medicine, and engineering, as well as an essential component in the formation of students' scientific literacy. The existence of policies that restrict science opportunities for secondary students is a major inequity, particularly for urban students. Although the national trend in physics enrollment has shown an increase in recent years, the rate of participation is much lower for students in urban schools. This study examines the availability of physics in an urban district in the U.S., and whether access is related to organization and school-level variables. High schools that successfully offer physics are compared to those that do not. Discriminant analysis is utilized to create a latent variable that ranks individual variables in order of importance when combined to predict characteristics of schools that provide physics access. By highlighting differences in the means of specific independent variables between physics and non-physics schools, urban districts may formulate effective models for the promotion of physics study. The evidence presented here is a starting point for identifying the extent of inequities in order to develop long-term reform efforts to improve physics access for all.

Lisa Kenyon, Christina Schwarz, Barbara Hug, Hamin Baek, Brandy Buckingham Incorporating Modeling Practices into Elementary Students' Scientific Investigations

This paper reports on work within the elementary grade band 4th-5th examining how students' modeling knowl-

edge and practice changes over time. We focused on the elementary grade band in which we designed instructional materials and conducted empirical studies that will guide the development of this learning progression. In this paper, we share what we learned about the development of an elementary instructional modeling sequence and how it supported student engagement within scientific modeling. This modeling sequence is based in part on prior work (Authors, 2007) and is designed to illustrate an example for how modeling practices and relevant metamodeling knowledge (MMK) discussions and ideas can be introduced in a content area. Within this context, we collected empirical data to investigate what modeling practices and metamodeling knowledge elementary student developed over time. Our evidence supports the promise of this approach where elementary students showed growth in their epistemologies and engagement within the practices, one informing the other.

## Steven Kerlin, Scott McDonald, Gergory Kelly

Student Argumentative Discourse in a Seismology Inquiry Unit

This research study is an investigation of how student argumentation varies as a result of engagement with different scientific data sources and how student arguments contribute to developing shared classroom community knowledge. An earth science classroom involved with the Invisible College for Inquiry Study (ICISS) provided a unique opportunity to study student arguments based on various forms of scientific data. The students were engaged in investigations that utilized data from textbooks and the United States Geological Survey (USGS). These data sources became the basis on which students supported claims and demonstrated understanding through argumentation in class discussions. An emergent coding scheme was utilized to provide a description of the different activities, science content, and type of scientific data. The inquiry unit has been analyzed in such a way that it can be used as an example of science inquiry teaching. The research includes the creation of a framework specific to the analysis of arguments based on scientific data. Analysis of student discourse shows that students are able to develop arguments using USGS data throughout a range of reasoning and inference levels, as they were able to do with the simpler textbook data.

#### Diane Jass Ketelhut

The Impact of Student Self-Efficacy on Scientific Inquiry Skills

This exploratory study investigated data-gathering behaviors exhibited by 100 seventh-grade students as they participated in a scientific inquiry-based curriculum project, delivered by a multi-user virtual environment (MUVE). I examined the relationship between students' self- efficacy on entry into the authentic scientific activity and the data-gathering behaviors they employed while engaged in that process, over time. Three waves of student behavior data were gathered from a server-side database that recorded all student activity while engaged with the MUVE, and were analyzed with individual growth modeling. I found that self- efficacy played a role in the number of datagathering behaviors students engaged in initially, with high self-efficacy students engaging in more data gathering than students with low self-efficacy. Moreover, the impact of student self-efficacy on rate of change in data gathering behavior differed by gender; by the end of the study, student self-efficacy did not impact data gathering. In addition, students' level of self-efficacy did not affect how many different sources from which they chose to gather data. There are indications in my results that embedding science inquiry curricula in novel platforms like a Multiuser Virtual Environment might act as a catalyst for change in student learning.

#### Tahsin Khalid

Teachers' Classroom Attitude and Behavior and Their Effects on Students' Science Learning

The purpose of this qualitative study was to determine pre-service teachers' attitude toward science and to determine the factors that influenced their attitude. It was conducted at a Midwestern university. The subjects were juniors and seniors majoring in elementary education. Data were collected for four semesters from fall 2005 until spring 2007. The instrument had six questions asking students about their experience in science learning at various levels. A total of 78 responses were collected. The responses were divided into two broad categories: "Like Science"



and "Don't Like Science" and were further categorized into Teacher Motivation, Teacher Interaction and Teaching Strategies. Participants who did not like science complained about their teachers' lack of motivation and interest in science teaching. They blamed their teachers' poor instructional performance for their negative attitude toward science. Those who liked science admired their teachers' motivation and interest in the subject. They claimed that they liked science because of the positive attitude of their science teachers. The study has implications for teacher educators that they should not only teach content and pedagogy but also emphasize on developing positive attitude toward science and science teaching among the future teachers.

### Rola Khishfe, Shannon Palouci, Todd Medintz

The Relationship Between Nature of Science and Argumentation

The purpose of the study was twofold, (a) explore the relationship between NOS and argumentation, and (b) investigate the influence of argumentation instruction on the NOS understandings when dealing with a socioscientific issue. Participants were a total of 117 seventh and eighth grade students in one public school in the Midwest. The seventh and eighth grade intact classes were randomly assigned to two treatments: (a) Treatment I: NOS and argumentation instruction, and (b) Treatment II: NOS with no argumentation instruction. The treatments lasted for eight weeks and involved a unit from SEPUP Issues Evidence and You (IEY) about the water usage and safety. Participants were pre- and post- tested using scenarios that target controversial socioscientific issues to assess their understandings about NOS and argumentation. Pearson correlations were used to explore the relationship between NOS and argumentation. Further, the percentage of participants with informed views about NOS and those with valid arguments were compared between and across the treatment groups. Results showed a general improvement in participants' views of NOS for all groups. The correlations indicated a possible relationship between argumentation and NOS. The implications for the teaching and learning about NOS and argumentation are discussed.

#### Hanna Kim

Students' Perceptions of the World Wide Web as a Research Tool in Science Learning

Student use of computers and the internet has increased rapidly in recent years. Teachers ask what types of learning experiences can be facilitated by using the internet in their classrooms (NSBF, 2007). This study investigates the use of the World Wide Web (WWW) as a research tool to promote self-directed learning in a group of 7th grade students. Performance questionnaires were used to determine the effectiveness of the WWW in enhancing students' understanding about ozone; attitude questionnaires were used to ascertain positive/negative effects on student learning. The results showed many positive aspects of using online resources for self-directed learning of ozone, including increased student understanding of abstract science concepts and motivation in taking responsibility and control over one's learning.

#### Sun Young Kim, Irving Karen

Genetics Instruction with History of Science: Nature of Science Learning

This study explored the impact of history of genetics in teaching genetics and learning the nature of science (NOS). This study is a quasi-experimental control group research design with pretests, posttests, and delayed posttests, combining qualitative data and quantitative data. The experimental group received the Best Practice Instruction with History of Genetics (BPIw/HG) utilizing various historical materials from the history of genetics, while the control group received the Best Practice Instruction (BPI) without historical materials. Genetics Terms' Definition with Concept Mapping (GTDCM), NOS Terms' Definition with Concept Mapping (NTDCM), and View of Nature of Science (VNOS-C) were administered to investigate students' understanding of genetics and the NOS. The results showed that the experimental group demonstrated better understanding of the NOS immediately after the intervention (p.05).

#### Byoung-Sug Kim, Norman Lederman

Utilizing Nature of Science as the Context of Doing Science

The purpose of the present study was to investigate how students' utilizing NOS for their doing inquiry affected their views of NOS and transfer of NOS to novel content contexts. Utilizing NOS refers to reflecting on NOS before an inquiry activity as a metacognitive tool to justify why students are doing what they are doing and monitor their inquiry activities. Two 7th grade classes were randomly assigned to either the control or experimental group. Two phases were set up. Phase I was aimed at teaching NOS in an explicit and reflective manner for both the control and experimental groups. During Phase II the control group was taught NOS in the same way as in Phase I (i.e., explicit and reflective instruction), but the experimental group was taught how to utilize NOS. The pre-and the post-test of the NOS questionnaire were administered and analyzed. Results indicated that the treatment of utilizing NOS was more effective than explicit and reflective NOS instruction in improving participants' views of NOS and partially more effective in transferring acquired views of NOS to new content contexts. Results imply the importance of utilizing NOS as a metacognitive framework in doing science.

#### Mijung Kim, Heesook Yoon, Youngrae Ji, Jinwoong Song

A Link between Science and Life: An Evaluation of Everyday Science Class

To increase public understanding and interest in science, Korea Science Foundation suggested Everyday Science Class (ESC) project in partnership with universities and local government offices in national level. ESC is a context-based out-of-school science learning project. This study focuses on looking into the development and effects of ESC program. Children and their parents in ESC program participated in questionnaires and interviews and the classes were recorded for further analysis. The study showed that ESC program helped participants understand the connection between science and their everyday lives. Also, more than 80% of participants agreed that they could learn science with confidence and interest during the program. From the interviews, we understood that learning subjects and materials based on their everyday life contexts influenced participants' positive attitudes toward learning science. They explained that the familiarity of topics and materials encouraged them to learn science with more interests. With these findings, this study raises further questions of how school science can enrich everyday life contexts in school science so that learners could get engaged in science learning with interests and motivation. Based on the findings, the presentation will expand a discussion further on cultivating public understandings of science and participatory scientific literacy.

#### Brian Kinghorn

Elementary School Teachers' Learning of Science Content Through Teaching

Solid subject matter knowledge is crucial for effective teaching, yet the amount of subject matter that can be covered in teacher education programs is limited, especially for elementary education majors who are expected to teach the spectrum of subject matters. Professional development, educative curriculum, and modeling have all been implemented to help close the gap between what elementary teachers know and what they need to know. However, while teachers have reported that they get the most improvement from actual teaching, few studies have explored how elementary school teachers learn content from teaching. Even fewer studies focus on science content. In this study, 11 elementary school teachers with between 2 and 26 years of elementary school teachers learned new science content from the teaching process (including preparing to teach, actually teaching and reflecting on teaching). All but one teacher (who managed to avoid teaching science her entire career), reported having learned new science content as a result of the teaching process. These teachers learned content as they prepared to teach, as they were actually teaching their classes, and as they reflected on their teaching.



#### Susan Kirch, Christina Siry

"Maybe the algae was from the filter": Theorizing 'maybe' and its use by young children in conversation

The initial findings reported here emerged primarily from data analysis of semi-structured interviews with small groups of early childhood students (7-8 years old). In this proposal, the conversational tools and resources that students use in the re/production and coproduction of science process skills are identified and discussed. Early childhood school children coproduced sophisticated science process skills and utilized 'maybe' in conversations as a gateway term to possibility and potentiality. The social forces that shaped the use of 'maybe' in conversations among peers and between students and teachers are identified and examined. The implications these forces have for equitable science teaching are considered.

#### Susan Kirch

A Comparative Science Study: Uncertainty in the Laboratory and in the Science Education Classroom

Science flourishes on uncertainty. This study will demonstrate that uncertainty reveals itself in many ways. This proposal presents a comparative conversational analysis of two representative groups engaged in science learning. The participants were 1) young children discussing an experiment as a whole class following small group investigations and explorations and 2) scientists discussing recently acquired data in a weekly laboratory meeting. The focus is on the treatment of uncertainty in each conversation. Evidence is provided that uncertainty and ambiguity are the subject of conversations in science whether in the laboratory or in the classroom. Coping with uncertainty and ambiguity puts pressure on the participants during conversational transactions. This study explores the implications of these findings for teaching and learning science.

#### James Kisiel, Jeanine Ancelet

Uncovering Visitor Conceptions of Fossils and the Fossil Record

One of the common features of any natural history museum is its fossil collection. We must expect, however, that a visitor's prior knowledge (and possibly misconceptions) related to fossils and how fossils are used to make sense of past events (and even the concept of evolution) can greatly influence how visitors make sense of these iconic displays. For this study, over 150 museum visitors were interviewed during a trip to the museum to find out how they would define 'fossil'; they were also asked to interpret the presence or absence of fossils within an illustrated cutaway of a fossil bed with clear stratigraphic layers. Findings showed that while visitors referenced a wide range or breadth of salient characteristics when defining fossils, their level of mastery ('correctness') was relatively low. Visitor explanations for why fossils might appear in one layer, and not another, often included references to evolution and extinction, although not as related processes. The utility of the methodological approach used here, as well as the implications of these results for science museum practice, will also be presented.

#### Thilo Kleickmann, Kornelia Miller

Do Teacher In-Service Training Courses Have an Impact on Teachers' Conceptions of Teaching and Learning and on Students' Understanding in Primary Science?

In-service teachers' existing conceptions of teaching and learning often conflict with conceptions that emphasize cognitively engaging and conceptual change oriented science instruction. Therefore teacher in-service courses should aim at conceptual changes in teachers' conceptions of teaching and learning. But how relevant are teachers' conceptions of teaching and learning that have been modified through in-service courses for students' understanding in primary science? In a quasi-experimental study the impact of long-term teacher in-service courses with tutorial guidance on teachers' conceptions of teaching and learning and on students' understanding in primary science was compared to the impact of a control group that did not have this tutorial support. Compared to this control group, teachers, who participated in the courses with tutorial support, showed significant stronger changes in their conceptions of teaching and learning and achieved stronger gains in conceptual understanding on behalf



of their students. Concerning this effect, teachers' conceptions of teaching and learning, which have been modified through the in-service courses, seem to play an important mediating role.

## Aviva Klieger, Yehuda Ben-Hur, Nurit Bar-Yossef

What Facilitates Integration of One-to-One Laptops According to Science Teachers?

The study examines the professional development(P.D) of middle-school teachers participating in the Israeli "Katom" (Computer for Every Class, Student and Teacher) Program, begun in 2004. A three- circle support and training model was developed for teachers' P.D. The first circle applies to all teachers; the second, to all teachers at individual schools; the third to teachers of specific disciplines. The study describes science teachers' attitudes to One-to-One laptop integration and to the P.D model. Two factors influenced science teachers' P.D: 1.Introduction of laptops to the teachers and students. 2. The support and training system. Interview analysis shows that the disciplinary circle is most relevant to teachers; they also prefer face to face meetings in their school. They are very interested in belonging to the professional science teacher's community. Among difficulties they noted were the new learning environment, including control of student computers, computer integration in laboratory work and technical problems. Laptop computers contributed significantly to teachers' professional and personal development and to a shift from teacher-centered to student-centered teaching. One-to-One laptops changed the schools' digital culture. The findings are important to designing concepts and models for P.D. in the introduction of technological innovation into the educational system.

#### Eunkyung Ko, Byoung-Sug Kim, Norman Lederman

An Examination of Fifth- to Eighth- Grade Students' Understandings About Inquiry and Doing Inquiry

The purpose of this research is to investigate the relationship between students' understandings about inquiry and their abilities to do inquiry as a cross sectional study. A total of 233 students from 5th through 8th grade were purposefully selected and data collected from two questionnaires (the Understandings about Evidence-based Explanations (UEBE) and the Abilities to Develop Evidence-based Explanations (ADEE) questionnaire) and a follow-up interview. No significant relationship was found (p>.05) for all four groups and it means that students' adequate understandings about inquiry would not guarantee their performance of a scientific investigation and vice versa. It was clear that students usually do not have adequate understandings about inquiry and the development of understandings about inquiry lagged behind the development of abilities to do inquiry.

#### Eunkyung Ko, Norman Lederman

Fifth Grade Students' Understandings About Inquiry and Doing Inquiry

Reform documents emphasize students' knowledge development through inquiry and both students' abilities to do inquiry and understandings about inquiry are equally stressed (NRC, 1996; 2000). However, research on scientific inquiry is often based on the intuitive assumption that students' performance of doing inquiry necessarily reflects their understandings about inquiry and the purpose of this research is to assess the assumption that students?understandings about inquiry reflect their abilities to do inquiry. A total of 84 fifth grade students from four different science classes were purposefully selected and data collected from two questionnaires (the Understandings about Evidence- based Explanations (UEBE) and the Abilities to Develop Evidence-based Explanations (ADEE) questionnaire) and a follow-up interview. No significant relationship was found (p>.05) and it means that students?adequate understandings about inquiry would not guarantee their performance of a scientific investigation and vice versa. This finding implies that science teachers need to emphasize the connection between understandings about inquiry in order for them to reinforce each other.



#### Thomas Koballa, Julie Kittleson, Leslie Bradbury, Michael Dias

Science Teacher Thinking About Mentoring as Revealed Through Written Cases

The study investigated the mediational tools that science teachers use when learning to mentor and how use of tools leads to the construction of new understandings about science teacher mentoring. The context of the study was a science-specific mentor-training program. Cases written by secondary science teachers (n=34) served as the primary data source, with responses to a self-report questionnaire and recordings of mentor group meetings serving as contextual data. Dilemmas of practice and images of mentoring presented in the cases were taken to reflect new understandings of mentoring constructed by science teachers through the use mediational tools. The findings indicate that teachers' own teaching experiences, including experiences of being mentored, served as the primary mediational tool, followed by strategies and skills developed through participation in the mentor training program. Dilemmas facing science teachers when learning to mentor are not restricted to issues of science teaching and learning, but also center on issues of school culture and personal relationships. Images of mentoring created by the science teachers while participating in the program highlight dimensions of teacher professionalism, emphasizing a specialize knowledge base for science teacher mentoring and a commitment to helping beginning science teachers succeed.

#### Konstantinos Korfiatis, Tasos Hovardas

A Methodological Framework for Studying Worldviews' Changes

Within the frame of the present research and being motivated by the theory of social representations, we propose a word association's technique as a method that can provide the necessary information for evaluating worldview changes invoked by the teaching procedure. The proposed method includes content analysis of word associations provided by participants' responses to stimulus terms, structural reconstruction of the conceptual representation using median values of the rank and the frequency of appearance of each association, and measurement of cohehrence using cluster analysis. The proposed method contributes in addressing a series of assumptions that most frequently cultivate a tension between quantitative and qualitative methods.

#### Connie Korpan

Scientific Literacy: College Students' Evaluations of Media Reports

The ability to read and critically evaluate information in media reports of scientific research is an important skill for citizens in today's society. When reading research conclusions reported in the media, literate individuals are able to identify and consider a variety of research features. Such features include the credentials of the researchers, the researchers' theory, methods used, evidence collected, etc. In this study, 78 college students were given two tasks, a Generation Task and a Cued Task. In each task, they were presented with four news reports about scientific research. In the Generation Task, participants generated a list of questions they wanted answered to determine if the reported conclusion was accurate. In the Cued Task, they rated each conclusion before and after being provided details about the underlying research and identified the scientific nature of sentences embedded in the news reports. Students' performance on the Generation and Cued Tasks were not always consistent; each task tapped into different types of knowledge and competencies. Participants' ratings of each conclusion's accuracy increased as a result of being provided with details about the underlying research. The ability to identify some research features (theory vs evidence) improved with formal science training.

#### Susan Kowalski

Students, Language, and Physics: Discourse in the Science Classroom

Women and minorities do not enter science professions at rates consistent with their populations (Rosser, 2000). A variety of theoretical frameworks and associated interventions have been cited in the literature; yet, the gender and racial gaps remain. Theoretical frameworks and the associated interventions to promote the success of women



and minorities in the sciences have, primarily, been one dimensional: they address issues of Self (associated with experiential and psychoanalytical framings) or Language (categorical and deconstructive framings) (Grumet & Stone, 2000). Furthermore, research in science education with few exceptions (Hanson, 2004), has failed to address race and gender through an intersectional analysis. This study investigates the inclusion and exclusion of girls and minorities in the sciences by examining the connections between Self and Language in physics group work conversations. Critical Discourse Analysis was used to explore the connections between Self and Language. Eight students in two groups were the focus of the study. Transcription of conversations and coding of transcripts with students' subject positions, genres, and registers provided evidence of the reflexivity of Self and Language. Furthermore, the study demonstrated how group discourse and power imbalances within groups serve to simultaneously facilitate and constrain learning opportunities and learning itself.

#### Kerstin Kremer, Detlef Urhahne, Juergen Mayer

Relationship Between Students' General and Theory-Specific Scientific Beliefs on the Nature of Science

The development of an adequate understanding of the nature and epistemology of science is an important educational objective in science education. Therefore, in contemporary educational psychology domain-general as well as domain-specific scientific epistemological beliefs and their impact on learning are widely investigated. Inspired by this kind of research, the study presented here aims to elucidate the relationship of general and more issuespecific epistemological beliefs within the domain of science. About 200 students were asked about their general and theory-specific scientific epistemological beliefs. Relying on this data, correlation and regression analyses were performed. As a result differences of students' theory-specific scientific epistemological beliefs and relationships of these to general epistemological beliefs are reported. With regard to our findings the conclusion can be drawn that general and theory-specific scientific epistemological beliefs are similar but not the same. Accordingly, both perspectives on the nature and epistemology of science should be taken into consideration in science education. Students should learn in issue-specific activities accompanied by an explicit reflection of the general nature of science. By this, a process of lifelong learning in a society characterised by science and technology should be initiated.

#### Anne Laius, Miia Rannikmäe

The Comparison of Scientific Creativity Levels Between Students and Teachers

This study describes the use of a test of scientific creativity for comparing the levels of the nine grade students and their science teachers in order to pilot the test for evaluation of SSI teaching in science classes. The 7-item scientific creativity test developed by Hu and Adey (2002) was translated into Estonian, slightly modified and fulfilled with 190 students in autumn 2006 in seven different Estonian secondary schools. 41 teachers (biology, chemistry, physics, geography and science), belonging to the sample, were participators of the in- service courses for science teachers "Sustainability of Science and Technology Education in Estonia" and the test was carried out in the beginning of these courses in 2006. According to the results of this study, the average results of the whole scientific creativity test of the teachers and students did not differ significantly, but in the results of four items (2,3,4,6) there occurred statistically significant difference. The results of this study showed that the students are better in creating research questions and designing and the teachers are more subject-centered and get better results in the items where they can use their knowledge. In addition the students use more social components in their answers than their teachers.

#### Sarah Lang

An Analysis of the Association of Gender and Ethnicity With Departure From the Biology Major

Although biology is a very popular major, it is, by numbers alone, the most left major. This has had a noticeable effect on the numbers of qualified biology teachers graduating from college. This paper addresses not only who is leaving the major in terms of gender and ethnicity, but also why these students are leaving. Results of survival analysis of registrar data from a large, public, research-one institution show that white females were less likely to



persist in the major than their white male or Asian female classmates. Questionnaire data from a sample of these students demonstrated that white females were more likely than their male counterparts to leave due to issues with instruction and their own performance, despite earning the same grades as white males. Moreover, whites, whether male or female, were more likely to persist in the major than African-Americans and Latinos, who reported leaving because they were turned off to biology because of the content and lack of fit in the major. Despite advances made in the representation of women and minorities in the biology major, there is still progress to be made to ensure proportional representation.

#### Deanna Lankford, Lloyd Barrow

The Analysis of Diabetes Education in High School Biology Textbooks

The purpose of this study was to develop, validate, and implement a textbook evaluation matrix to be used to assess biology textbooks for diabetes education content. The evaluation matrix focused on major biological concepts and their connection to various forms of diabetes. The preliminary matrix designed for this study was validated by two physicians, a nurse specializing in treatment of diabetes, and a professor of human physiology. The final matrix was redesigned based upon the feedback and suggestions provided by evaluators. The analysis demonstrated clear differences between the textbooks in terms of the manner in which content was presented as well as the connections made between content and real-world concerns about human disease. There are two potential contributions for this research. First, by investigating the development and implementation of effective textbook evaluation matrices, in-service and pre-service teachers can be prepared to more accurately assess and compare content and contextual relevance of textbooks. Second, the matrix can also address relevant biology content in personal and social perspectives as supported by the NSES and make biology more relevant, meaningful, and engaging for students as clear connections are made between course content and real-world context.

## Kimberly Lebak, Norma Boakes

Connecting Professional Development to Classroom Based Instruction

The purpose of this research is to study the effect a professional development institute has on the development of standards-based instruction for teachers of science and mathematics in grades 3-8. This study is part of a larger on-going three year program, funded by the United States Department of Education, designed to increase student achievement in science through sustained professional development. Forty-four teachers participated in a two-week long professional development institute intended to increase teachers' content knowledge in life science. Mathematics and technology was integrated within the life science study. Data collection included pre and post tests, concept maps, and participant generated units of study. This research provides evidence that sustained, focused professional development can increase the content knowledge of classroom teachers and can directly translate to standards based instructional practices.

## Judith Lederman, Norman Lederman, Per-Olof Wickman

An International, Systematic Investigation of the Relative Effects of Inquiry and Direct Instruction: A Replication Study

The purpose of this investigation was to systematically study the relative effects of direct instruction, inquiry-oriented instruction, and a mixture of the two approaches with eighth grade science students. The design involved an international collaboration between the Illinois Institute of Technology and the Stockholm Institute of Education so that the findings would be more globally generalizable. This was a replication of a previously completed investigation. The results do not support the current contention that there is a difference between the relative effects of direct and inquiry-oriented instruction. With respect to subject matter knowledge, there was no difference among the three instructional approaches. The same was true for outcome variables related to knowledge about inquiry as well as attitudes toward science. There was a slight advantage in favor of the mixed instructional approach for all three outcome variables, but this advantage was not statistically significant. A delayed posttest was also conducted to see if there were long-term differences across instructional approaches, but the results remained insignificant



across treatments. Alternative explanations are possible related to the restrictions of scientifically-based research designs applied to educational settings.

## Norman Lederman, Judith Lederman, Kevin White

Linking Progressive Development of Teachers' Understandings of Nature of Science and Scientific Inquiry with Progressive Development of Instructional Ability

Linking Progressive Development of Teachers' Understandings of Nature of Science and Scientific Inquiry with Progressive Development of Instructional Ability The purpose of this investigation was to track the relationship between the development of teachers' understandings of NOS and SI and how this development was related to their ability to teach NOS and SI. The sample was 15 science teachers who were simultaneously enrolled in courses on NOS/SI and Advanced Teaching Strategies. Data collected included pre and posttests on the Views of Scientific Inquiry survey and the Views of Nature of Science survey. In addition, teachers' book reports related to books read and reaction papers related to short readings, were analyzed, along with videotaped lessons, lesson plans, and self-critiques. A clear relationship between the development of teachers' understandings of SI and NOS was evident. As lessons were analyzed spanning the semester it was clear that teachers became more proficient at explicitly addressing NOS and SI during instruction as their knowledge became more internalized. The results indicated a strong relationship between the progression of teachers' understandings and their instructional practice. However, it was also clear that the progressive development of classroom practice lagged behind the progressive development of knowledge.

#### Hyunju Lee

Misconceptions University Students Have in Astronomy

University non-major students were examined with quantitative survey and qualitative in-depth interview to understand their conceptions of 'the speed of light', 'the Milky Way' and 'the center of the universe'. Students had misconception that the speed of light varies depending on its wavelength, and it was from students' intuitions and partial and immature conceptions of 'time', 'distance', 'wavelength', 'frequency' and 'energy'. Students had different ideas about the nature of the Milky Way and its light. Misconceptions were also found regarding the center of the universe. Students believed that there must be an astronomical object or raw material remnants from the big bang, or at least a 'starting point' associated with the concept of the expanding universe.

#### Hyunju Lee, Hyunsook Chang

Experienced Science Teachers' Talks on Teaching SSI: Exploration of Teachers' Personal Practical Knowledge

Regardless of the importance of addressing SSI, science teachers still overwhelmingly follow the traditional view of science. In order to encourage them to pay attention to SSI and include SSI in their science teaching, this study attempted to explore experience science teachers' personal practical knowledge, which had been piled up over the past several years of teaching SSI, and to suggest practical implications for teaching SSI. The authors, therefore, contacted a teacher interest group in Korea which has been concerned about teaching SSI. Most of the teachers in the group have at least several years of experiences in teaching SSI and developing SSI teaching materials. The data source included three group discussions and interviews with individual teachers. In results, their group discussions and interviews represented that the teachers had thought of different practical issues regarding teaching SSI, on the basis of their personal reflections on the purpose of teaching SSI. In the process, SSI got to be more personally meaningful to them and teaching SSI became an important part of their science teaching. And the teachers had developed their personal view of science and personal meaning of SSI. Their view of science and personal meaning of SSI were interrelated.

#### Eun Ah Lee, Byeong-Geon Park

High School Students' Understanding of the Distinction Between Scientific Theories and Scientific Laws

The purpose of this study is to explore high school students' understanding of the distinction between scientific theories and scientific laws. Understanding of the distinction between scientific theories and laws, though it is an important part of the nature of science, has been receiving little attention in science education in Korea. We surveyed thirty-two students from a local high school with open-ended questionnaire. The result revealed that these students had general misconceptions such as scientific theories are unproven, scientific laws are proven and absolute', and if a theory is proven with enough evidence, it becomes a law'. Moreover, students seemed to view some disciplines such as earth science as less developed because it contains lots of theories, while viewing other discipline such as physical science as more sophisticated. This result indicated that teaching the difference between scientific theories and laws explicitly may help students have appropriate view toward various disciplines in science.

#### Kristen Lennon, George DeBoer

Probing Middle School Students' Understanding of Ideas About Interdependence in Living Systems through Content-Aligned Assessment

With funding from the National Science Foundation, we are developing an online collection of student assessment items for middle school science that are precisely aligned with national content standards. These distractor-driven multiple choice items, in which common student misconceptions are used as distractors, will enable educators to probe student understanding of targeted concepts and gain a better understanding of student ideas about those concepts. Each item is developed and analyzed using a procedure designed to evaluate an item's alignment with important science ideas and its overall effectiveness as an accurate measure of what students do and do not know about those ideas. During the item development process, the items are pilot tested by middle school students at schools throughout the Unites States. This poster presents data collected from assessment items aligned to a middle school idea related to the dependence of organisms on other organisms for food and describes how we use information gathered from the students to gain valuable insight into their ideas and cognitive abilities, as well as about the quality of the assessment items themselves.

#### Jacqueline Leonard, James Davis

Cases Studies of Elementary Preservice Teachers' Science Efficacy and Inquiry-Based Practices in Urban Schools

Earth Links, a two-year study funded by the National Science Foundation, provided preservice elementary teachers with the following supports: (1) mentoring, (2) texts and supplies, (3) community-based internship, (4) professional development, and (5) summer course. In this study, we examined the teacher efficacy and inquiry-based science instruction of teacher interns in out-of-school and in-school settings. Findings from case studies show Katrina's and Alyson's self-efficacy decreased while Jamie's and Tanya's self-efficacy increased, as measured by the STEBI-B. Oservational ratings (STIR) show Katrina was more inquiry-based in her science instruction during student teaching than Tanya, Jamie, and Alyson. Journal entries provided rich qualitative data about these interns. Katrina's educational history reveal real-world connections, relevancy, and projects shaped her attitudes about cross-curricular instruction and learning environments. Jamie explicitly made the connection between the Earth Links program and her university-based field experiences. Tanya believed the methods courses allowed her to become a constructivist. Moreover, Tanya was the only intern to attend the summer Earth science course, and the data show she greatly benefited from it. Analyses of qualitative and quantitative data reveal teacher beliefs, educational histories, methods courses, institutional context, and instructional supports impact teacher efficacy and behavior.

## Tami Levy Nahum, Rachel Mamlok-Naaman, Avi Hofstein

Diagnostic Research, Development and Implementation of a New Approach to the Teaching of Chemical Bonding

This research consists of a diagnostic study, followed by a curricular development and implementation regarding the teaching of the bonding concept. The diagnostic study focuses on students' difficulties over two decades. We



focused on how the structure and content of the Matriculation Examinations conducted in Israel influence the way bonding is taught and assessed. The traditional approach for teaching bonding is often overly simplistic and not aligned with the most up-to-date scientific ideas. Based on the analysis of this study and supported by researches worldwide, we suggest that the general approach of the bonding curriculum along with the current system of assessment cause students to study by rote- memorization. We then describe the development of a new conceptual framework that provides an advanced scientific and pedagogical foundation for the teaching of bonding; this process was conducted with chemistry lead-teachers, senior chemistry educators and eminent chemists. The new approach rationalizes all bonds based on a small set of underlying assumptions. We also suggest stressing the idea that a continuum scale exists between extreme cases of different bonding scenarios. Our study indicates that both students and teachers acquired a deeper understanding of the underling key-concepts while studying according to the new conceptual framework.

#### Elizabeth Lewis, Dale Baker, Senay Yasar-Purzer, Sibel Uysal, Michael Lang

Measuring Short-Term Teacher Learning of Scientific Classroom Discourse Communities

Measuring Short-Term Teacher Learning of Scientific Classroom Discourse Communities Abstract The Communication in Science Inquiry Project (CISIP) provides school-based teams of secondary science and English/ELL teachers with year-round professional development with the goal of establishing scientific classroom discourse communities (SCDC). Teams participated in one of two three-week CISIP summer institutes. Five CISIP model elements of a SCDC can be framed within Veal and MaKinster's (1999) PCK taxonomy at two levels, domain-specific PCK (academic language development, written discourse, and oral discourse) and general pedagogy (scientific inquiry), as well as overarching learning principles (National Research Council, 2000, 2005). By situating the CISIP professional development model within teacher knowledge this clarifies the purpose of the institutes and the PCK taxonomy can be employed as a research lens. With the exception of scientific inquiry, both science and English/ELL teachers broadened their pedagogical awareness, but need more time to refine their conceptual framework of the five SCDC pedagogies. Participants appear to have put a higher priority on the ALD and discourse pedagogies than the scientific inquiry, which was addressed less in the professional development activities. Both science and English/ELL teachers would benefit from more explicit distinctions between domain-specific and general pedagogies.

#### Anna Lewis

Enacting Systems Thinking in Science Education

At present researchers are understandably eager to conduct carefully controlled empirical research and then translate these results immediately to classroom practices. However, there is also something to be gained from contemplation of theoretical and philosophical perspectives to assist us in better understanding the nature of science education and potential new ways to conduct it. This position paper examines 'systems thinking' models to provide a contemporary approach to teaching pre-service K-12 science educators.

#### Min Li, Guillermo Solano-Flores, Melissa Kwon, Shinping Tsai

"It's Asking Me Like As If I Were the Mother...": Examining How Students From Different Cultural Groups Interpret Test Items

This paper investigates the relevance of considering students' interpretations of test items. We present a conceptual framework for examining how culture influences student interpretation and performance in science assessment. Three hundred and sixteen students from twelve cultural groups were given one of four NAEP (National Assessment of Educational Progress) science items. After they finished responding the items, they were interviewed individually about what the items asked from them (What is this item about? What do you have to know or be able to do to solve it?). To examine students' responses, a coding system characterized and evaluated the context and content aspects of students' interpretations. The preliminary analysis of six groups shows that the students from the cultural minority and economically disadvantaged groups included in the study tended to attend to item



contextual information when making sense of the items whereas students from mainstream and economically advantaged groups seemed to identify the content and knowledge domains addressed by the items. The results also indicate that the students' interpretations of test items strongly influenced their performance on the science test items and provide evidence of the relevance to assessment cultural validity.

## Jhy-Chong Liang, Chin-Chung Tsai

The Use of Internet-Based Instruction for the Development of Conceptions of and Approaches to Learning Science in a Physiology Class

Abstract The purpose of this study was to investigate students' development of conceptions of and approaches to learning science by involving in some Internet-based inquiry learning activities. The sample consisted of 43 university students majoring in department of early childhood and education. These students were asked to find more online information to explore scientific knowledge related to physiology taught in science class. They were also requested to search Internet information to resolve related issues, and they were allowed some opportunities to participate in related on-line or traditional discussions and debates. This study set out to examine the effects on the development of students' conceptions of learning science and approaches to learning science. By gathering questionnaire responses at the beginning and the end of this treatment, the findings revealed that their conceptions of learning science, in some aspects, became more advanced; and their approaches to learning science were enhanced.

#### Ling Liang, David Majerich, Richard Clevenstine, Raymond Howanski

Improving Students' Conceptual Understanding of Physics and Chemistry: A Modeling Approach

The purpose of this study was to examine the effects of a modeling approach upon science learning and teaching in the 9th grade introductory physics and 10th grade introductory chemistry courses. Four teachers and 93 students in a Mid-Atlantic High School participated in the study. Repeated Measures Analyses of Variance with between-subjects factors were applied to students' pre-/post-scores on the physics and chemistry concept tests, respectively. Each teacher was also observed three times and rated by using the Reformed Teaching Observation Protocol (RTOP) instrument. It was found that the physics and chemistry students' mean concept test scores improved significantly over the semester. Moreover, the results suggested that a higher RTOP score for teachers based on classroom interactions may contribute to their students receiving higher concept test scores. Implications and recommendations for future studies are also discussed.

#### Sang-Chong Lieu, Wen-Ling Chen, Sufen Chen, Shu-Fen Lin, Mao-Tsai Huang, Tung-Hsing Hsiung

Research and Development of Nature of Science-Explicit Curricular Materials- Pedagogy Perspective

Teachers play a critical role in actualizing the visions of reform. However, it was frequently reported that many teachers misunderstood the competence indicators (CIs) of Nature of Science (NOS). This project face the challenge of developing an innovative way of researching and developing NOS-explicit curricular materials for promoting the implementation of NOS-CIs into practices. The NOS-CIs in the Science Curriculum Framework were unpacked through focus group discussions followed by science teachers designing lessons to teach targeted NOS tenets. After literature review and a series of discussion with participant teachers, the authors proposed a teaching principle called balanced teaching which incorporate two major teaching activities called evidence-raising activity and persuasive activity. After presenting the pedagogy and curriculum materials to a group of master teachers from various counties, a three-phase professional development program was suggested to promote elementary teachers' understanding of NOS, as well as their pedagogy in teaching NOS explicitly.

## Gilsun Lim, Robert Yager

A Web-Based Science-Technology-Society Program for Gifted Students in South Korea: Development and Implementation

The purpose of this study was to develop a Web-based instructional model for scientifically gifted students. The



goal of high-quality science education is for those students to improve problem-solving skills and increase creativity concerning scientific concepts and theories. This goal was used to develop an instructional model for scientifically gifted students. Web- based instructional model consists of five steps: 1) Selecting the problem, 2) exploring the solutions, 3) examining the principal concepts, 4) refining solutions, 5) implementing solutions into new settings. To determine the value of such an instructional model, a questionnaire was developed, and completed by 10 specialists and one class of scientifically gifted students in South Korea. According to the results of the participants' evaluation of the program activities, students unanimously preferred class lessons based on WB-STS to traditional lecture-based STS lessons. Eighty percent of the students reported that the WB- STS enhanced science learning in making ways, including personal motivation, collaboration with peers, and information sharing. Almost ninety percent of students used brainstorming and discussion to choose their problems and solutions. Sixty percent of the students employed brainstorming and discussion to decide on their research directions and refinement of questions. Two-thirds of the students believed they would have benefited from more thorough planning, Statistical analyses helped identified a variety of personal benefits of the WB-STS: increased basic research skills; scientific knowledge; and cooperation.

#### Shu-Sheng Lin, Po-Hung Huang

Improving the Argumentation Skills of the Sixth Graders Through the Instruction of the Socioscientific Issues in Taiwan

The purpose of the study is to improve the argumentation skills of the sixth graders through the instruction of the socioscientific issues. The study took eight months to improve three teachers' knowledge regarding argumentation and socioscientific issues. Then the teachers designed their units and implemented them to enhance students' argumentation skills. The study reported the results of one of the three teachers. For his class, which consisted of thirty four students, the teacher chose ist establishment of Ma-Guo National Park;" as the topic of teaching. The unit took eighteen hours. The data were collected through questionnaire, classroom observation and interviews with students and the teacher. The findings showed that during the instruction, the students have learned to make arguments. In general, their warrants became improved both quantitatively and qualitatively after the instruction. The low and medium achievers made significant progress in refuting others' claims and warrants through the instruction. However, they have some problems on raising reasonable evidences to support their claims or warrants. The other problem lies in that some students refute others' claims without considering their warrants. Besides, some students made inconsistent arguments due to the lack of logic between warrants and evidences, while others only mentioned the source of their evidences without contents.

#### Ming-liang Lin, Ming-jun Su, Jeng-fung Hung

BEST Model of Professional Development: Helping Science Intern Teachers to Meet the Needs at the Front Line

The "Becoming Excellent Science Teachers (BEST)" program was designed to promote professional development for secondary science intern teachers. Its major purpose was to implement a two-phase study to explore the most important factors affecting intern teachers' professional development and to construct the BEST model for interns through the lens that frontline teachers own. In so doing, it seeks to contribute to meet the practical needs while intern teachers begin their teaching career. The instruments used in this study, comprised of two five-point Likert scale questionnaires concerning teachers' competences and factors of professional development, were constructed via Delphi-like method. Afterward two surveys, one on importance and the other on expectancy and actuality of the factors, were conducted to collect data from teachers countrywide. Results based on exploratory factor analysis indicated six most important competences that intern teachers should possess, and six most effective factors affecting intern teachers' development. According to above findings, we developed the BEST model which built an online learning community and published a manual to provide supporting, guiding, monitoring and evaluating to help interns to meet the needs at the front line. The preliminary results showed that volunteer participants highly recognized the helpfulness of the BEST model.



## MingChao Lin, ChunYen Chang

The Application of the 3D Virtual Reality on Field Trip: Taking the Example of Hsiaoyukeng

The 3D Compound Virtual Field Trip (3D-CVFT) system was built by combining the Graphic- based VR and the Image-based VR. Students can make preparations for the trip on the 3D- CVFT before actual Hsiaoyukeng field trip, a post-volcanic activity area, and learn the particular knowledge about there. Then, we go to actual Hsiaoyukeng field trip to feel the sulfureous smell and finish some manual tasks. For theaters, the 3D-CVFT system is not only preparation but assessment. Students maybe asked to present their finding and the group home work on the 3D-CVFT system as a platform.

#### Chuan-Shun Lin, Shiang-Yao Liu

How Do People Make Decisions on Local Environmental Issues? Investigating Reasoning Modes of Elementary School Teachers in Taiwan

Understanding teachers' concept and reasoning modes about environmental issues may inform ways of effectively promoting the professional development of teachers. The research reported in this article investigates elementary school teachers' decision making and reasoning modes on two local environmental issues by using the survey method. A non- contiguous opposition bipolar scale questionnaire was designed to survey reasoning modes and decision making. The sampled participants included 525 elementary school teachers across four different areas in Taiwan. Results showed that the majority of participants were more likely to adopt a single point of view - the environmental based consideration, when making decisions on both environmental issues. Chi-square tests indicated that teachers who preferred economic, social and technology oriented reasoning would more likely to vote ¡¥agree' on the construction projects. It is expected that teachers should be able to reason their decisions on controversial issues from multiple perspectives. The findings suggest that empowering teachers reasoning ability should be an important agenda in teacher professional development for environmental education.

#### Jing-Wen Lin, Mei-Hung Chiu

Investigating the Influences of Mental and Model Based Teaching-Learning Sequences on Students' Learning in Electricity

Lin (2006) proposes a novel approach (cladistical approach) which is time/effort-saving to predict the evolutionary pathways of pupils' mental models in electricity scientifically. These pathways have been validated by an acrossgrades survey (440 students from grade3 to grade9) (Lin & Chiu, 2007a). In this study, we are interested in the effectiveness of the Teaching-Learning sequences (TLSs) which are based on these pathways to design. We take educational reconstruction as the research framework to implement teaching experiments. Thirty 7th graders with equal achievement and diagnostic test scores are selected from 212 7th graders and then are assigned to 6 groups (3 mental models, experimental and comparison groups) which based on their mental models (attenuation model, mixed model and clashing current model). Then the evolutionary pathways of these models are integrated with the structure of science concepts to design mental model based TLSs. After teaching experiments, 30 students take achievement test, diagnostic test and affective questionnaire to examine the effectiveness of designed TLSs. The results indicate the designed TLSs could help students to attain the objectives of current curriculum and to overcome alternative conceptions more efficiently. Furthermore, they also reveal the cladistical approach is helpful in designing effective TLSs indirectly.

## Li-Fen Lin, Ying-Shao Hsu, Hsin-Kai Wu, Fu-Kwun Huang

Development of Senior High School Students' Modeling About Air Quality

The purpose of this study was to investigate how students develop modeling abilities after the scaffolded modeling curriculum and what characteristics of high performance students differ from those of low performance students in their modeling practices. The data included thirteen students' (10 males and 3 females) pre and post modeling abilities test, and pre and post interviews. We designed and analyzed the interviews according to a coding scheme



developed for an expert-novice study (Hsu et al., 2007). The results showed that students' modeling abilities in designing a research to explore air quality have been improved, particularly in the reasoning process of anticipated conclusion and determine research variables of planning, and different performing students made a different improving pattern. The scaffolded modeling curriculums designed by the researchers shorten the gap between expert and novice in modeling air quality.

### Chao Ling, Tang Juan, Yen Fen, Wang Hua, Wang Lung

Integrating FAM-WATA into Elementary School Natural Science and Technology Education: Analyzing the Benefits for Students With Different Cognitive Styles

This paper discusses the impact of FAM-WATA on the learning outcomes of 5th grade elementary school students as well as the differences in the academic achievement and learning experiences between students with different cognitive styles. This study uses a quantitative research method on 4 classes of students for a total of 135 participating students. Web-based teaching was used for the experimental group (N=71) and traditional teaching was used for the control group (N=64), although both groups were taught by the same natural science and technology teacher. The research tools we used included: Hidden Figures Test (HFT), the WATA Formative Assessment Strategies Scale and Learning Achievement Tests. An analysis of covariance was performed to evaluate the benefits of e- learning to student learning in general. The results showed a significant difference on the results of the learning outcomes post-test between the control group and the experimental group, demonstrating that FAM-WATA had a positive effect on elementary student learning. Furthermore, with respect to cognitive styles, field-independent (FI) students achieved better learning outcomes than field-dependent (FD) students, different learning styles didn't impact e-learning experiences and a generally high level of positive attitudes towards e-learning was displayed.

## Marcia Linn

Program Committee-Sponsored Keynote Symposium, "Science, Technology and Policy"

Recent advances in technology provide stunning opportunities for research programs in science education. This talk will showcase current findings, identify sound evidence for policy makers, and provide a blueprint for future research in the field. Research conducted by the Technology Enhanced Learning in Science (TELS) center, funded by the National Science Foundation, documents effective uses of technology for student learning, teaching, and assessment. Inquiry environments combined with powerful scientific visualizations can improve understanding of complex science topics. These environments gather a plethora of evidence about student learning that can inform teachers and strengthen interactions between teachers and learners. By documenting learning as it occurs, researchers gain insight into the effectiveness of specific learning activities and can begin to identify patterns of instruction that have widespread benefits. Policy makers can use the evidence from current research in setting curriculum standards, funding technology, and designing professional development programs to improve science teaching. Researchers can use the TELS instructional modules on topics like meiosis, global climate change, or chemical reactions, knowledge integration assessments, professional development activities, and open source design environment and community at no cost to enhance their own investigations. These resources offer one avenue for creating a vibrant, interconnected, and cumulative research program in science education.

## Han-Chin Liu, Hsueh-Hua Chuang

Investigating the Use of ThinkerTools to Promote Learning of Newton's Laws of Motion - A Case Study

Computer simulations were found to be useful in helping students learn principles of Newtonian motion. This case study investigated how middle school students reacted to a computer program called ¡§ThinkerTools;", and how their use of ThinkerTools package influenced their learning. This study also sought to identify the problems that a particular case encountered while using the program. The student's homework answers were compared against their pretest answers and classroom observations to realize the process of an individual's conceptual change. This case study found that the participant's understanding of Newtonian motion was improved by using Thinker-



Tools program. With the supportive materials and activities, the participant's prior knowledge was connected to the physics principles. Moreover, this program was found promote conceptual change by allowing students to design their own experiments and to observe the results from the computer outcome. The computer activities also promoted interactions between students when they worked in groups collaboratively. However, more guidance would be necessary if the activities require more advanced knowledge to understand the concepts behind the simulations. Otherwise, the simulations would possibly lead students to develop alternative conceptions.

### Xiufeng Liu, BaoHui Zhang, Ling Liang, Gavin Fulmer, Beaumie Kim

Alignment Between the Physics Content Standard and Standardized Test: A Comparison Among US-NY, Singapore, and China-Jiangsu

Alignment between content standards and standardized tests is a significant issue in both social impact and science pedagogy. This study compares the alignment in physics among three education systems: Jiangsu (China), New York (US), and Singapore. A same coding framework for content standards and standardized tests is used to compute the alignment indices in the three education systems. The alignment indices are found to be close among the three education systems. However, there are different emphases of topics in the standardized tests among the three systems; the emphasized topics in the test are also different from that in the content standard within each system. The different emphases on cognitive levels among the three systems as well as within each system on the test and standard are even more apparent. Overall the Chinese test tends to overemphasize cognitive reasoning on Understanding and beyond by deemphasizing Remembering; the Singapore test tends to overemphasize cognitive reasoning on Applying and beyond by deemphasize Remembering and Applying by deemphasizing Understanding. The above findings have important implications for science content standards and classroom instruction.

## Loucas Louca, Zacharias Zacharias, Aristos Evagorou

A Discourse-Based Analysis of Student Inquiry in Elementary Science Classroom: Examining Students' Mechanistic Reasoning, Analogical Reasoning, Argumentation and Scientific explanations

The aim of the study was to analyze a series of elementary student conversations in science, seeking to better understand students' abilities for four particular elements of scientific inquiry in classroom settings, namely, mechanistic reasoning, analogical reasoning, argumentation and scientific explanations. Using four coding schemes adopted from the literature we describe in detail students' mechanistic reasoning, analogical reasoning, argumentation and scientific explanations in authentic science learning contexts. Our findings suggest that the study's participants were able to use a number of different components of the four elements, at various levels of sophistication with the exception of the most sophisticated component of each element. This and other evidence in the literature suggest that prior to any formal instruction students have at least the beginnings of abilities regarding these four elements of scientific inquiry. We also suggest that the role of instruction should be less on the direct teaching of elements of student inquiry and more on recognizing abilities that students already have and help them to develop reliable access to those abilities.

## Loucas Louca, Zacharias Zacharia, Constantinos Constantinou

Describing the Construction Process of Models of Physical Phenomena: A Discourse-Based Analysis of Elementary Student Modeling Conversations

The purpose of this paper was to refine our understanding about how learning in science takes place in approaches that rely on the use of computer-based programming tools for the construction of models of physical phenomena. We analyzed discourse data (student conversations) from six case studies drawn from two elementary science/computer clubs in which students used the Stagecast Creator software to develop models of physical phenomena. In doing so, we seek to provide descriptions of the characteristics of model construction in elementary science education, describe the different types of conversations during the construction of models and the different contexts in



which these conversations took place. The findings revealed three types of student discourse during model construction: (a) the (initial) phenomenological description of the targeted physical system, (b) the operationalization of the physical system's "story", and (c) the construction of algorithms. Additionally, the findings suggest two different contexts for model construction [(i) the translation of the story of a physical system into programming code and (ii) the evaluation of student-constructed models] that can support productive conversations for constructing models of physical phenomena.

#### Julie Luft, Gillian Roehrig, Krista Adams, Selcen Guskey, Sarah Hick, Jonah Firestone

Building a Continuum of Practice: First Year Secondary Science Teachers

The first years of teaching are often described as the most difficult for all teachers. While this point is not debateable, an increasing amount of data suggests that first-year content specialists are impacted in ways not considered by earlier researchers. This study follows 115 first-year secondary science teachers in order to understand how their practices, knowledge bases, and beliefs about teaching change during their first year in the classroom as a newly qualified teacher. The study uses a concurrent mixed methods study (Creswell, 2003), which has a quantitative component to understand the trends and a qualitative aspect to provide insight into our findings. The findings in our analysis reveal, too list a few, the support that a teacher receives may impact the use of certain classroom practices, traditional practices are still prevalent in the classroom, and certain types of knowledge are impacted as a teacher engages in the first year. Ultimately, our data suggest that we need to reconsider how our new science teachers are enculturated into the profession in order to ensure their on-going development and success.

## Julie Luft, Gillian Roehrig, Jennifer Neakrase, Jonah Firestone, Allison Kirchhoff, Selcen Guzey

Exploring the First Year of Teaching in Secondary Science Classrooms

The first years of teaching are often described as the most difficult for all teachers. This poster symposium shares findings from the first year of a longitudinal study that follows 110 first-year secondary science teachers in order to understand how their practices, knowledge bases, and beliefs about teaching change as a newly qualified teacher. Each separate study considers a different aspect of the experiences of a first-year teacher ñ how they interact with different formats of induction, mentors and colleagues, the availability and influences of curricular materials on classroom practices, the impact of teaching out-of-field on classroom practices, the role of teacher preparation programs, and the role of school context. Ultimately, our data suggest that we need to reconsider how our new science teachers are enculturated into the profession in order to ensure their on-going development and success, as well as providing guidance to induction program developers

## Cynthia Lundeen, Diana Rice, Sibel Kaya

The Effects of a Science Teaching Intervention on Elementary Teachers' Beliefs About Science Teaching

Abstract: Limited science teaching time is the pervasive finding when looking at elementary classrooms due in large part to teacher choice. Survey and observational research reveal that students spend consistently less time in science instruction compared to language arts and math (Bybee & Kennedy, 2005). In this study, we examined the results of a Science Teaching Intervention Professional Development Program in terms of teachers' beliefs about their science teaching. Elementary teachers attitudes and time spent teaching science were assessed montly over one school year. Data sources included observations, anecdotal records, interviews and pre- and post- Science Teaching Efficacy Belief survey STEBI-B (N= 25). Results revealed statistical significance in the improvement of science teaching self- efficacy but not in student outcome expectancy beliefs. Teachers' demonstrated heightened confidence and comfort in designing and delivering science lessons individually and cooperatively beyond program completion. A sustained and supportive science professional development program appears to reverse some negative beliefs about science teaching which may increase both quality and quantity of science instruction time within the elementary classrooms.



#### Sharon Lynch, Curtis Pike, Mike Vitale, Nancy Butler-Songer, Carol O'Donnell, Randy Yerrick

Considerations and Complexities of Large Scale Studies

The NARST membership is often responsive to policies and directions for research dictated by funding sources. With recent revisions and reorganizations of several areas of educational research, it is essential that science educators keep in step with new techniques of analysis in educational contexts as well as ethical considerations and implications for large scale studies. The members of this research panel will discus their attempts to employ Hierarchical Linear Models (HLM) of analysis to science education curriculum and instructional and assessment phenomena. Presenters will discuss important considerations for future studies including: 1) design samples, 2) nested effects, 3) power analyses, 4) replication, and 5) effect size. There are many kinds of large scale studies and analyses and specific issues related to quasi experimentation studies that do not take the forefront of NARST discussions but that may have a profound impact on funding and future support of research institutions. It is important that the NARST membership be actively engaged in the public discourse surrounding these studies and it is the intent of this panel to educate the membership (especially the younger members) of issues associated with large scale studies. Audience members will also be invited to speak to issues of large scale studies and future trends of reform and funding for science education.

#### Iris Mackensen-Friedrichs

How Do Domain Specific Learning Stimuli Influence the Students' Self-Explanations While Learning With Worked-Out Examples in Biology?

Previous studies have shown that the effectiveness of learning from worked-out examples depends on the quality and quantity of self-explaining. Many studies indicate that it is easy to influence the quantity and quality of the student's self-explanations, which had a positive influence on the learning outcome. However, it is not known in detail, what the stimuli effect at the level of the self-explanations. So the goal of this study is to analyse, how domain specific learning stimuli that are taken the student's prior knowledge into account influence the self-explanation in detail. For this purpose the instructions in the form of learning stimuli are implemented in a sequence of ten worked-out-examples. These learning stimuli should evoke special kinds of self-explanation like "using prior-knowledge" or "initiating conclusions", which are known to be effective for learning in dependency on the student's prior-knowledge. This special kind of learning stimuli should improve the quality of self-explaining and the learning outcome accordingly. The analysis of thinking aloud protocols show that the special learning stimuli evoke the desired self-explanations and in addition other effective self-explanation, too. So it could be shown that they have a positive influence on the quality of self-explanation and the learning-outcome.

#### Monica Macklin, April Adams

Explicit Nature of Science Instruction: Can It Change In-Service Teachers' Perceptions of NOS?

This paper presents the results of modifications to a science content course to include explicit nature of science instruction. The graduate level course integrates science content and science education concepts. The course included instructional interventions designed to integrate explicit NOS instruction into all aspects of the course. The students were given two assessment instruments (VNOS-B and SUSSI) as pre and post tests. The results indicate that all but one student made gains towards more informed views of the nature of science. A description of the modifications will be discussed. Results of both open-ended written responses and Likert items will be analyzed.

## Kathy Malone

The Effect of Model-Based Physics Instruction on the Development of Problem Solving and Metacognitive Strategies

This study was designed to compare the problem-solving strategies used by high school physics students taught utilizing model-based and nonmodel-based pedagogies. The research questions for this study were: 1) Will the model-based participants demonstrate more iexpert-likeî problem- solving strategies than the nonmodel-based stu-



dents? 2) What metacognitive differences exist between the two groups due to the model-based pedagogy? 3) Will the model-based participants commit fewer physics errors while catching a larger proportion of those errors?

#### Rachel Mamlok-Naaman, Avi Hofstein

New Reform Regarding Students' Assessment in High School Chemistry

The release of the National Science Education Standards in the USA (NRC, 1996) and in other countries around the world was a step of profound importance in achieving scientific literacy for all. The National Science Education Standards define the science content that all students should know and be able to understand. They also provide guidelines to assess the degree to which students have learned that content. The national standards also include the teaching strategies, the professional development, and the support necessary to provide high quality science education to all students. There is no doubt that the new content standards call upon implementation of new and varied pedagogical interventions and instructional techniques, tailored to a diverse student population. As a result, the assessment of students should be multidimensional, drawing information from various sources and based on a variety of teaching and learning techniques. In recent years, similar reform in science education was also conducted in recent years also in Israel (Tomorrow 98, 1992). The study described here was conducted in the context of this reform.

## Charles Mamolo, N. Sanjay Rebello

Future Elementary Teachers' Epistemological Beliefs and Views about the Nature of Science

We administered EBAPS (Epistemological Beliefs in the Physical Sciences) and VNOS (Views of the Nature Of Science) at the beginning and end of a physics course for future elementary teachers. The course was taught in a learning cycle format and involved hands-on activities and active learning in the classroom. We report on the EBAPS and VNOS results. We also compare students' scores on these two survey instruments with scores on other traditional measures of assessment used in the class.

## Constantinos Manoli

Factors Influencing Students' Ecological Actions Following Participation in an Earth Education Program

The purpose of the study was to investigate changes in children's ecological actions after they had attended an educational program. More specific, the study identified potential influencing factors on students' ecological actions and further investigated the effects of these factors on program completion. Participants were 18 6th grade students from three different schools that took part in Earthkeepers, an earth education program. The results revealed a positive relation between program completion and teacher and parent support. However, failure to complete the program was not a good indicator of lack of action.

## Sandra Martell, Elizabeth Drame, Raquel Oxford

Informal Settings for Learning and Achievement:: Museums in Action

The University of Wisconsin-Milwaukee School of Education, Great Lakes Water Institute, and Manfred Olson Planetarium, along with United Community Center, Milwaukee Public Museum, and Friends of Milwaukee's Rivers formed the Informal Settings for Learning and Achievement: Museums in Action (ISLA: MIA) partnership. ISLA: MIA's primary goal is to promote classroom teachers' acquisition of science content knowledge, increased epistemic understanding, positive attitudes towards science, self-efficacy in teaching science and implementation of effective science instructional practices. Project activities promote teachers' socialization into the scientific community in order to foster the engagement of underrepresented and underserved populations in science through community-based informal science learning activities focusing on environmental issues. The theoretical frameworks underpinning the study include the practice-based theory of professional development combined with a cognitive science perspective. This poster will present findings from a pilot study of analyses of several measures



administered to teachers in Milwaukee public schools related to beliefs about science as a discipline and efficacy in teaching science prior to and after participation in informal science activities, including descriptive statistics and multiple regression analysis. The authors predicted that more sophisticated views of the nature of science would occur for teachers if scores on two or more measures increase.

#### Patricia Martinez, Brenda Bannan-Ritland, Anastasia Kitsantas, John Baek

The Impact of an Integrated Science Reading Intervention on Elementary Children's Misconceptions Regarding Slow Geomorphological Changes Caused by Water

This paper describes a design research project which examined the impact of a science- reading integrated instructional sequence (INSCIREAD) for fourth grade dual language learners involving inquiry into the processes related to erosion, deposition, and transportation caused by water movement. INSCIREAD consisted of three phases: a pre- instruction elicitation, an instructional phase, and a post-instruction elicitation of students' ideas. Data sources included both writing and drawing responses from sixty-five fourth grade students including 8 with disabilities. The data sets were analyzed using systemic networks. The semi-quantitative analysis of students' misconceptions before and after the instructional sequence indicated a positive impact, with significant changes being noted in several aspects of children's understanding.

## Lisa Martin-Hansen, John Wilson, Joseph Placanica, Robert Gable

## Effects of Embedding Nature of Science Concepts in a College Level Physical Science Course

Researchers investigated the effects of embedding nature of science (NOS) as an explicitly taught component of an integrated science course and a concurrently taught science teaching methods course. Science concepts and NOS concepts were learned from a historical context through nontraditional textbooks and explicit NOS course activities. In the science content class a modified version of a VNOS questionnaire was given to the students as pre- and post-assessments. The students overwhelmingly changed from naïve views of NOS on the pre-assessment to more informed views on the post-assessment. In addition, some VNOS questions related to atomic structure were incorporated into the final exam. All students demonstrated positive gains in understandings and descriptions of atomic models and why the models changed over time. This question highlighted the importance of learning both science content and NOS content in an integrated way. The science teaching methods instructor observed students applying their integrated science course content in lesson development including both typical science content and NOS during the science content course with the same students, recognized and documented continued expression of NOS understandings and integrations in lesson plans during that semester.

#### Michael Matthews

The Model Muddle: The Necessity of Epistemology for Learning Science

The ubiquity of models in the history and current practice of science is widely recognised, and it is difficult to even think of science without models. Attention to the epistemological side of model construction, functioning and testing is of special current importance because of the unprecedented importance being given to 'Nature of Science' objectives in science curricula around the world. Just as models are ubiquitous in science, so also are 'mental models' (or their surrogates) ubiquitous in studies of the learning of science. But, regrettably, there has been less attention to epistemology in theories of learning than there has been in theories of science. This has contributed to a significant 'model muddle' in science education literature. Most psychologists skirt around the central epistemic question: how do our mental models relate to the world? Although recognising the ubiquity of models in human reasoning is important, and an accomplishment for psychology, this recognition just makes more important the need to combine epistemology with learning theory, the more so for the learning of science.


## Mary Mawn, Kathleen Davis

Elements of Online Inquiry: Integrating Inquiry With Content in an Online Chemistry Course for Teachers

The online learning environment may seem intrinsically text-based; however, through inquiry and constructivist approaches, learners can be engaged in authentic learning experiences that integrate science content and process. Such online courses can provide alternatives for in-service teachers with limited options for professional development due to geographic remoteness, time, or both. This study explores how an online chemistry course supported teachers' learning of science content through inquiry-based instruction. Analysis of course data reveals that teachers worked as scientists as they hypothesized, experimented, analyzed, and discussed fundamental chemical concepts. They used the tools and techniques of science to design and perform investigations, often proposing and carrying out extensions to these investigations, thus continuing the cycle of inquiry. Along with conducting experiments, in-depth dialogue among course participants allowed them to construct new understandings with their online community. Upon completion of this course, pre- and post- course survey data comparisons showed significant gains in teachers' confidence for teaching these concepts to their own students.

#### Kirsten Mawyer, Daniel Edelson

The Influence of Beliefs, Knowledge and Goals on the Implementation of Literacy Strategies in the Science Classroom

Despite great strides in the reform of science education, teachers are not regularly trained to understand the role of discursive and text-based practices in science. One result of this history is that literacy has been insufficiently addressed in science education. This paper contributes to an understanding of the place of literacy in science education. It examines four teachers implementing literacy strategies as they plan and enact environmental and earth science curricula. Drawing on fundamental cognitive constructs, it asks how a teacher's educational beliefs, teacher knowledge and goals influence their implementation of literacy strategies. Findings suggest that over time teachers develop knowledge about literacy strategies that informs an ideal planned curriculum itself also informed by their educational beliefs and goals. This study also contributes to current understandings of curricular design as an ongoing process that takes into account the practices of teachers including the implementation of literacy strategies, the planning and enactment of the curriculum. Ultimately, this paper suggests that the future design and refinement of curricular and professional development materials better support science teacher learning.

## Dyan McBride, Dean Zollman

Investigating Students' Ideas About Wavefront Aberrometry

We describe a qualitative study of student understanding of the functions of the human eye and the resources used in understanding wavefront aberrometry, a relatively new method of diagnosing vision defects. Twelve students enrolled in an introductory physics class participated in a semi-structured clinical interview in which the functions of the eye, traditional diagnosis methods such as the eye chart and wavefront aberrometry were discussed. Results from this study indicate that students do not initially understand the subjective nature of traditional diagnosis techniques and that the use of physical models of the eye and aberrometer can facilitate the transfer of prior knowledge to these concepts.

## Cherie McCollough

New Pre-Service Experiences in Authentic Settings: Family Learning Events in Science Teacher Education

While the literature states that education must involve instruction that is linguistically and culturally appropriate, the majority of teacher training programs in universities and colleges have little experience working with diverse students and their families. In addition, teacher education programs often function in isolated spaces that have little to do with authentic experiences outside of educational institutions. One strategy that has been shown to be successful is the use of Family Learning Events where culturally relevant examples, materials, and activities are structured to encourage parent and child teams to work together to solve problems or investigate natural phenom-



ena. Rather than operating within a conventional field experience, the Family Learning Event model provides a more open, fluid, improvisational and collaborative pedagogical model that is designed to foster development of skills necessary to operate creatively in a complex and dynamic school environment. After initial conflict in the form of anxiety and even fear, pre-service teachers reported having a strong sense of excitement and inspiration. Pre-service teachers reported that they learned to see science everywhere, to integrate scientific experiments with artistic activities, to take risks, and not to underestimate the students' abilities as they interacted with students and their parents.

## Michelle McCombs, Marco Molinaro, Ken Peterson, Richard Ponzio

Preliminary Use of an Assessment for Scientific Inquiry Creativity

Enhancing K-12 students' understanding of inquiry and approaching problems in a scientific manner, much in the same way a scientist would, has been a goal of science education reform (AAAS, 1993; O'Neill & Polman, 2004). This paper presents preliminary results for a new technique for assessing Scientific Inquiry Creativity. Biology students in an urban high school and undergraduates at a local research university were given a timed pencil and paper creativity assessment. This assessment was based upon observations and creative thinking made when a white powder (baking soda) interacted with a clear liquid (vinegar) in a bottle capped with a balloon. Creativity was measured by counting the number of responses (fluidity), responses not cued from visible materials (imagination), and numbers of responses given by fewer than 10% of large samples of students using these procedures (divergence). Preliminary results indicate a statistically significant increase in Scientific Inquiry Creativity Assessment (SICA) score between pre and post instruction, for both these High School and Undergraduate science classes. We conclude that the SICA procedure is effective for documenting the learning, which results from science problembased inquiry (Delisle, 1997) and confirms the earlier similar findings of Peterson (1978).

## Tom McConnell, Tianyi Zhang, Meilan Zhang, Mary Lundeberg, Jan Eberhardt

"I'm Invested in the Outcome": Professional Development that Matters in the Eyes of Teachers

The purpose of this study was to identify patterns in teachers' perceptions about what matters in professional development. Individual and focus group interview responses from thirteen K-12 teachers provided insight into the factors teachers consider when they decide to enroll in and continue participating in an extended science teacher professional development program. One group of four participants had enrolled in a third year of the program, while another group of nine teachers were interviewed as they were ending their participation in the project. Findings of the study suggest that several features should be included in the design of professional development in order to attract and retain teachers. Among these are an emphasis on content learning in topics chosen by participants, time to develop and implement curriculum in participants' classrooms, a wide range of resources to support teacher learning, on-going collaborative analysis of practice in learning communities, and an atmosphere of professional development standards and design guidelines, but also emphasize the importance of considering the needs of the target audience when designing professional development.

## Barry McCrae, Raymond Adams, Peter Fensham, Robert Laurie, Rodger Bybee, Manfred Prenzel

PISA 2006: Results from an International Assessment of Scientific Literacy

In December 2007 the Organization for Economic Cooperation and Development (OECD) will release the international results for the 2006 Program for International Student Assessment (PISA). PISA 2006 had science as the major domain; mathematics and reading were minor domains. PISA 2006 included 55 countries and approximately 500,000 students. The assessment emphasizes 15-year-olds' performance on science competencies (as opposed to curriculum oriented assessments; e.g., TIMSS). This symposium will include: 1) an introduction to PISA 2006 and an overview of results; 2) a description of the design, development, and implementation of the assessment; 3) specific results for student performance on iknowledge about science; 14) the assessment of attitudes;



and 5) implications for public policy. The presenters all participated on the iscience expert groupî that oversaw the 2006 science assessment.

## Jim McDonald, Catherine Koehler,

Membership and Elections Committee-Sponsored Session: New Researcher and Junior Faculty Early Career Discussion

Membership and Elections Committee Organised Session: New Researcher and Junior Faculty Early Career Discussion Organisers: Catherine M. Koehler, University of Cincinnati; Jim McDonald, Central Michigan University. Chair: Jim McDonald, Central Michigan University The position of assistant professor at a university can be overwhelming for many academics. The pressures of tenure, publications, teaching and research are suddenly thrust upon junior faculty and often- times, they are unsupported by senior faculty at their home institution. The protective blanket of graduate school has dissolved and new career support is essential. NARST supports new researchers and junior faculty by providing a venue where ideas and issues can be discussed in an open forum. This session is particularly designed for the early career, junior faculty who need support during the first years of their academic career. The focus will be a panel discussion with experienced faculty who can guide junior faculty through important issues that pertain to the tenure process and other issues. Discussion topics include, but are not limited to: publications, research in the new position, collaboration with different colleges within the university setting, teaching loads, etc. We invite all junior faculty interested in this topic to join us.

## Scott McDonald

Understanding Professional Vision in Inquiry Science Teaching

Classroom inquiry science teaching as a form of pedagogy is universally advocated in science education. However, what inquiry science teaching looks like in real classrooms is lost somewhere between high-level standards describing broad classroom scientific practices and particular idealized examples of inquiry used to exemplify the standards. In addition, examples from typical classrooms are problematic as novice teachers cannot attend to the aspects of practice critical to understand when teaching is inquiry science and when it is not. In other words, they cannot iseeî a classroom as an expert does ñ they do not have professional vision. This study investigates the questions: How do expert and novice teachers see science teaching differently? And how can these differences begin to define categories that comprise professional vision in the context of classroom inquiry science teaching? The study occurred in the context of the Invisible College of Inquiry Science Study (ICISS), a professional learning community consisting of practicing and prospective science teachers, graduate students and university faculty in science education. Results suggest that novice and expert teachers see science teaching quite differently in terms of pointof-view, activity and grain-size and these differences create significant barriers to novices' understanding of inquiry science teaching.

## Christine McDonald

Exploring the Influence of an Argumentation-Based Science Content Course on Preservice Elementary Teachers' Views of Nature of Science

The purpose of this paper is to explore five preservice elementary teachers' views of nature of science (NOS) in a science content course. The existing science content course was modified to include explicit, contextualised NOS instruction, and explicit argumentation instruction in both scientific and socioscientific contexts. Data sources included open-ended questionnaires, interviews, classroom discourse, and written artefacts. Results indicated that all five of the participants expressed limited views of the majority of the examined NOS aspects at the commencement of the study. At the conclusion of the study four of the five participants expressed improved understandings of the majority of the examined NOS aspects. This paper will examine influential factors such as the context of argumentation, and pre-existing beliefs about NOS on the development of participants' views of NOS. The paper will conclude with some implications for future research involving NOS and argumentation in preservice teacher education.



#### James McDonald

Facilitating Content Knowledge Through In-depth Examination of Environmental Issues

The purpose of this presentation is to communicate the findings of a science learning action team project completed in a required elementary science methods course and a required introductory environmental education course that allowed students to gain knowledge and develop skills that will lead to more science content knowledge of an issue that they researched. Pretest results indicate that students were willing to take passive sorts of action on environmental issues. Overall results show that students could make a difference concerning local environmental problems after doing extensive research on the environmental issues over the course of a semester long project.

## Jacqueline McDonnough, Juanita Jo Matkins

Field Experiences of Elementary Preservice Teachers: Does the Involvement of the Science Methods Instructor Make a Difference in New Teacher Confidence?

The focus of the study was to compare the effect of variations in field experience at two institutions on the science teaching confidence of elementary preservice teachers. Participants in the study were preservice teachers enrolled in graduate-level elementary education programs. Preservice elementary teachers were administered the STEBI-B instrument to measure their self-efficacy at the beginning and near the end of the science methods courses at both institutions. In addition, six students at each institution were selected for structured interviews. A Mann-Whitney U test was conducted to evaluate the hypothesis that students with embedded field experiences would score higher, on average than preservice teachers without that experience. The results of the test were significant, z = .284, p = .024. As expected the Institution B preservice teachers with the embedded field experience had an average rank of 54.47, while the Institution A preservice teachers had an average rank of 47.87. These results give support to the practice of closely linking the field experience of preservice elementary teachers to their science methods course. The study supports the practice of embedding field experience with the science methods course in addition to the concentrated student teaching experience that is common practice in teacher education programs.

## J. Randy McGinnis, Angelo Collins

Publications Advisory Committee-Sponsored Session: Publication in the Journal of Research in Science Teaching

Participants in this session will become familiar with the submission, review, and the communication process of the Journal of Research in Science Teaching. This session welcomes all those who are interested in submitting and publishing articles in JRST or anyone who would like to become a reviewer for the journal. JRST Editors, Associate Editors, Editorial Board Members, reviewers and JRST Editorial Office Staff will be present to share information, experiences, and answer questions.

## J. Randy McGinnis, Marbach-Ad Gili, Dantley Dantley, Benson Spencer, Amy Dai, Rebecca Pease

Landscape Baseline Data in a Large Scale Science Teacher Preparation Model

The project reported was designed to develop and test a science teacher professional development model that prepares, supports and sustains upper elementary and middle level specialist science teachers. It was a funded NSF project in the Teacher Professional Continuum program. The participants (interns and beginning science teachers) were hypothesized to benefit from a baccalaureate program that featured connecting transformative undergraduate science content courses with reform-aligned science method courses, supported internship experiences with adolescent students in informal education contexts, field placements in urban professional development schools, and ongoing innovative educational experiences that targeted the needs of minority and urban students. Two different types of universities participated in the project: a Historically Black College/University (HBCU) and a Predominately White University/College (PWUC). We collected baseline data that revealed a landscape in science teacher preparation. Firstly, we audiotaped and analyzed the institutions' science and education advisors' reported beliefs



and stated actions regarding the recruitment of college students to science teaching, particularly African Americans. Secondly, we collected and analyzed responses to a valid and reliable survey by all the previous year's graduates of the two institution's teacher preparation programs. Constructs analyzed included respondents' attitudes, beliefs and practices of science and science teaching. Findings were reported.

## Rebecca McNall, Joe Straley, Sally Shafer, Kelly Bradley, Jessica Cunningham, Jeffrey Osborn

Do Middle School Teachers Integrate Content They Learn in a Physical Science Distance Learning Course into Their Instruction?

Distance education programs are becoming increasingly popular at institutions of higher education due to their low cost and the large audiences serve. It might also be a potentially powerful medium for professional development in science. Researchers at a large mid- western university have developed a distance education project which offers hands-on inquiry based physical science courses to middle school teachers in Central Appalachia. Preliminary findings have indicated substantial gains in teachers' content knowledge after completing the course (Author, 2007). This case study investigated how a subgroup of teachers to complete the temperature and heat course content and activities they learned in the course integrated into their instruction. Ten teachers were observed twice during units on temperature and heat. Pre and post observation interviews also were conducted to learn of teachers' experiences teaching the lessons observed. Findings indicated all 10 teachers integrated course content and activities in a logical manner compared to teachers with fewer years experience. Additional descriptions of teachers' integration of inquiry are discussed. Study findings suggest distance learning could be an effective medium for science professional development programs in rural areas.

#### Colleen Megowan-Romanowicz

Framing Student Discourse for Optimal Learning in Physics

This study considers the dynamics of group cognition and learning in physics and mathematics classes taught with the Modeling Instruction technique (Hestenes, 1996). Observations were made in four different settings: a middle-school math and science resource class, a 9th grade physical science class, an honors physics class in high school and an engineering physics class at a community college. Video tapes taken in the classes were transcribed and analyzed to discern how the students' conversation about space, time and interactions were shaped by their conceptual structures and the spatial representations they created to represent them.

## Brett Merritt

A Matter of Concern: Marginalizing the Voice of Reason(ing) in College Science Teaching

There is a long history of philosophical debate about the degree to which the discipline of science itself is a discursive/linguistic construct, but regardless, many university science courses construct science de facto for their students discursively/linguistically. Especially in large-enrollment courses, students are regularly offered science content through lectures where the course instructor bears most of the discursive responsibility. For teacher educators, the implications of this linguistic construction are significant: the lecture constitutes a major site—especially for prospective science teachers attending these courses as students—for the construction of science, as a subject matter, and what it might mean to reason scientifically. If teacher educators desire a clearer understanding of how science and scientific reasoning have been constructed for their prospective science teachers, it follows that they should pay closer attention to the instructional discourse occurring in undergraduate courses. In this paper, I use the example of a four-day unit on photosynthesis in an undergraduate biology course to illustrate how two coinstructor's discourse can relegate important, disciplinary-specific organizing concepts to the instructional (i.e., linguistic) periphery of the course. In residence at the periphery, these concepts are rendered unavailable to students in their repeated attempts to understand key ideas in biology.



## Xenia Meyer, Barbara Crawford

The City as A Research Site: Using Inquiry with English Language Learning Students in an Urban Middle School to Investigate Ecological Concepts

This study took place in a science class at Eastern Middle School (EMS) [pseudonym] in New York City. EMS provides bilingual instruction to nearly 180 linguistically and culturally diverse students at the 6th, 7th, and 8th grade levels from predominantly Latino backgrounds. Teachers at the school recently developed and adopted integrated curriculum focused on ecological concepts and inquiry across the school with the goal of increasing students' interest in school and engaging them in active and meaningful learning. As a part of the restructured curriculum, the entire school participates in an Integrated Projects Month (IPM), when students and teachers conduct locally-situated experiential investigations. We were interested in how this form of instruction could be instructionally and culturally congruent to students' backgrounds and how it might support them in conducting inquiry and learning about the nature of science. Findings from this exploratory study of curricular changes have implications for educational programs working with black, Latino, English language learning, or other marginalized students, and provide promise for school sites with similar demographics to implement similar instructional approaches.

## Shirley Miedijensky, Tali Tal

Embedded Assessment for Learning: Students' Views

This study aimed at describing students' views of assessment and understanding how the employment of Embedded Assessment for Learning (EAfL) affects these views. The theoretical framework focuses on assessment for learning, multiple assessment modes and gifted education. The participants were 60 gifted students participating in three programs for the gifted who elected Project-Based Science courses. The data included questionnaires, distributed at the beginning and at the end of the assessment processes, and in-depth interviews with 12 students. The questionnaires and the interviews were analyzed according to three main categories that addressed the students' views regarding: the concept of assessment, different assessment modes, and connections between assessment and learning. These categories were then classified to subcategories that emerged from the data. We found that students viewed the EAfL as an integral part of the learning process, and perceived it as a means to express autonomous learning and a range of performances, which corresponds with their unique needs of learning. In addition, Students addressed to cognitive and social processes they undergone. This implies that assessment which is explicitly designed to promote learning can be a powerful tool for teachers as well as for students, and can enhance meaningful and life-long learning.

## Helmut Mikelskis, Lutz Kasper

A Dispute on Colour Optics

In this study we make a research contribution in the field of history and nature of science as a basis for learning physics. Dialogues have always been used as a media for instruction throughout the history. However, we chose to create a fictional dialogue since the Goethe- Newton-controversy seems to be unique and exemplary at the same time. Goethe's critique focuses sharply on traits in Newton, which are characteristic features of modern natural science. In the developed dialogue authentic source material is used. The project is also a contribution to empirical research on multimedia learning, since the dialogue is designed to be presented in a computer learning environment and was evaluated in an empirical study. Physics teacher students in their second year of study show astonishing poor knowledge about the subject of the dialogue. Therefore factual information is given, to understand the core of the controversy. As evaluation data show students are interested in the multimedia program and ask for more information about other controversies in science. 'Scientific dialogues' may open the door for interest in science in general, because science learning should be more than a pure accumulation of facts, but rather an introduction into the nature of science.



## Silke Mikelskis-Seifert, Julie Luft, Rainer Wackermann, Georg Trendel, Hans Fischer

Can a Learning-process Oriented Training of Physics Teachers Using Video-Feedback Alter Teachers' Subjective Beliefs?

We conducted a learning-process oriented training of physics teachers and evaluated its effects on teachers' subjective beliefs. Sample size is 2x18 in-service physics teachers in a quasi-experimental pre-post-design with control group. Theoretical background of the training is the theory of basis models of teaching and learning by Oser and Baeriswyl. Learning-process orien-tation is thus operationalized as basis model orientation. Main features of the intervention com-prise coaching of physics lessons, video analysis according to the theory of basis models and post-reflection with teachers. Participating teachers were investigated in areas of education aims and professional aims as well as perceived personal achievement of those aims. The training could, as expected, significantly alter the intervention group teachers' views on importance of instructional aims and importance of professional development, but not the variables of achieve-ment of aims. However, a subgroup of five teachers within the intervention group, who put an especially big amount of effort into the training, reports significant achievement increases, which is supported by additional student and classroom data. In future therefore, evaluation pro-grammes should control for intensity of training and/or efforts put into training by participants and include evaluation levels of student outcome and classroom actions.

#### Silke Mikelskis-Seifert, Reinders Duit

Physics Teacher Professional Development in the Program "Physics in Context"

iPhysics in Contextî (Piko) is a project funded by the German Ministry for Education and Research. 15 teams of some 10 teachers each from 11 of the 16 German federal states participate. The key goal of the project is to improve the range and quality of teachers' thinking about teaching and learning physics as well as their teaching behaviour by developing new teaching and learning methods. The process of improving teachers' thinking is deliberately supported. Evaluation includes teacher and student measures. Results of the evaluation show that teachers in general are very pleased with their work in Piko. They also claim that their way of thinking about instruction as well as their way of teaching changed significantly. Questionnaires provided at the beginning and the end of a school year reveal that teachers' beliefs on various scales did not change but their perceptions of the own instruction changed as claimed by the teachers and second that student affective variables (like interest and self-concept) did not decrease during a school-year as was the case for a control group. These generally positive results will be critically discussed.

## **Chris Miller**

The Impact of State Testing Under NCLB on Elementary Science Curriculum

This paper reports on a study of the impact of state science tests on the elementary science curriculum and curriculum management in three Wisconsin school districts during 2004 and 2005. The study suggests that state testing in science under NCLB can bring a focus to elementary science programs and accelerate the alignment of curriculum to state standards in elementary schools when the capacity to do so exists at the central office. The study also revealed that organizational structures at the central office level may change in response to the need to articulate curriculum across grades and schools.

## Catherine Milne, Jimmy Ma

Using Rasch Analysis and Classroom Observations to Examine High-Stakes Testing

Using probabilistic Rasch Analysis we examine students' responses to a Regents' Chemistry exam, make predictions and analyze student responses using observational data from a year-long examination of the teaching and learning of chemistry in an urban high school. We also use Rasch to analyze differential item functioning to identify the items on the Chemistry Regents' exam that males and females answer differentially. Our analysis using



both observations and Rasch analysis indicates some of the limitations of the Chemistry Regents' exam for students whose experiences of the phenomena, explanations, and symbolism of chemistry has been limited prior to their participation in the Regents' chemistry course. Most importantly the study highlights the lack of connection between the chemistry curriculum as represented by the exam and students everyday chemistry experiences leading us to argue for the need to critically evaluate the current chemistry curriculum.

## Rommel Miranda

## Highly Qualified Does Not Equal High Quality: A Study of Urban Stakeholders' Perceptions of Quality in Science Teaching

This qualitative study sought to determine the perceptions that urban stakeholders hold about what constitutes high quality in science teaching, and the extent to which urban high school teachers who meet the criteria for being "highly qualified", as defined by the NCLB Act, possess the characteristics identified by stakeholders as being evidence of high quality in science teaching. The findings suggest that there is little congruence between urban stakeholders' view of high quality in science teaching and policy makers' and politicians' view of a "highly qualified" teacher. The findings further reveal that some of the urban high school science teachers who were deemed to be "highly qualified", as defined by the NCLB Act, engaged in practices that threatened quality in science teaching and often failed to display the characteristics which urban stakeholders hold as evidence of high quality in science teaching. Thus, the criteria for "highly qualified" prescribed by policy makers and politicians do not necessarily translate into effective science teaching in urban settings. These findings emphasize the importance of stakeholder involvement in the design of educational reform initiatives.

## Nicola Mittelsten Scheid, Corinna Hößle

Students' Competence of Argumentation

ABSTRACT (180 words) With the development of new technologies in biology and medicine moral judgement competence recently has become an important aspect of science education. In reaction to that, Germany's state ministers of education decided that students should learn this competence in secondary school. This study explores and categorises structures and levels of students' moral judgment competence within science education. We have analyzed 108 interviews of 8th and 10th grade students by qualitative content analysis and quantitative approaches (frequent analysis and latent class analysis). This paper presents the research on students' argumentation competence as one skill of moral judgment competence. Our main research questions is: To which extent are students able to put forward arguments, especially those that are arguments opponent to their personal point of view? Secondly, we investigate how students are able to analyse and combine essential elements of argumentations. For this, we referred mainly to theories on both argumentation in natural settings as well as philosophical reasoning. Our findings indicate both theoretically and statistically firmed levels. They may serve to evaluate and stimulate students' competence in science teaching and learning.

## Andrea Moeller, Christiane Grube, Juergen Mayer

Skills and Levels of Students' Inquiry Competence in Lower Secondary Biology Education (Grade 5-10)

The aim of our study was to empirically differentiate inquiry skills as well as levels of inquiry competence. On the basis of 24 open test items a multi-matrix design was used to test 1700 German students (grades 5-10) on their inquiry competence. The used items equally represented four predicted inquiry skills "formulating questions", "generating hypotheses", "planning of investigation", and "interpreting data". Each skill was divided in five competence levels, hierarchized after degree of difficulty. Factor analysis supports the existence of the four predicted skills as domains of one common competence. The four skills correlated in a small to medium range. All five expected qualitative competence levels for each skill were present and percentages increased with grade. Higher levels are positively correlated with biology subject knowledge. Overall students' abilities are lower than required in the German Federal Education Standards for biology education in grade 5-10. Our results strongly suggest to implement scientific inquiry as a standard within the German science curriculum. Also, the confirmation of the predicted



inquiry skills and levels may provide a guideline for teachers on how to assess and approach students' individual competences. Implications for novel teaching concepts that are adjusted to different performance levels are discussed.

## Sabine Mogge, Helmut Vogt, Bernd Wollring

Qualitative Analysis of Primary Level Students' Scientific Competencies Working With M(odeling)-Open Problems

Qualitative analysis of primary level students' scientific competencies working with M (odeling)-open problems The presented study aims at investigating and evaluating scientific competencies of selected primary level students when working with biological or mathematical M(odeling)-open problems, the above subject to their typological occurrence of attitude towards school and Sachunterricht lessons (TOASL: Zest-for-Learning-Type (ZLT), Bored-Frustrated-Type (BFT) and Aim-oriented-Achievement-Type (AAT)). During the survey, the students worked on two input-based M-open problems from the biological and mathematical domain, first individually, then in collaboration with a student of the same TOASL. By analyzing the data with a newly developed competence matrix, we found that the students increased the range of competencies (i. e. the number of shown (sub )competencies) from the individual to the collaborative treatment, but not the penetration of these competencies. Differentiated by domain, the students showed a greater competency range for the mathematical domain than for the biological one, while there were no noticeable differences concerning the penetration. In turn the three types of attitude do not distinguish remarkably as to the range of competencies, but the students of the ZLT and of the AAT demonstrated a greater penetration than those of the BFT.

## Lindsey Mohan

Orchestrating Productive Discussions: A Study of Dialogic Exchange in Science Classrooms

The focus of this study was to develop a theory of dialogic exchange in science classrooms. Research on classroom discourse has primarily documented one type of classroom interaction more than any other: the initiate, respond, evaluate (IRE) structure. Rather, the goal in this study was to develop an understanding of classroom discussions that do not use IRE, but instead are more dialogic. We videotaped the classroom discussions of three exemplary science teachers and conducted video recall sessions and interviews with the teachers. We found numerous features that distinguish dialogic discussions from those seen during traditional recitation. Students tend to ask more questions of the teacher and their peers, as well as evaluate each other's ideas. Students' explanations are positioned in alignment or opposition to one another using a variety of discussive moves by the teacher and students. Evidence becomes of critical tool for evaluating competing perspectives and coming to consensus about the most plausible explanation. We argue that dialogic exchange is critical for engaging students in ways of thinking and communicating not only during classrooms discussions, but also for making decisions as citizens.

## Rachel Moll

Enabling Constraints: How Physics Olympics Competitions Can Create Meaningful Learning Experiences

This paper reports on a study that investigated studentsâ€<sup>M</sup> experiences of participating in a Physics Olympics event. The study was guided by the question: what structures or features of the Physics Olympics and its activities promote meaningful learning experiences for senior high school physics students? Objects of study at several levels of analysis (individual students, teams and projects) displayed key characteristics of complex systems such as self organization, coherence, diversity, and emergence. It was also clear that participating in the event was an intense emotional experience therefore meaningful learning will be examined by drawing heavily on complexity thinking in education and by paying particular attention to affective constructs such as emotions, science identity and attitudes towards science. The complexity of the system and its enabling constraints were supported using student experiences and interview data. Characteristics shared by the Physics Olympics and complex systems were described and it was clear that many of these characteristics promote conditions of emergence and learning. Enabling constraints such as employing decentralized control and neighbour interactions were explored and the results



provided recommendations for classroom applications such as introducing students to a community of practice of physics and engaging them in emotionally engaging activities such as challenging design projects.

## Rebecca Monhardt, Vessela Ilieva, James Barta, Kurt Becker

Community Advisory Panels in American Indian School Communities

As part of the NSF funded project, Communities of Effective Practice: A Professional STEM Development Model for Teachers of American Indian Students, Community Advisory Panels (CAPs) were established in two schools in American Indian communities in the Intermountain West. One school community served predominantly Ute students; the other Navajo. The role of the CAPs in each of the communities was to provide guidance in the creation of a teacher professional development model for teachers in grades 4-6. The intended goal the professional development experience is to help teachers develop strategies for the delivery of student-centered, culturally responsive STEM instruction, reflecting a balance between students' home and school cultures. By incorporating the best of both worlds, it is believed that relevancy and meaning will be created for students which will ultimately result in their increased success in school. This paper will describe the process of establishing the CAPs, focusing on both challenges and positive outcomes. Recommendations for others who choose to use a similar model to guide professional development in American Indian communities will be shared.

## Felicia Moore, Magnia George, Eileen Parson, Brian Williams, Jomo Mutegi, Bryan Brown

Promoting New Directions in Science Education: Part 2, Conceptual Frameworks

The purpose of this symposium is to present new or under-utilized approaches for addressing issues we feel are pertinent to research in science education around issues of diversity, equity, teacher education, and student learning. Drawing upon multiple theoretical frameworks, positions, and research approaches, this symposium takes seriously the notion of transforming, challenging, and educating teachers and students in science education around challenging issues facing educators and researchers in education. Therefore, we invite teacher educators and graduate students who are who are interested in understanding what it takes to think critically and creatively in meeting the needs of diverse students. Part 1 of this symposium (NARST 2007) focused on research done by six science educators related to diversity in teacher education, language, and race. In Part 2 of the symposium, we will present the theoretical frameworks or iconceptual toolsî that guide our research and teaching.

## Felicia Moore, Alejandro Gallard

Equity and Ethics Committee-Sponsored Pre-Conference Workshop: Building a Community of Scholars in NARST: Gaining Strength Through Diversity

The focus of this workshop will be on strategies for building a stronger community of scholars in science education. A particular focus will be on the needs and experiences of scholars of color, with attention paid to what it means to develop a research trajectory and to gain voice in the academy. The conference will be structured to allow participants to work in groups that reflect their current place in the academy (i.e., pre-and post-proposal graduate students, early career faculty with 1-2 years, and early career1faculty with 3 or more years) in order to allow the workshop to be tailored to the specific needs of individuals.1The workshop will begin with an opening keynote by Felicia M. Moore with the theme of "Good Beginnings," which will focus on how scholarship in progress (particularly towards a doctoral dissertation) represents a beginning, and some strategies for making a good beginning.1The keynote will be followed by small working groups, each headed by two scholars of color, presently active in NARST. The workshop will close with a concluding keynote by Alejandro J. Gallard, who will speak about his international efforts to craft a research agenda focused on equity and excellence, what scholars of color can expect as they seek to author a space in the academy, and how to meet those challenges and opportunities.



#### Felicia Moore

Planning and Teaching in Culturally Responsive Ways: Elementary Preservice Teachers' Integration of Multicultural Themes and Goals in Science Curriculum

Using excerpts from final microteaching papers, this study highlights elementary preservice teachers' reflective comments on planning, teaching and assessing science in multicultural ways in urban elementary classrooms. Specific examples the teachers provide in support of multicultural themes and goals in curriculum materials using the Project 2061 analysis criteria, Banks' typology of multicultural education, Gay's tenets of culturally responsive teaching, and Ladson-Billings characteristics of culturally relevant teaching are presented. Implications for teacher education and curriculum development are discussed.

## Nancy Morabito, Kefyn Catley, Laura Novick

*Lizards and Frogs or Lizards and Mammals: University Students' Understanding of Most Recent Common Ancestry* In its current form, evolution education is replete with information about Darwin's theory of evolution through natural selection and its supporting evidence. Despite this focus, as well as the widely-accepted view of the importance of evolution instruction, curricular materials developed for the teaching of these concepts fail to convey many other fundamental facets of evolutionary theory. One concept which is typically overlooked is that of common ancestry and its relevance for investigating evolutionary relationships among taxa. This paper provides evidence that students fail to acquire and/or retain an understanding of the significance of most recent common ancestry when considering such relationships, regardless of their exposure to these concepts throughout their K-12 and postsecondary education. Although having greater background knowledge improved the accuracy with which subjects could identify a diagram depicting evolutionary relationships among three familiar extant taxa, the overall performance of all subjects was poor. A stronger background in biology also appeared to have some positive effects on how subjects explained their reasoning about these taxa. Regardless, the results indicate a need to improve evolution education in order to ensure that students acquire a deeper understanding of relationships among taxa and, consequently, evolutionary processes as a whole.

## Eduardo Mortimer, Marina Lima-Tavares, Maria Pilar Jiménez-Aleixandre

Exploring Students' Dialogue with Evolution and the Influence of their Questions in the Teacher's Discourse

Exploring Students' Dialogue with Evolution and the Influence of their Questions in the Teacher's discourse Eduardo Fleury Mortimer1, Marina de Lima-Tavares1 & Mar'a Pilar Jiménez-Aleixandre2 1 Universidade Federal de Minas Gerais, Brazil, 2 Universidade de Santiago de Compostela, Spain This paper examines the episodes initiated by student's deep reasoning questions during three sessions of a teaching sequence on evolution in the 12th grade. The focus is on the dialogue that the students establish with the thematic content of the lessons, and on the ways in which their spontaneous questions influence the teacher's discourse. The students' questions were subjected to a double analysis: 1) in terms of epistemic practices, that is, in connection to knowledge construction; and 2) in terms of its thematic content. In terms of epistemic practices, the results show that the questions belong to these categories: knowledge articulation (e.g., transfer, establishing connections); difficulties in meaning making; acknowledging social legitimization (NOS); connecting content with daily life, media etc. In terms of the thematic content, the questions that exerted greater influence on the classroom discourse were related to cloning and to the mechanisms of speciation. The subtle ways in which the teacher adjusted the planned explanatory structure of the lesson to account for the questions are also discussed.

**Rosa Moscarella, Mark Urban-Lurain, John Merrill, Gail Richmond, Ronald Patterson, Joyce Parker** Understanding Undergraduate Students' Conceptions In Science: Using Lexical Analysis Software to Analyze Students' Constructed Responses in Biology

The large enrollment of many undergraduate introductory science courses often restricts assessment to multiple



choice exams. However, constructed response assessments may better reveal student conceptual barriers. We explored the feasibility of using lexical analysis software to help identify biological concepts in students' open-ended responses. We created two items in an on-line course management system where we asked students to trace carbon during cell respiration. Data were collected during the fall semesters of 2004 and 2006. We created a custom library of biological terms using SPSS Text Analysis for Surveys which we used to analyze students' open-ended responses. With the custom library, we were able to correctly classify 90% of student responses. Comparing pre- to post-tests, a larger proportion of students provided more accurate responses on the post-test, but also the proportion of students that provided vague responses slightly increased. Additionally, students seem to understand where the carbon is, but they are either confused about the processes by which it got there or they understand the processes, but do not know the compounds. We believe that lexical analysis software can be used to help instructors assess students' conceptual barriers to improve science instruction.

#### Hedy Moscovici, Irene Osisioma

Navigating the Bottleneck of Curriculum Planning: Exploring the Struggles in planning the Pre-service Elementary Science Method Course.

This paper is an account of the struggles of two secondary science faculty as they navigate the bottleneck of planning a course for pre-service elementary teachers. Through introspective reflection, the faculty elaborates on how they built upon past experiences of teaching education and science courses in general, recommendations from national and state documents and state requirements regarding teacher accreditation, as well as extensive literature search to uncover the complexity involved in making decisions regarding the course. This reflection also gives account of their effort to develop goals, course assignments, assessment strategies, and course materials, all in an effort to better prepare the pre-service elementary teachers to be able to meet the new demands in contextualized urban science classrooms focusing on inquiry science and students' use of higher order cognitive skills.

## Richard Moyer, Susan Everett

Examining the Ability to Construct a 5E Learning Cycle Science Lesson Plan

Engaging students in inquiry-based science is fundamental to the national reform movement in science education. One common pedagogy for inquiry-based science teaching is the learning cycle approach. Many students continually struggle with writing an inquiry-based lesson plan that follows the 5 E format. This study investigates the relationship between the ability to write inquiry-based lessons and three key factors—content knowledge, ability to modify demonstration activities and the ability to identify variables in a hands on investigation. Using an exam we evaluated the inquiry-lesson plan writing ability of pre-service elementary teachers who were enrolled in one section of an elementary science methods course. The two factors that correlated significantly with the exam score were science content knowledge and the ability to construct effective explorable questions. There was little correlation between identifying variables and the exam score and a small negative correlation between the exam score and the number of science credits earned. Further, we established that the most difficult phase of the learning cycle was the engage where pre-service teachers are required to set up an explorable question for students to investigate. If teachers are unable to develop an effective question, success with inquiry-based science teaching seems doubtful.

## Frackson Mumba, Vivien Chabalengula, William Hunter

Balance of Scientific Literacy Themes in Zambian High School Chemistry Textbooks, Syllabus and Examinations

The purpose of this study was to find out the extent to which scientific literacy themes are balanced and emphasized in the current Zambian high school chemistry course in an attempt to find out whether or not the course has the potential to contribute to the preparation of scientifically literate citizens. Analyses of the national chemistry course materials were carried out following a valid and reliable framework and procedure developed by Chiapetta, et al. (1991). Results show that chemistry textbooks placed more emphasis on basic knowledge of science while the chemistry syllabus and grade 12 final practical examinations emphasized the investigative nature of science theme.



The interaction of science, technology and society theme was the least emphasized in the chemistry course. However, the high school chemistry course has the potential to contribute to the preparation of scientifically literate citizens. Implications for curriculum development and teaching and learning have been stated and discussed.

## John Murdock

Comparison of Curricular Emphasis on Inquiry and NAEP Science Scores

Comparison of curricular emphasis on inquiry and NAEP science scores Abstract This study will examine the relationships between inquiry, state standards, and National Assessment of Educational Progress (NAEP) scores. This study is a descriptive, exploratory analysis. The findings will describe relationships that exist between inquiry emphasis in state curricula and student learning of science. Each state's K-8 science curriculum will be analyzed to describe the emphasis within the grade level expectations related to inquiry, and a survey will be used to measure the overall emphasis on inquiry in each state. The NAEP average scale scores for each state have been analyzed by the National Center for Education Statistics to determine which states' scores differ statistically. The results of this study will reveal patterns and relationships between learning and emphasis on curriculum. This study will contribute to the ongoing discussion of reform related to both inquiry and standards in science education. This study will provide data that can be built upon for further study and will add to the rapidly growing body of research related to inquiry.

## Colette Murphy, Jennifer Gallo-Fox, Karen Carlisle, Christina Siry, Kathryn Scantlebury, Ken Tobin

Introducing Coteaching as an Important Element of Science Teacher Education

Extensive research documents the effectiveness of coteaching as a way to enhance the experience of pre-service and in-service teachers. Coteaching differs from traditional student teaching in that it fosters equity between the teaching partners by promoting mutual learning. This symposium discusses how coteaching has been used successfully in a range of contexts and considers the potential impact of coteaching research on current policy-making. The first paper overviews science coteaching in 70 elementary schools and reports benefits for children, pre-service and cooperating teachers. It uses activity theory to explore critical relationships for successful coteaching. The second focuses on coteaching as professional development of secondary-level cooperating teachers and reports significant improvements in terms of current and future practice. The third paper describes the experience of coteaching on pre-service teachers in elementary schools and discusses its effects on confidence, agency, authenticity and symbolic capital. The final paper provides an overview of coteaching in traditional secondary science methods and science education programmes and discusses an effective approach to developing both pre- and in-service teachers' professional identities as science teachers. This symposium aims to generate discussion as to whether coteaching should be adopted internationally as an important element of science teacher education programmes.

## Jomo Mutegi, LaTasha Thompson, Julius Davis

Notes on Making STEM (Science, Technology, Engineering and Mathematics) Education a Culturally Transformative Tool for African Americans

In spite of the continued underrepresentation of African Americans in STEM fields, STEM researchers working to address underrepresentation have not answered fundamental curricular questions, "Do we need more African Americans in STEM fields?" "Why?" "What should STEM education provide for African American students?" Instead we too often operate on the naïve assumption that "we need more Black scientists simply because there are none." Unfortunately, this naïve assumption and the body of work that it has produced have guided African American STEM education in the wrong direction for over 30 years. This essay seeks to begin the process of addressing that misguidance, by bringing these fundamental curricular questions to the fore. To accomplish that aim we will (a) present a summary of STEM education literature written to address African American participation in STEM fields for the purpose of identifying the assumptions guiding extant work; (b) present results of interviews with key researchers in STEM education to identify their rationale for conducting research on African American American American American STEM education to identify their rationale for conducting research on African American American American American American STEM education to identify their rationale for conducting research on African American American



can participation in STEM; and (c) present an alternative set of assumptions that could guide African American STEM education.

## Samson Nashon, David Anderson

Interpreting Student Learning Through Integrated Classroom-Field Trip Science Discourses in Kenya

This paper reports on key outcomes of part of a study that employed case study methods to investigate and elucidate Kenyan high school students' ways of knowing (WOK) in science discourses. The evocation of WOK was catalyzed in the context of implementing activities in a science unit that required the students to interpret and understand the science knowledge underlying production activities in local informal sector industries. The outcomes include (1) students' disposition toward understanding and personalizing science knowledge in their local environment, 2) students "clandestinely" adopt and use strategies considered undesirable to understand or master knowledge they perceive to be useful in terms of curricular and examination demands, (3) the students have the ability to be independent learners as demonstrated in the group presentations they made following in- class group learning tasks that involved reflection on and interpretation of the preceding field trip visit experiences, and 4) there is a disconnect between what the students expect to learn and be taught, how they learn, and the way curriculum is organized and implemented in Kenya. These revelations implicate on how high school science curriculum and instruction ought to be organized and implemented in Kenya.

#### Ross Nehm, Alicia Carassco, Mary Driscoll

Development, Implementation, and Evaluation of a New Assessment Instrument for Measuring Student Knowledge of Genetics and Natural Selection

In order to work with teachers to support their understanding of how assessment results can be used to inform instructional practice and foster learning gains in important content areas, it is necessary to have valid and reliable assessment tools capable of measuring student conceptual understanding. The overarching goal of our project was to collaboratively develop, implement, and evaluate a new diagnostic assessment instrument for the life science topics of genetics and natural selection for 9th grade students, many of whom were English language learners (ELL). Methodologically, we used four sources of information to construct our initial instrument: (1) the NY State Living Environment content standards for evolution and genetics; (2) the extensive literature on student misconceptions about genetics and natural selection; (3) the AAAS Atlas of Science Literacy; and (4) Living Environment teachers' classroom knowledge and experience. Using the Rasch Model, we determined the fit of the instrument to student ability, calculated item response statistics, and explored reliability measures. Finally, questions characterized by poor performance were identified and the AAAS question evaluation procedure was used with targeted sets of students. These results were used to modify and improve existing instrument questions and develop additional questions.

## Tamara Nelson, Keith Johnson, Charlotte Waters, Linda Lebard

## Improving Our Practice: Teachers' Stories About Supported Collaborative Inquiry

The focus of this poster session is secondary science teachers' stories about collaborative inquiry into some aspect of their teaching or their students' learning. Their collaboration is framed by an inquiry cycle in which they define a focus grounded in some element of a co-constructed vision of high quality learning and teaching, develop and implement a plan for change, and collect and analyze classroom-based data to further their understanding. This inquiry process is supported by a three-year professional development project that helps supports teacher development through professional learning communities. At least two teachers will each provide a synopsis of his or her PLC's inquiry question, classroom-based data collection, collaborative analysis procedures, and findings relative to student learning and professional growth. Discussion will also consider the supported collaborative inquiry processes and the external supports and challenges to collaborative inquiry.



#### Tamara Nelson, Angie Foster, David Slavit, Anne Kennedy, Wendi Laurence

Teachers' Collaborative Inquiry: Making Sense of Classroom-Based Data

With the increased emphasis on accountability for student learning, there is an associated movement in school districts for data-driven decision making. This research looks at a three-year professional development (PD) project that employed a professional learning community (PLC) framework for engaging teachers in collaborative inquiry. The purpose of the collaborative inquiry was to improve student learning by identifying areas of weakness, implementing teaching that targeted these areas, and collecting/analyzing classroom-based data to understand the impact on student learning. This paper presents the findings from a three-year case study of teachers' collective learning about using student data in the process of collaborative inquiry. In demonstrating the complexities and challenges teachers faced when trying to identify and meaningfully use student data, this case study represents a general trend across the 35 PLCs in the project. As the teachers collectively explored how to identify, collect, analyze and benefit from classroom-based evidence, they generated new ways of working and talking together and collectively considering and valuing their own practices and content knowledge. Based on these findings, we raise questions and make suggestions about what types of PD activities can better support teachers to collaboratively use data to make instructional decisions.

## Karen Nelson, Gili Marbach-Ad, Katerina Thompson, Patricia Shields

MathBench Biology Modules: Web-Based Math for All Biology Undergraduates

We investigated student and instructor responses to web-based modules that bridge the gap between math and biology. There is a pressing need to increase quantitative skills in the undergraduate biology curriculum. However, student and faculty attitudes pose significant barriers. We developed MathBench Biology Modules to introduce the mathematical underpinnings of the biological content being taught in lecture. The modules cover a variety of topics but focus repeatedly on a core set of skills and concepts. Each module steps the students through a set of mathematical tools using highly intuitive explanations, then provides a mathematically-informed discussion of biological applications. Biology majors at our institution encounter more than 25 such modules during their first 5 fundamental biology courses. Student feedback indicates that they find the modules clear, interesting, and non-threatening. On average, the students rated the modules from 4.5 to 4.7 on a 5-point scale, and 83% said that the interactivity was useful in helping them understand specific concepts at their own pace. Instructors who have used the modules were pleased that lecture time spent on mathematical foundations was reduced. We feel that the modules have broad applicability for increasing math fluency in undergraduate biology students.

#### Knut Neumann, Anna Lau, Hans Fischer, Elke Sumfleth

Content Linkage and Cumulative Learning in Chemistry and Physics

Based on psychological research on learning theories, German researchers reckon, that a lacking cross-linking of contents in German instruction may be responsible for the average only performance of German students in TIMSS (Beaton et al., 1997) and PISA (OECD, 2001, 2004). However, content linkage, its function in science education and its influence on students learning processes are not yet investigated very well. In turn, the presented project aimed for an analysis of the relation between content linkage and cumulative learning in an attempt to provide evidence on reasons for German students' poor performance on international level. For this purpose a model of content linkage was developed. Based on this model, 10th grade chemistry and physics instruction was video recorded and analyzed with respect to content linkage. High and low linking teachers were identified and, in a next step, the knowledge structures of these teachers' students' knowledge structures. In doing so, teacher specific and especially subject specific differences could be observed. The presentation gives an introduction to the model and an overview of the results in comparison between physics and chemistry.



#### Len Newton, Andy Noyes, Andy Clapham

Influences on Undergraduate Physical Science Learners' Subject Decision Making

Encouraging participation in science and mathematics higher education is a key issue in many developed economies internationally. This paper reports a small scale study of early undergraduates' experiences of learning physical sciences in a research intensive UK university. The goal of the study was to give voice to students' learning experiences and to identify influences on their subject division making that could provide insights into students' experiences and motivations and inform pedagogical developments in university science teaching. Nominal Group Technique (NGT) was used in structured interviews with groups of undergraduate physical science students. The research revealed student self efficacy as a key determinant of decisions to study in physical sciences. The use of NGT was seen to be a useful too in this type of study and raised interesting methodological issues in its design and implementation.

## Mansoor Niaz

What 'Ideas-About-Science' Should be Taught in School Science? A Chemistry Teachers' Perspective

Objective of this study is to facilitate chemistry teachers' understanding of nature of science and what 'ideasabout-science' can be included in the classroom. Study is based on 17 in- service teachers who had registered for a 11 week course on 'Epistemology of Science Teaching' as part of their Master's degree program. Course activities included written reports, classroom discussions based on presentations and written exams. Based on results obtained this study has the following educational implications: a) Experimental data need to be interpreted carefully due to underdetermination of theories by data; b) Kuhn's normal science manifests itself in the science curriculum through the scientific method and wields considerable influence; c) Trilemma posed by Collins (2000), viz., creation of new knowledge Kuhn's normal science teaching nature of science, provided a big challenge and was thought provoking; d) Of the different aspects of nature of science suggested by experts, these teachers endorsed the following as most important: Creativity, Historical development of scientific knowledge, Diversity of scientific thinking and Scientific method and critical testing; e) With respect to contradiction between positions of Lederman et al (2002) and Osborne et al (2003), a majority supported the former, viz., scientific method as a myth.

## Martina Nieswandt

Between Theory and Practice: Beginning High School Science Teachers' Beliefs About Science and Science Teaching Over Time.

This longitudinal study followed a group of six beginning high school science teachers from their first days in a teacher preparation program to the end of their second year of teaching in order to develop a deeper understanding of teachers' individual rights needs for a successful and satisfying professional career. Using a series of interviews the study explored the relationship between high school science teachers' espoused beliefs about teaching and science and their actual teaching practice (beliefs-in-use). Furthermore, the study asked whether beginning teachers' attempts to implement their espoused beliefs into beliefs-in-use intersect with and are challenged by factors such as pedagogical content knowledge or the school environment (i.e., school administration, departmental support). Preliminary results demonstrate the need for beginning teacher to develop an understanding of factors influencing their teaching practice. Thus, they need to develop skills to unveil the sources of their beliefs-in-use and link them back to their espoused beliefs with the aim of reconciliation. These results call for mentor programs that transcend subject-independent issues and instead stress the relationship between what teachers want to do vs. actually do, what hinders them from implementing desired intentions and the understanding of the nature of subject-knowledge (e.g., NOS).

## Pernilla Nilsson, Jan van Driel

Experienced Primary Teachers' and Primary Science Student Teachers' Collaborative Learning through Reflection on Their Science Teaching

This paper addresses the questions of what and how two mentoring primary teachers and two science primary

student teachers learned from their common experiences while planning, implementing, and reflecting on different science teaching activities with students aged 7-9 during a four-week school practicum. During four weeks, two lessons each of the student teachers and two of the mentors were video recorded. In connection to each lesson, the student teacher and the mentor, working in pairs, reflected on the video recorded lesson in a stimulated recall session. The student teachers had had training in scientific knowledge but only brief experience of teaching. The mentors were well experienced in the pedagogy of primary teaching and mentoring, but did not feel confident with their science content knowledge. During the reflections the student teachers and the mentors expressed an increased understanding of both teaching and learning science, an improvement of their own practice, and a collaborative learning experience throughout the process of working, observing and reflecting together. The results support new insight into what learning comes from professional relationships built on the process of planning, teaching and reflecting together.

#### Catherine Norton, Margaret Corbit, Luis Ormaechea

A Comparison of Self-Directed Learning in a Virtual World Environment to Traditional Science Teaching Methods

Four ninth grade science class periods in a rural school were randomly assigned to learn an introductory genetics unit for three days in either an online, multi-user, virtual world computer environment or in a traditional classroom setting using lecture, worksheets and model building. The groups were then reversed for a second three day trial. Quizzes were given before, at midpoint and at the end of the study. The study demonstrates that self-directed learning can occur while exploring a virtual environment, although perhaps not quite to the extent that it does in a traditional classroom. The student participants stated a preference for a variety of teaching methods, which suggests that mixed modalities may be a good way to engage students who are uninterested in science.

#### Laura Novick, Kefyn Catley

#### Assessing Students' Understanding of Cladograms

Scientists depict cladograms (diagrams representing evolutionary histories among species or groups of species) in two formats—tree and ladder. Although trees are more common in the professional practice of biology, ladders are seen more often in high school and college textbooks. The present study investigated whether there are differences in the ease of comprehending information presented in the two formats. University students were divided into two groups, designated as those with weaker (n=65) versus stronger (n=62) backgrounds in biology. All students answered comprehension and relationship questions about primarily familiar taxa represented in both tree and ladder cladograms. The results indicated that the ladder format is more difficult to understand, particularly for students with weaker biology backgrounds. Even the stronger background students, however, found the ladders to be harder to understand when answering the more difficult relationship questions. These results have clear implications for both biology textbook designers and classroom teachers, who need to take into account the cognitive difficulties associated with comprehending the ladder format. More broadly, accomplishing the educational goal of producing scientifically-literate students requires that students be familiar with cladograms as visualizations of processes acting in time and space and as tools for thinking and learning about biology.

## Ingrid Novodvorsky, Vicente Talanquer, Debra Tomanek

Preparing Secondary Science Teachers at the University of Arizona

Since 2000, the undergraduates at the University of Arizona who wish to become secondary science teachers have been prepared in the College of Science, in a program designed to prepare them to teach for understanding. This program was designed by newly hired science education faculty members, in consultation with area secondary science teachers. Courses are taught by science education faculty members and experienced secondary science teachers, and field experiences are included in most of the program's courses. In this interactive poster session, we will describe the origins of the program, results in terms of number of teachers prepared and retention in the teaching profession, and costs associated with the various aspects of the program.



## Maria Nunez-Oviedo, Rosa Catalan, Juan Godoy, Sergio Rojas

Effectiveness of a Learning Pathway Based on Model Construction and Criticism Theory

This generative and exploratory case study has two purposes. The first purpose was to determine whether a œlearning pathway based on mental model construction and criticism theory (Clement, 1989, 1993) increased students understanding about concepts of chemical solutions and colligative properties. The second purpose was to describe how the different teaching strategies included in the sequence fostered student mental model construction. The overall goal of the study was to bridge the gap between Model-Based Co-construction Theory that attempts to integrate cognitive and social elements with real teaching practice. Quantitative and qualitative descriptions of the students outcomes and the effect of the teaching strategies on the students learning processes were developed from two pre-test and post-tests and video taped lessons and transcripts of selected episodes. It was found that the sequence was effective in promoting students learning. It was also found that students were able to build explanatory mental models of unobservable phenomena. Students were active participants in the process. Detailed diagrams were built to describe the learning process.

#### Michael Occhino, April Luehmann

Out-Of-School Learning-To-Teach Experiences as Support for Professional Identity Development: Impact of Facilitating an Inquiry-Based Camp

This exploratory case study examines two cohorts of students (n=14) consisting of beginning master's students, ending master's students and doctoral students enrolled in a science teacher education program that emphasizes inquiry-based science teaching. A critical component of the program is a week long, out-of-school inquiry science camp that is intended to provide a highly supportive and engaging context for preservice teachers to try on their developing identities as inquiry-based science teachers. In this study, we explored the self-reported identity changes that occurred because of the participants' experiences in designing and facilitating the inquiry camp. Primary data sources include interviews, surveys, field notes, videos and blogs. The theoretical lens guiding this study is identity, operationalized as consisting of four elements: understanding, appreciation, commitment, and confidence, in this case with respect to inquiry-based teaching practices. Findings include that most students in both cohorts reported an increase in understanding of, appreciation for, commitment to, and confidence with inquiry as a teaching methodology, and the changes were most significant for master's students beginning their program. Dilemmas and tensions that preservice teachers faced in developing their identity as an inquiry-based science teacher further demonstrated the potential impact of this type of out-of-school learning-to-teach experience.

## Carol ODonnell, Sharon Lynch

Fidelity of Implementation to Instructional Strategies as a Moderator of Science Curriculum Unit Effectiveness

Current emphasis in policy circles on "evidence-based" research has created renewed interest in the importance of fidelity of implementation. This study examined fidelity of implementation to an inquiry-based science unit's instructional strategies as a moderator of curriculum unit effectiveness in the context of a large-scale quasi-experiment. Using Rasch analysis, Likert-like observation scores were converted to a reliable continuous fidelity measure for each middle school classroom (n = 48). Multiple regression indicated an interaction between curriculum condition and observed fidelity to instructional strategies. Post hoc analyses showed treatment classrooms with High Fidelity to the instructional strategies were predicted to have higher classroom mean achievement than comparison classrooms with High Fidelity (p < .05); no statistical differences in achievement existed between Low Fidelity classrooms. Although inquiry-based science instructional practices were observed in both treatment and comparison classrooms, these practices were related positively to outcomes only in classrooms supported by the treatment unit. This paper intends to contribute to the NARST members' discussions of how science education research, and the careful consideration of fidelity of implementation to science curriculum materials, impacts public policy in the context of large effectiveness studies.



#### Erika Offerdahl, Lisa Elfring, Debra Tomanek

Drivers for change in faculty members thinking about teaching

The primary objective of this study was to characterize the nature of biochemistry faculty's "instructor thinking" with regard to teaching upper-level, large-lecture biochemistry courses. For the purposes of this study, "instructor thinking" was defined as an instructor's thoughts about (1) teaching, including the role of instructors, student engagement, instructional strategies, assessment, and teaching effectiveness and (2) students and learning, including personal experiences with learning, student roles and capabilities, and student learning. Guided by a model adapted from the Teacher-Centered Systemic Reform model (TCSR) by Gess-Newsome, Southerland, Johnston, and Woodbury (2003), this study employed mixed methods to gather data related to three university faculty members' instructor thinking over the course of two semesters. Semi-structured, in-depth interviews, faculty members' reflective journals, and investigator field notes served as qualitative data sources. Classroom observations were utilized to gather quantitative data using the Reformed Observation Teaching Protocol (RTOP). Reported as case studies, results include not only the characterization of instructor thinking, but also the identification of drivers for change in instructor thinking. These drivers for change opened the door for new lines of self-inquiry and intro-spection about teaching and, in some cases, created new prospects for change in teaching practice.

#### Feral Ogan-Bekiroglu, Abdulkadir Gunay

Impact of Portfolio Assessment on Student Learning in Physics

In spite of the commendations for the use of portfolio assessment, there is little evidence demonstrating that such assessment actually supports and encourages student learning. Hence, this research study aimed to empirically identify the effects of implementation of portfolio assessment on student learning. Experimental design was utilized for the study. Participants of the study were nine-grade high school students. Portfolio assessment was implemented in the experimental group for eight-week duration in the physics course. Findings illustrate that the students assessed by the portfolio were constructed more knowledge than the students assessed by the exam. Results of the study reveal that portfolios are not only an indication for student growth but also a learning tool.

#### Alan Oliveira, Huseyin Colak, Valarie Akerson

"Who Polluted the Potomac?" The Translation and Implementation of an Environmental Story in Brazilian and Turkish Elementary Classrooms

This study examines how elementary teachers in Brazil and Turkey approached the translation and subsequent classroom implementation of an instructional activity that promotes environmental awareness through a combination of student role playing and teacher oral delivery of an environmental story about river pollution. A discourse analysis showed that translation into Portuguese was literal, an approach that fostered a classroom implementation that overemphasized detached transmission of knowledge (frequent interruptions of oral delivery for the provision of textual, contextual and recontextualizing information to students). In contrast, translation into Turkish was free, that is, with lots of modifications that led to a highly decontextualized and detached text. Implementation of this text was excessively focused on the creation of student involvement, being dominated by oral strategies such as religious analogies (heaven and hell), and parallel repetitions of statements of shared guilt. Based on these findings, it is concluded that both translation approaches failed to promote an equivalent form of environmental instruction (i.e. involved transmission of environmental knowledge). Furthermore, an argument is made that quality translation requires that original and translated curricula foster analogous levels of involvement (or detachment) as well as equivalent forms of classroom relationships and social roles (pragmatic equivalence).



## Mark Olson

Developing Assessments of Science Content Knowledge for Teaching

There is broad agreement that content knowledge is important for high quality science instruction. But despite the apparent consensus, there are significant questions about how much content knowledge is necessary and what the nature of that content knowledge is. In addition, the measures used – disciplinary major, passing a subject matter exam administered by a state department of education or testing company, or the possession of an advanced degree – are poor proxies of teacher content knowledge (Wilson, Floden, Ferrini-Mundy, 2001). This paper presents findings from a project to both conceptualize the content knowledge for teaching secondary science and to develop assessment instruments to measure that knowledge. Using data from preservice and inservice science teachers, it is shown that two primary explanatory structures: narrative and paradigmatic, can be used to account for the ways in which teachers use content knowledge in instructional representations such as demonstrations, activities and examples. Implications for science teaching practice, teacher education and professional development are discussed.

## Joanne Olson, Michael Clough, David Vanderlinden

Should "Proof" and "Truth" be Targeted First? Evidence for Addressing Some Nature of Science Concepts and Misconceptions Earlier Than Others

The purpose of this study is to analyze how students interpret questions embedded within four short stories designed to teach the nature of science and science content. The short stories traced the development of two fundamental concepts in geology: continental drift and deep time. The questions required students to apply the historical narrative to key issues in the nature of science. 278 students in undergraduate introductory geology read the short stories and completed the questions as homework. Analysis of their open ended responses indicates that most students responded accurately to 7 of the 16 questions. However, students struggled with several nature of science concepts. The most substantial struggles occurred for students who held views that science provides absolute "proof" or "truth." This misconception was often held concurrent with a view that a single scientific method must be used by scientists, and that this method ensures complete objectivity and proven, truthful answers. These misconceptions appear to have inhibited students' understanding of other nature of science ideas. When teaching science, we suspect that "proof," "truth," and "scientific method" need to be understood by students before certain other nature of science concepts are addressed.

## Nir Orion, Carmit Cohen

Earth Systems Education in a Multidisciplinary Focus

The new module "Oceans and the earth systems" has been developed as a part of the environmental-based interdisciplinary component of the Israeli high school earth sciences program. The module focuses on the understanding of authentic oceanographic phenomena such as global warming, ocean currents, climate changes, hurricanes, El-Nino, tsunami, sea pollution and artificial islands. The module includes two parts. The first part is an inquiry based unit that takes part in the lab and in the field. The second part is a project based learning unit where each student chooses a topic that interest him/her; write down a research question and answer it through a literature review and then present his/her findings orally with a power point presentation. The study included more then hundred 12th grade earth sciences students and was based on a mix of qualitative and quantitative research tools that helped to understand the student knowledge and attitudes towards other sciences namely chemistry, physics and biology. Following the learning process the student passed through a meaningful conceptual change. They improved significantly their understanding of basic concept such as pressure, heat transfer, chemical composition of water, dissolution, food web and density. Following our results it is suggested that the earth system approach could serve as a powerful platform for motivate students to study the complicated scientific concepts and processes from all scientific discipline.



## Christian Ostermeier, Manfred Prenzel, Reinders Duit

Improving Science and Mathematics Instruction: The SINUS-Project as an Example for Reform as Teacher Professional Development

An example of teacher professional development based on a perspective of situated learning and implemented on a large scale is presented. We consider teacher professional development from three perspectives. First, teacher professional development is a key factor in improving classroom instruction. Second, teacher professional development is a vehicle for conveying knowledge from research into classrooms. Third, teacher professional development is an object of research itself. A German project to improve science and mathematics teaching (SINUS) ñ comprising 180 schools in a pilot-phase and more than 1,700 schools in a second phase of scaling-up ñ serves as an example of this framework for teacher professional development. Evaluation revealed that the schools participating in the pilot programme were typical schools, not a special sample of exceptionally high- or low- performing schools. Teachers were highly engaged in the programme and accepted its underlying ideas to a large extent. A large-scale comparison between SINUS schools and a representative sample of German schools tested in PISA 2003 showed positive effects of the programme with regard to students' interest and motivation as well as competencies in science and mathematics.

## Valerie Otero, Kara Gray

Learning to Think Like Scientists with the PET Curriculum

Abstract. Instructional techniques based on research in cognitive science and physics education have been used in physics courses to enhance student learning. While dramatic increases in conceptual understanding have been observed, students enrolled in these courses tend to shift away from scientist-like views of the discipline (and views of learning within the discipline) and toward novice-like views. Shifts toward scientist-like views are found when course materials and instruction explicitly address epistemology, the nature of science, and the nature of learning science. The Physics and Everyday Thinking (PET) curriculum has specific goals for helping non-science majors explicitly reflect on the nature of science and the nature of science learning. We show that in PET courses with small and large enrollments, shifts toward scientist-like thinking ranged from +4% to +18% on the Colorado Learning Attitudes about Science Survey. These results are compared to results from other studies using a variety of similar assessment instruments.

## Valerie Otero, Danielle Harlow

Evolution of Students' Model-Building Practices

Central to the practice of the scientific community is model building. Model-based reasoning involves testing for a hypothesized process involving underlying mechanisms that could drive observable phenomena. While modelbuilding is one of the primary activities of science, it is rarely practiced in the science classroom. In order to better understand students' model-building practices, we investigated students' language development during a series of activities during which adult students developed a model of magnetism in an inquiry based physics course. Throughout the activities, the students develop increasingly sophisticated models of magnetism, ultimately developing a tiny-magnets model of magnetism. The data also suggest that as the students develop and revise their model to account for additional evidence, their model-building practices evolved from their initial practices of stringing together scientific words to more sophisticated mechanic reasoning practices. This study provides evidence that by explicitly engaging in model-based reasoning, these students were able to learn model-building practices of the scientific community.

## Sinan Ozgelen, Esme Hacieminoglu, Ozgul Yilmaz-Tuzun

Investigation of Pre-service Teachers' Reasoning Abilities and Learning Approaches in Inquiry Based Learning Environment

The purposes of this study were to investigate the effect of inquiry based science laboratory course on pre-service teachers' (PTs) reasoning abilities and learning approaches, the relationship between PTs' learning approaches and



reasoning abilities, and how well do the learning approach and reasoning ability predict PTs' achievement. The sample of this study consisted of 83 pre-service elementary science PTs and elementary mathematics PTs, minoring in science education. Data were collected from Science Laboratory Application Course (SLAC). This course is only the science laboratory courses taken at education faculty. Inquiry based teaching (IBT) approach was implemented. The course instruction was designed to help PTs understand scientific concepts by engaging science activities rather than just following cook book instruction. According t-test results for reasoning ability scores, PTs' pre-post test scores revealed that using IBT method in the lab course significantly increased the PTs' reasoning abilities. Also, inquiry approach did not increase the PTs' learning approaches. Chi square analysis revealed that the probability of participants being accepted as formal level was about 11.4 times more likely when the participants were doing meaningful learning as opposed to rote learning. Multiple regression analysis revealed that students' achievement was correlated with students reasoning abilities.

#### Marios Papaevripidou, Constantinos Constantinou, Zacharias Zacharia

The Development and Implementation of a Modeling-Based Curriculum to Enhance Ecosystems' Understanding: A Design Experiment With Fifth Graders

We present two cycles of design-based research studies with fifth graders that help us understand how to facilitate students' development of robust conceptual understanding about ecosystems. In the first cycle, we implemented a curriculum in which we incorporated implicitly principles from modeling-based learning and the iterative design of a role-playing game. In the second cycle, we redesigned and implemented our modeling-based curriculum by incorporating explicitly principles from modeling-based learning and by using a computer- based tool. The findings indicated that the explicit modeling-based curriculum, which also integrated the computer modeling tool, had a greater contribution in enhancing fifth graders' understanding of ecosystems as compared to the contribution of the implicit modeling-based curriculum that integrated a role-playing game as a modeling medium.

## Enrique Pareja, Sandra Abell

Student learning in an Informal Setting: Rainforest Ecology in the Amazon

Learning science in informal settings is an important area of research in the development of science teaching practice. Providing opportunities in these informal environments exposes students to a variety of experiences beyond those normally encountered in classroom settings, leading to the development of knowledge and increased motivation The purpose of this study was to observe the experiences students had when they moved from a traditional classroom setting to foreign international, outdoor learning environment within the context of a tropical ecology course. We followed a group of 8 undergraduate and one graduate student who took the course and have never traveled to the Amazon before. We found that personal experiences played an important role in student adaptation and learning in a foreign setting. Likewise socio-cultural interaction among the students, instructors and local guides and researchers, especially when addressing cultural differences, played an important role in student learning. Students' change in roles from passive to active learners and researchers was in many ways facilitated by the change in setting from class room to field station and the interactions observed. We also determined how that the interplay of these different factors within each context benefited students when learning science.

## Eun Jung Park

Understanding the Relationship Between Learning and Forms of Representations by Analyzing Students' Mental Models of Atomic Structure

Atomic models have been used to help students' understanding of scientific theories by illustrating the theoretical structure of atoms in an imagery representation. Although atomic models are represented as concrete images, the models transfer the abstract nature of atoms into students' minds. As a part of a larger study, this paper is based on the analysis of the written and diagrammatic responses of 20 college students who also volunteered for interviews. The 20 students' pre-/post-responses on the questionnaires were explored in detail for this paper and a follow-up



study comparing this findings with interview responses will be discussed in a subsequent proceeding paper. The questionnaires and interview were designed to ask questions about atomic structure and students described their understanding in verbal and non-verbal forms. Students' responses show different levels of understanding in verbal and imagery representations. The difference between representations supports that coding systems for the concept of atomic structure seem to work separately, as explained in the dual coding theory. In addition, this study shows imagery units were better recalled than verbal units in understanding the concept of atomic structure. This would indicate that students learn best when the lesson of atomic structure is presented with visual materials.

#### Soonhye Park, J. Steve Oliver

The Analysis of Instructional Variations Among Chemistry Teachers

This study examined how individual teachers enacted their pedagogical content knowledge (PCK) in different ways while they were teaching the same topics and further identified what factors influenced this idiosyncratic nature of PCK. This study utilized qualitative research methods. The participants were three chemistry teachers who worked at the same high school. Major data sources were non-participant observations and interviews. Data were analyzed through the constant comparative method. The data analysis revealed that the teachers' idiosyncratic enactment of PCK was mainly influenced by five factors: a) orientations to science teaching, b) teacher efficacy of teaching a specific topic, c) understanding of the dynamics of the class, d) understanding of subject mater, and e) past teaching and personal experiences. The degree of the idiosyncrasy also varied at different stages of instruction. This study suggests that idiosyncrasy both across different teachers' instruction and within a teacher's instruction is an important means by which teachers translate their PCK into practice and further express their professionalism. Accordingly, teaching expertise, at least partially, results from this idiosyncratic nature of instruction.

## Eun Jung Park, Su Swarat, Greg Light, Denise Drane

Exploring Variations in and Developing Typology for Undergraduate Students' Conception of "Size and Scale"

The rapidly growing field of nanoscience and nanotechnology calls for the inclusion of general nano-education in our educational agenda. Student understanding of one of the key concepts in nanoscience, Size and Scale, serves as a prerequisite for students' learning of more advanced nanoscale science and technology. This paper presents the findings of two studies exploring students' understanding of Size and Scale at the college level. Students from two different engineering courses participated in this study – one for engineering majors and the other for non-majors. To examine students' understanding of Size and Scale, semi-structured interviews were conducted with twelve college students, and a set of short- answer questions based on the interview results were administered to ninety-five students enrolled in the same courses in the following year. Results suggest wide variation in the way students understand this concept. This study identifies a preliminary typology of student conceptions of Size and Scale as it relates to macro and sub-macro phenomena along three key dimensions. In addition, the follow-up study using short-answer questions confirmed the applicability of such a typology to differentiate students' conception of Size and Scale and Scale and to identify variation in levels of understanding for a wider range of students.

## Do-Yong Park, Marilyn Morey, Myon U Lee

Facets of Effective Science Learning Environment: Preservice Elementary Teachers' Observations of Their Clinical Experience in Korea and the U.S.

This study examined preservice elementary science teachers' observations of their 3-week clinical experience in terms of six facets of effective science learning environment in Korea and the U.S.. Observational experiences of 97 Korean students and 64 students were surveyed by an instrument that we developed with defined items through literature reviews. The follow-up interviews provided a clearer picture of what preservice teachers were observing in school settings during their field experiences. Korean preservice teachers were experiencing various contexts of science teaching environments whether it is desirable or needs to be improved whereas the U.S. preservice teachers reported limited opportunities to observe effective science learning. At the end of this paper, we discussed about



issues and problems of clinical placement to improve preservice teachers?experiences that meet the goal of the science teacher education program.

## Miwha Park, Gyoungho Lee, Jinwoong Song, Young-Shin Park

Enhancing Student Teachers' Reflective Thinking Through Reflective Practices

The purpose of this study was to qualitatively explore student teachers' reflective thinking in terms of its change and content when participants experienced three different stages of teacher preparation program: taking course at campus, demonstrating micro-teaching and teaching students in the real context of classroom in a sequence. Data were collected through artifacts, questionnaire, interviews, and reflective practice journals. Two different modified tools (van Manen, 1977; Lee, 2006) were employed to analyze student teachers' change and content of reflective thinking respectively. Student teachers showed overall majority of technical reflective thinking and little of professional and critical ones, whose frequency increased as they experienced real teaching with peers or students. About change in the content of reflective thinking, student teachers displayed five different (teacher, learner, knowledge, evaluation, and context) contents of reflecting thinking from their real teaching. To promote student teachers' professional and critical type of reflective thinking in all five different content areas, teacher preparation program at universities must provide them with much longer period of field experience where they reflect on their theory and practices well enough. This is very critical factor for teacher preparation program when compared with the period of only 6 weeks field experience in Korea.

## Carolyn Parker, Taryn Bayles, Julia Ross

Engineering in Health Care: A Multimedia Curriculum for Secondary Science Teachers

The INSPIRES Curriculum: INcreasing Student Participation, Interest and Recruitment in Engineering and Science (INSPIRES), a National Science Foundation Instructional Materials Design grant seeks to provide new curricula that incorporates hands-on experiences and inquiry-based science learning with 'real world' engineering design and science inquiry exercises that are aligned with the National Science Education Standards and the National ITEA Standards for Technological Literacy. Five curriculum units will be described. Student outcome data from the projects first unit, "Engineering in Health Care: A Hemodialysis Case Study" will be presented and analyzed.

## Loran Parker, Gerald Krockover

Middle Level Teacher Reflections on Inquiry and Standards Based Science Instruction

Recent education reform efforts have emphasized increased education of in-service teachers focusing on assisting teachers in becoming "highly qualified and successful" practitioners (NCLB Act, 2001). This study examines the reflections of 16 teachers as they navigate an in- service education program that aims to assist them in integrating both standards-based teaching and inquiry-based teaching into their science and mathematics curricula. This study looked at the ways that science teachers reconcile two approaches to science teaching that are often perceived as conflicting, i.e., inquiry-based teaching and standards-based teaching. It is important that teacher educators study how teachers perceive these two approaches so that we can design ways to assist teachers to integrate the two in a way that keeps curiosity and inquiry alive in the middle level science classroom.

## Eileen Parsons, Rhea Miles, Spike Petersen

Differences in High School Students' Perceptions of What Helps Them Learn Science: A Missing Piece in Decision-Making Regarding Practice and Reform

When addressing quality science education for all, a focus of reform, students' perceptions are not typically discussed. Because perceptions influence to what students attend, perceptions are important. Viewed from a phenomenological perspective, any differences in perceptions among student groups were of interest in this study.



This study addressed the following: 1) What characterizes high school students' perceptions of effective science teaching? 2) With respect to ethnicity (African American versus European American), gender, grade level (9-12), and science courses completed by students, do differences exist in students' perceptions? If so, what is the nature of these differences? Survey responses from 310 high school students were qualitatively analyzed and resulted in seven categories that characterized the students' perceptions of effective science teaching. The dominant category, instructional strategies, was subdivided into active and passive methods. ANOVA at p< .05 indicated an ethnic-ity-instructional strategy interaction. These results showed that European American students appear to choose science courses according to instructional strategies. African American students whose responses highlighted passive instructional strategies in their perceptions of effective science teaching took more science courses than African American students whose responses highlighted passive instructional strategies in their perceptions of effective science teaching took more science courses than African American students whose responses than African American students whose responses emphasized active teaching methods.

## Cynthia Passmore, Julia Svoboda, Carole Hom, Grosberg Rick

Undergraduate Learning at the Interface of Mathematics and Biology

Much as chemistry revolutionized biology in the 19th century and genetics transformed biology in the 20th century, mathematics will profoundly change all of the biological sciences in the 21st century. The collaborative approaches needed to address such problems require transforming the traditional education of biologists and mathematicians, beginning with the earliest stages of undergraduate education. To achieve this transformation, curricula must (1) provide life sciences students with quantitative skills beyond basic calculus and statistics; (2) give students in mathematics the background needed to appreciate the richness of biological problems amenable to quantitative analysis; (3) reinforce and develop these skills through problem-solving in the classroom and laboratory and (4) remove cultural barriers to communication between students in the mathematical and biological sciences. One of the most effective ways to accomplish these changes is through collaborative research-training programs that empower teams of young scientists from mathematical and biological backgrounds. Such a program has been designed and implemented at a large western university and a thorough research and evaluation effort has tracked outcomes of the project. Here we describe one aspect of the research effort accompanying this project and present findings from the first cohort of students who participated in the program.

## Cynthia Passmore, Connie Hvidsten, Lin Xiang, Arthur Beauchamp, Wendell Potter, Hedman Rich

Inquiry into Practice: How Teachers Learn to Engage Their Students in Model-Based Reasoning

The empirical research literature in science education has demonstrated that taking a modeling approach to science instruction shows a great deal of promise with regard to meeting the calls for students to be engaged in constructing deep understandings of both the content and process of science. We know very little as a field about how to bring teachers to practices that promote model-based reasoning on a larger scale in a sustainable way. Thus, the main goal of the study reported here is to understand how teachers first adopt and then promote pedagogical practices that engage students in model-based reasoning. To that end we report on the first year of a two-year design experiment. Specifically, we describe our conjectures and design commitments and the empirical findings related to them highlighting the importance of teachers experiencing and reflecting on new pedagogical practices.

## Maya Patel, Deborah Trumbull, Elizabeth Fox, Barbara Crawford

Learning the Process and Nature of Science in the Context of Cutting-Edge Plant Biotechnology Research

This qualitative study explored the nature of undergraduates' learning in a 10-week summer research experience at the forefront of plant biotechnology and genomics. We were interested in how the authentic context contributed towards undergraduates' understandings of contemporary science and their personal development as science practitioners. The theoretical framework guiding our research design included an apprenticeship model (Collins et al., 1989) and the view that learning is situated (Lave & Wenger, 1991). Research questions included, 1) to what extent do interns develop understandings of plant biotechnology and cutting-edge techniques? 2) to what extent



do interns develop understandings about doing science? 3) to what extent do interns develop understandings of the nature of science? Many aspects of the research experience aligned with authentic scientific practice. Findings indicate that interns developed flexible, in-depth knowledge of current issues and techniques in plant biotechnology/genomics specific to their research project. The extent to which interns progressed along the novice-expert trajectory correlated with prior research experiences, project ownership and aspects of mentoring. Interns developed understandings of the nature of science, particularly the socio-cultural aspect of the scientific enterprise. Finally, interns reported gains in their personal development as a scientist from participation in this research experience.

#### Bruce Patton, Jennifer Esswein

The Development of Conceptual Thinking in Inquiry-Based Physics

Guided inquiry approaches to teaching have recently been the subject of much discussion and research. We report an investigation into the relationship between both the development of conceptual content knowledge as well as the development of scientific reasoning ability. Initial results suggest that key factors in student success are scientific reasoning ability and its improvement, coupled with an increase in content knowledge. The comparison of inquiry-based learning environment and traditional lecture approaches will be presented. The findings help identify the desired features that will aid teachers in producing an effective classroom strategy.

#### Debby Peck, Karen Sullenger

#### Enhancing Science Understanding for Middle School Students Through Interactions With a Field Botanist

Research shows that students' experiences affect their understanding of science (Talsma, 1997; Ntarajan et al, 2002; Barab and Hay, 2001;Resnick, 1987). Less is known of what they think and understand about themselves being scientists and actually doing science. Few studies report on the learning experiences resulting from scientists interacting with students and about the affects that this interaction has on students' understanding of what science actually is all about. This study focuses on middle school students' conception of the work of a botanist and of themselves doing botany. In a long term research program involving an after school science club, students made several field excursions with botanists. They described their experiences in drawings and interviews, illustrating that they were actively engaged in learning botany when they were guided through the process by an expert. They understood what botany was and what a botanist did. Indications were that they transferred their newly learned skills to the science classroom. Students were asked if they were doing science when they were doing botany work and why they felt this was so. The botanists felt that they had gained a new perspective on the challenges and benefits of interacting with students at the middle school level

#### Sara Peer, Daphne Goldman, Bela Yavetz

Relationship Between Environmental Literacy and Background Characteristics of Teacher-Training Students- Implications for Training Programs

A major challenge facing environmental education is to strengthen the environmental literacy component of pre-service teacher programs in Israel. This study aimed to characterize level of environmental literacy of students towards the end of their studies in teacher-training colleges and investigate the relationship between these variables and background factors. The study was conducted by a questionnaire administered to 454 students. Students' environmental knowledge was very limited. Although they maintain overall positive attitudes towards the environment, these are not translated into responsible environmental behavior. Students who chose to major in environmentally-related subjects demonstrated more knowledge and more environmentally responsible behavior as compared to students who chose non-environmentally-related fields. The ethnic groups differed significantly in all EL variables but differences were inconsistent: Jewish students scored significantly higher in environmental knowledge and attitudes while non-Jewish students scored significantly higher in environmental behavior. A positive relation-ship was found between students' knowledge and extent of their mothers' education. The EL of graduates found in this study highlight the urgency to integrate EL-instruction within teacher-training programs so that all graduates



will be equipped to function as leaders of environmental change in schools and community. EL- characteristics of the different students can provide guiding factors towards developing these programs.

## Deniz Peker

## Conceptualizing Scientific Explanations in Science Education: Methodological and Pedagogical Considerations

There is a burgeoning interest in scientific explanations in science education research. However, the term "explanation" is still a nebulous construct because there are so many different understandings of this term both conceptually and methodologically. One broad goal of this paper is to understand the nature of the ambiguity over the meaning of explanation in science education context. Specific purposes of this essay are 1) to examine different accounts of scientific explanations offered in various disciplines of inquiry such as philosophy of science and cognitive science, 2) to review science education literature with regard to scientific explanations and exhibit the different conceptions of scientific explanations, and while exhibiting different conceptions 3) to provide a discussion of alternative views by considering their methodological advantages and disadvantages for assessing the quality of student's explanations and also by weighing their pedagogical value for achieving science literacy goals.

## Jeremy Peterson, Laura Price, Nikki Hanegan

Scientific Argumentation and Teacher Expectations

This study examines how student practice of scientific argumentation using socioscientific bioethics issues affects both teacher expectations of students' performance and student confidence in their own work. When teachers use bioethical issues in the classroom students can gain not only biology content knowledge but also important decision-making skills. Learning bioethics through scientific argumentation gives students opportunities to express their ideas, formulate educated opinions and value others' viewpoints. Research has shown that science teachers' expectations of student success and knowledge directly influence student achievement and confidence levels. Our study analyzes pre-course and post-course surveys completed by students enrolled in a university level bioethics course (n=) and by faculty in the College of Biology and Agriculture faculty (n=34). Data analysis showed a disconnect between faculty and students perceptions of confidence for both knowledge and the use of science argumentation. Student reports of their confidence levels regarding various bioethical issues were higher than faculty reports. Upon completion of a bioethics course based on scientific argumentation, students significantly increased their confidence levels. This study suggests that professors' expectations influence student confidence levels in both knowledge and scientific argumentation.

## Lori Petty, David Lamp, Ratna Narayan, Bunuan Rommel, Cooper Sandi, Clem Darrellee

Force and Motion: Problem Solving Strategies

The purpose of this study was to determine what strategies high school juniors (novices) use to solve physics problems related to the concepts of force and motion and how these strategies compare to those used by experts. The ultimate goal of this research is to improve student's physics learning. This research study was modeled after previous research titled "Creating a Strategy Instruction Curriculum to Improve Math Students' Learning". This study was conducted by giving all participants, experts and novices, the same eight questions related to force and motion selected from the 8th grade Texas Assessment of Knowledge and Skills (TAKS) examination. The problems were modified by rewording them and removing multiple-choice answers were required. We examined instruction about the concepts of force and motion, the purpose being to incorporate those strategies into the middle school and high school physics curriculum. Solving of physics problems requires the use of mathematical (algebraic) strategies. Therefore an additional focus of this study was to identify mathematical problem solving strategies novice students and experts use while solving physics problems. We determined whether the strategies identified by our research regarding student's math learning are transferred or applied while solving physics problems.



## Linda Phillips, Anat Yarden, Hedda Falk, Stephen Norris, Mari' Pilar Jimenez-Aleixandre, Danielle Ford

Reading Scientific Texts: Adapting Primary Literature for Promoting Scientific Literacy

The use of primary scientific literature may help to develop scientific literacy among learners. In this symposium we will provide arguments for as well as evidence from using various forms of primary literature for high-school science learning. We shall argue that reading scientific text is an inquiry activity which could become a part of school science instruction through the use of adapted-primary-literature (APL). Indeed the enactment of APL-based curriculum promotes engagement, inquiry thinking, integration of knowledge, nature of science (NOS) understanding, and comprehension of the subject matter among high-school students. While analyzing the data in the Results section of APL, students display a large number of epistemic practices, mostly considered as scientifically authentic. Fewer such epistemic practices are found during the enactment of the Discussion section. A different format of APL, which is using hypertext, provides the opportunity for students to experience genuine contemporary applications of the science and mathematics that they are studying. A comparison between the argumentative and persuasive structure of a primary article, journalistic reported versions of the same article, and students' summaries of one of those journalistic reported versions, provides additional insights into the use of APL for science learning.

## Karen Phillips, Mya Marquis

Metacognition and Affect in the Language of Chemistry Tutors

This study examines the written and spoken narrative of high school chemistry tutors for evidence of their metacognitive thinking, depth of conceptual understanding, and affective response to the students they worked with. Two tutors, each with very different levels of demonstrated achievement and confidence in the subject, were observed throughout an intensive summer chemistry program in order to identify their perceptions about their own learning and the issues they had to face in their quest to be effective tutors. We demonstrate, through the language used during interviews and in daily journals, that the act of tutoring forces tutors to put learning into a metacognitive frame by encouraging them to become aware of their own thinking and evaluate their own ideas in the process of helping others. Analysis of their written and spoken narrative also reveal considerable differences between the two tutors in terms of their affective responses to their students. We illustrate how their own prior history of achievement relates to the direction of their metacognitive thoughts and perceptions about learning, as well as their ability to model self-directed learning behavior for their students to emulate while tutoring them in a manner that is sensitive to their past failing experience.

## Teddie Phillipson-Mower

Environmental Educators' Conceptions of the Nature of Science and the Role of Science in Environmental Education

An understanding of nature of science is thought to be crucial to decision making and citizenship. These are the same goals that environmental educators seek to achieve as an outcome of environmental literacy. The purpose of this study was to explore environmental educators' views of nature of science and their conceptions of the role of science in environmental education. A convenience sample of 20 environmental education practitioners (10 for-mal/10 nonformal; 10 science backgroung/10 non-science background) was selected. All participants completed a modified VNOS questionnaire and interview which included questions to elicit their conceptions of the role of science in environmental education. Findings included similarities with current research such as most environmental educators regardless of subgroup had views of NOS that were inconsistent with science reform documents. Different from the research literature, practitioners of EE over all had an understanding of science as socially and culturally embedded that was consistent with reform documents.



## **Molly Phipps**

iPods and Chaos: Using Design Research and Clinical Interviews in an Interactive Exhibit

Some exhibits at ISIs are very attractive to visitors but more or less ineffective; many visitors stop to interact with them and those that stop watch them for a long time and, yet these do not convey their intended message to most visitors. As museums have moved from collections of facts and objects to centers for learning and inquiry, how visitors interact and make meaning from exhibits has become more critical. This study uses the principles of design research to examine the impact of extra video content, delivered via video iPod, on visitor understanding of an abstruse exhibit. The exhibit in question is a double water wheel designed to model the patterns inherent in scientific chaos. Visitor understanding of the model (exhibit) and chaos are compared to the information available from the exhibit text and from the video clips on chaos using concept maps. Visitors' mental models of chaos are elicited through observations and clinical interviews.

## Jesús Piqueras, Nadia Seneby, Karim Hamza

Learning From Young Experts. A Study of the Interplay Between Students and Young Experts in a Biology Lab

In the present study we present the preliminary results of an analysis on the interplay between upper secondary students and novice experts in biotechnology in a laboratory activity at the school resource centre the House of Science. We used an analysis of epistemological moves developed by Lidar, Lundqvist and Östman (2006) as a methodological approach to analyze the connection between the experts' teaching practices and students' meaning making. In thirteen out 23 interplays, assistants' epistemological moves helped the students to achieve one of the purposes of the practical. We could identify several kinds of epistemological moves used by the assistants which had an effect on the students' practical epistemologies. We also found that the assistant's epistemological moves could be experienced in different ways by different students in the group. Our results are preliminary but it seems clear that assistant do not spend sufficient time with the groups to help them satisfactorily. It was, however, notice-able that the authority of the assistant as an expert in the field is easily accepted by the students.

## Wesley Pitts, Ashraf Shady, Gillian Bayne, Karen Phillips, Kenneth Tobin

Immigration, Culture and Science Education in New York City

This symposium looks at science education in New York City through the eyes of researchers who typify the multicultural learning environments that they study. Their focus is on the ways in which immigration has shaped the culture within urban science classrooms and the ways in which their lives as science teachers and researchers have been influenced by their own experiences. They examine science education as a form of cultural production in a variety of contexts and they identify the formation of interstitial cultures shaped by diversity. Each panelist in this symposium uses mixed methods for the collection and analysis of data resources and to support the claims of their research. These include Autobiography, Discourse and Conversation Analysis, and Authentic Ethnography. Each will present a slightly different perspective in relation to this overall theme, illuminating the specifics of their own research while illustrating the theoretical framework that underlies the whole symposium. All five presenters are either immigrants themselves or come from first generation immigrant families, so their research is, in many ways, very relevant to their own lives. All of the presenters also teach and perform their research in sites of cultural production where immigration and ethnic identity figure prominently.

## Wesley Pitts

Potentialities Beyond Deficit Perspectives: Improving Solidarity and Science Fluency During Chemistry Laboratory Activities in Urban High Schools

Abstract Often successful science lessons are not the result of a well-written curriculum or expert teacher (although both are important), but rather the product of a successful cooperation and coordination involving teachers and students. As such, solidarity is important in order to building science identities and create successful fluent en-



counters in science classroom across differences. The students and teacher highlighted in this study interact, trade roles, and enact culture appropriated from outside and inside the classroom in order to complete a science laboratory activity. Empirical evidence for solidarity and fluency was guided by physical and verbal displays of synchrony, mutual focus, entrainment, and emotional energy, body gestures, and prosody markers. What we can learn from successful student-student interactions is that creating structures and agency that supports positive emotional energy, science identity, and solidarity is a necessary ingredient towards the emergence of fluency in science. This study shows that classroom participants used a combination of prosody makers to appropriate resources and to create structures that help decrease the breaches of encounter across categories of age, ethnicity, and gender, and role.

## Julia Plummer, Rebecca Rice

## Inquiry and Astronomy: Investigations in Celestial Motion

The purpose of this study was to investigate the ability of students in an elementary science methods course to explain the apparent motion of the sun, moon and stars using the actual motion of the earth and moon and the impact on that understanding of their own inquiry investigations into these topics. Analysis reveals that these students do not hold scientific understandings of the patterns of apparent motion of the sun, moon and stars and that most students used the rotation of the earth to explain the day/night cycle did not use this to explain the apparent rising and setting of the sun, moon and stars. Students chose a range of questions to investigate for their inquiry projects, though all in the domain of celestial motion. Post-assessments showed that the most students improved in their description and explanation of stars' motion, areas where few students held accurate ideas before instruction. A comparison of individual students' inquiry projects with the change in their understanding reveals that while some students improved in both their area of inquiry and beyond, most students will need more structured instruction to make the connections between their own observations and the patterns and explanations of celestial motion.

## Julia Plummer, Joseph Krajcik

## A Learning Progression for Apparent Celestial Motion

Extensive research has shown that children's understanding of astronomy does not agree with the accepted scientific view. In this paper we have synthesized prior research to develop a learning progression that describes how students' initial ideas can be built upon to reach the scientific understanding. A learning progression gives a possible, though not inevitable, description of how students may move through successively more sophisticated ways of reasoning within a domain (NRC, 2007). The learning progression was built around the big ideas of astronomy from an earth-based perspective, focusing on the patterns of apparent motion of the sun, moon and stars. The development began with a domain analysis of the aspects of astronomy pertaining to the patterns of apparent celestial motion and a close examination of the research literature on children's conceptual understanding. The learning progression was further refined through analysis of children's ideas about apparent celestial motion across elementary and middle school, as learned through traditional schooling, observations of the world, and cultural interactions. An instructional intervention was then created and tested, based on the levels of the learning progression. We have used the results to report how this method of instruction can move students along the proposed learning progression.

## Khemmawadee Pongsanon, Alan Oliveira, Valarie Akerson, Abdulkadir Genel, Huseyin Colak

Getting the Big Picture: The Impact of a Summer Workshop on Teachers' Views of Scientific Inquiry, Nature of Science and Classroom Interaction

This study examines the impact of a summer workshop in which elementary teachers' views of nature of science, scientific inquiry and teacher-student interaction were simultaneously targeted through a combination of expert instruction on classroom discourse (questioning, hedges, backchannels, phatic expressions, solidarity, directives and politeness, involving and engaging), inquiry immersion, collaborative discussions, and discourse analysis of videotaped inquiry science lessons. Interpretative analyses of teachers' responses to various surveys (VNOS, VOSI



and Interactional) revealed that teachers held appropriate and well-informed views of scientific inquiry and nature of science prior to the workshop and for this reason their views remained largely unaffected by it. In contrast, the workshop had a strong impact on teachers' interactional views of inquiry, encouraging them to develop a new conception of inquiry science teaching centered on classroom discourse and teacher-student interaction. Not only did teachers become more aware of the social implications of the language they used to interact with students, but they also developed a more sophisticated and integrated view of inquiry-based science instruction by explicitly connecting classroom discourse and teacher-student interaction to particular aspects of inquiry and nature of science.

## Geoff Potvin, Zahra Hazari, Robert Tai, Philip Sadler

Adopting Gender Stereotypes: Unraveling Bias From Student Evaluations of Their Teachers

The evaluation of high school science teachers by their students is examined by analyzing nearly 7000 student surveys in three separate disciplines: biology, chemistry and physics. It is found that, in all three fields, the gender of the teacher is a significant predictor of their evaluations, even after controlling for a number of other factors, including the students' final grades. In all cases, male students rate their female teachers significantly lower than their male teachers while female students do so only for physics. There is additional evidence that male and female teachers in the sample are equally competent and effective in preparing their students for future college study. This implies that there may be discipline-specific gender stereotypes that have been internalized differently by students in these fields and are being externalized in their judgment of their teachers.

## Vaughan Prain, Russell Tytler, Peter Hubber, Stephen Norris

Representation and Learning in Science: Exploring Recent Perspectives from Cognitive Science

Recent accounts by second generation cognitive scientists of factors affecting cognition (Klein, 2006) imply the need to reconsider current dominant conceptual change theories of learning in science. These new accounts emphasize the role of context, feelings, embodied practices and narrative-based representation rather than decontextualized manipulation of symbols in learning science. In this paper we analyze data from a longitudinal study of children's learning across the primary school years, and data from video capture of science classrooms, as an empirical exploration of the usefulness of the ësecond generation cognitive science' framing of learning. Our study found that this framework provides some strong theoretical and practical insights into how children learn and the key role of representational negotiation in this learning

## **Peggy Preusch**

An Urban Elementary Teacher's Experience Surrounding Her Students' Participation in an Outdoor Environmental Science Field Trip

This case study focused on development of an understanding of a teacher's experience and use of an environmental science field trip as pedagogy. Fourth grade, urban students and their teacher were observed during a Fall, 2006 field trip to a wetland education center, and in the classroom pre- and post- field trip. The teacher's intentions and decision making process related to the field trip were the focus of interviews. One finding is that the standardization of the curriculum can bevery problematic for teaching students science due to low flexibility in the subjectmatter to be covered. In addition, the teacher was challenged to connect the study of science to the field trip due to the students' lower than 4th grade reading and writing levels and her own knowledge level and interest in teaching science. However, the teacher's ability to be responsive to the students and her understanding of the students' socio-cultural backgrounds enabled her to successfully create a positive learning environment during the field trip. Given that many nonformal science education centers offer funding to urban students, development of relation-ships with teachers to support related science education in the classroom should be a consideration in program development.





## Gjalt Prins, Astrid Bulte, Albert Pilot

Meaningful Learning About Models and Modelling Using Authentic Chemical Practices as Contexts

In science education students should come to understand the nature and significance of models. A promising strategy to achieve this goal is to involve students in an authentic modelling practice. The aim of this study was to design and empirical validate a curriculum unit using the authentic practice 'Modelling drinking water treatment' as context for chemistry education by means of a design research approach. The unit was enacted in classroom by 40 students in upper secondary chemistry education, grade 10-11. The findings reveal that students experienced the sequence of modelling activities as coherent. In addition, students developed the intended conceptual understanding of the purpose, reliability, scope and boundaries of models. As a result of using 'Modelling drinking water treatment' as context new science content was introduced and a logical integration of mathematics and chemistry was established. This study ends with implications of the design of 'authentic practice' based curriculum units.

#### Nana Quistgaard

#### Guided Dialogue at Science Centers

Data presented in this presentation involves asking questions to 15-16 years old students during a science center visit. The hypothesis was that it is possible to create a room for reflection at a science center by stimulating and facilitating a mutual dialogue. The background was the vast amount of studies showing that free-choice, unstructured school trips result in little (if any) student reflection. The underlying theoretical perspectives of the project are Bakhtin's concept of dialogism supplemented by Dewey's ideas of learning exchange and mutual communication Data indicates that guided dialogue holds potential to create high-level reflections both in the situation and following as demonstrated by interviews conducted one year later. Each of the five participating students constitutes a case, where level and number of reflections are correlated with learning style and long-term impacts. Data consists of video/audio recordings and interviews.

#### Jrene Rahm

A Look at Meaning-Making Inside Partnership Projects Among Scientists, Museums and Schools : Struggles, Confusions or Cocreations?

Partnership models among schools, scientists and museums have become a powerful pedagogical tool to make science more appealing to youth and in fostering science literacy development. Yet, little research has examined the forms such partnerships take over time and the manner science is talked into being as scientists, students and teachers interact with each other and the artifacts in the museum or brought to the classroom by the scientists. How do scientists and students talk to each other and co-construct scientific understandings? How do they position themselves in relation to science and each other, and in what ways does such positioning constitute meaning-making? These questions are explored from a sociocultural perspective with a focus on discourse and positioning work in seven partnership models that were part of an in-depth qualitative case study of these models, entailing a video ethnography of all activities and interactions, and qualitative interview data of all participants. The discourse analysis suggests that students and teachers transformed the authoritative talk of scientists' animations in classrooms and museums into interactive dialogue through active questioning which in turn led to more complex explanations by scientists of science concepts.

## Jrene Rahm

Positioning in the World of Science : A Look at Four Youths' Hybrid Identity Work Within and Beyond a Math and Science Upward Bound Program

How do youth experience opportunities outside of school to do science? Do they make possible the positioning as insiders to science? Are such experiences empowering making upward mobility a possibility or are they lived as yet another illusion of inclusion and insider status? How do youth manage to sort out the conflicting messages



they receive from such programs, family, and peers? To answer such questions, I explore the learning trajectories and hybrid identity projects of four youth that I followed over time and space as they first participated in a three year integrated Math and Science Upward Bound Program and in turn, began their college years. I examine their experiences from a sociocultural perspective and in light of the literature on the culture of community science programs. I draw upon video-ethnographic data from the Upward Bound Program collected over two years (2001-2003) to illustrate their forms of participation over time and space while using interview data (2004 & 2006) to make evident their positioning work and figured worlds of science and self over time. I discuss the value of such opportunities despite the fact that participation in the world of science often positioned them as marginal within their own communities.

## Mary Anne Rea-Ramirez

Determining Effective Target Concepts and Learning Pathways

Ordinarily there are many more topics one could teach in an area of science than one has time for in a particular course. How instructional topics are chosen and sequenced becomes central not only to determining what to teach, but whether students are able to construct dynamic mental models that can be used in causal reasoning. Designing curriculum so that students construct complex models through successive small stages, moving from one intermediate model to the next until the final target model is reached, appears to be a key to fostering this type of reasoning. This study used in-depth tutoring interviews with middle school students in a controlled environment to document steps students took in constructing dynamic models of respiration. The analysis of the data allowed the researcher to identify a learning pathway that was generally consistent among students. The researcher was then able to use this information to design a curriculum that used realistic intermediate target concepts to break the final target into steps that made up a learning pathway for the study of human respiration. Understanding obtained from studies of this kind may be key to designing science curricula that support students' construction of complex models in biology.

## Bryan Rebar

## Changes in Children's Conceptions of Nature Following a Residential Environmental Education Experience

Field trips to residential environmental centers provide unique opportunities for learning. However, few studies have attempted to characterize children's conceptions of nature resulting from a residential environmental education experience. Conceptions of nature contextualize knowledge and attitudes, which are measures of learning typically reported. Thus, this study begins to address this relative knowledge void by employing qualitative and phenomenological methods rather than quantitative tools. Interviews, writings and drawings on the topic of nature were collected from 5th grade students before and after a three-day residential outdoor school program conducted on the Oregon coast. Students' responses were analyzed in terms of breadth and depth of their nature conceptions. Individual students' additions to the emergent categories of breadth, including new organisms, habitats, processes, and non-living things, were used to measure change in the breadth of students' nature concepts. Change in depth of students' nature concepts was measured by means of emergent hierarchical typologies representing ideas included in students' understanding of nature. Findings indicate almost universal gains in breadth and modest gains in depth of students' nature concepts. Implications for both research and practice, in terms of targeting appropriate learning outcomes and methods to document such learning resulting from an informal setting, are discussed.

## N. Sanjay Rebello, Edgar Corpuz, Jacquelyn Haynicz, Bijaya Aryal, Dyan McBride, Edward Redish, Dean Zollman Investigating Dynamic Transfer in Multiple Contexts

All presentations in this symposium are centered around a common research theme ñ How do students make sense of everyday devices and phenomena? In addressing this question, we adopted a framework of transfer of learning, which focuses on the dynamic construction of knowledge by learners as they make sense of a context. To examine the process of knowledge construction we utilized teaching interviews to investigate how students learn when



provided a repertoire of scaffolding in the form of questions, hints and cues as well as hands-on learning experiences. Our research results highlight the types of knowledge and reasoning resources that learners activate and how scaffolding can be used to facilitate the process of knowledge construction.

## Giuliano Reis, Shelley Ross, Catherine neé Pennachetti, Wolff-Michael Roth

Motivation Theory in Action: Using Saltwater Aquaria to Teach Science in Schools

In the school context, field trips to marine aquaria are considered valuable for scientific literacy purposes. Likewise, marine science represents a curriculum and instructional approach that deals with relevant problems faced by students. In this scenario, the implementation of saltwater aquaria in school is a powerful educational strategy that combines in one chilled tank the study of marine life with the hands-on aspect of fieldtrips. In providing students and teachers with the necessary motivational elements to support learning in an engaging environment, it also informs educational policy design. Therefore, the purpose of the present research is to present a study of the motivational impact of marine aquaria in schools, and discuss the policy implications that arise from it.

## Brian Reiser, Christina Schwarz, Joseph Krajcik, Elizabeth Davis

Progress and Challenges in Making Modeling Practices Meaningful

In this fifth paper in the set, we review the attempts to develop a vision of modeling practice and incorporate it into science learning in elementary and middle school classrooms. We synthesize the arguments and findings of the first four papers in this paper set on the theoretical learning progression, studies of elementary and middle school students, and studies of teacher learning, to identify the aspects of modeling practice we have been successful in bringing to classrooms, and the challenges that have emerged. We consider the tensions between itypicalî classroom culture and the associated understandings of ischool scienceî with the perspective and epistemology necessary to buy into and engage successfully in modeling practices.

## Leonie Rennie, Rosemary Evans, Fiona Mayne

Responses to Traveling Do-It-Yourself Science Exhibits in Community Settings

Twelve Do-It-Yourself Science Exhibits form part of the outreach program developed by a science centre to provide interactive science resources for schools and community groups, particularly those located in non-urban areas. The exhibits are easily transportable and available for loan to libraries, tele-centers and other community venues. This study explores responses to these Exhibits set up in a regional mining museum, and in a civic library. Data were collected by observations of children and adults using the exhibits, structured interviews with adults, surveys of children and interviews with the organizers who hired the Exhibits. The evaluative aim of the research was to determine the effectiveness of the exhibits in terms of how they were used and how they might promote science learning; broader questions concern the science education value of such sets of exhibits. Do these Exhibits really help adults and children learn about science or become more interested in science and science-related careers? Or are they just interesting pieces of equipment that create a brief but enjoyable experience?

## Bronwen Rice, SueAnn Bottoms, Shawn Rowe

Teacher Perspectives in Ocean Sciences Education: A Look at the SMILE-CIOSS Partnership

The Cooperative Institute for Oceanographic Satellite Studies (CIOSS) partners with The Science and Math Investigative Learning Experiences (SMILE) Program to bring ocean sciences and satellite oceanography to high school students and teachers around the state of Oregon. This study was conducted as a formative program assessment during the third year of this partnership. Small group (2-4 person) interviews were conducted with twenty SMILE high school teachers during a professional development workshop in February, 2007. Interview questions focused on usage and understanding of select framing and content terms: ocean literacy, remote sensing and satellite oceanography. Responses from these interviews, as well as individual interviews with a SMILE staff member,



former SMILE graduate assistant, and representative from CIOSS, were analyzed for emerging themes. The results from this study are being used to inform the design and implementation of future professional development programming for SMILE high school teachers. In addition, the small-group interviews present a test of a research method that can easily and inexpensively be included in workshop or professional development components of education programs.

## Diana Rice, Cynthia Lundeen, Sibel Kaya

Preservice Elementary Teachers' Ideas about Evolution: Interrelationships with Self-efficacy, College Science Courses, and Science Content Knowledge

This study investigated 240 preservice teachers' ideas about evolution in relation to their college science coursework and their science teaching self-efficacy. A 13-item instrument including 10 questions from the NSF Survey of Public Attitudes Toward and Understanding of Science and Technology and three designed by the instructor was administered as part of the class discussion of nature of science teaching in an elementary science methods course. Two sections of the methods course (N=36), a subset of the participants, were also given the STEBI-B, a measure of science teaching self efficacy beliefs, both pre and post. Findings revealed that 42 percent of participants had ideas more consistent with creationism than evolution based upon four questions from the NSF Survey. This group scored significantly lower on the 13 item science instrument than those whose responses were more consistent with evolution. Also, significantly fewer in the former group correctly classified 'humans' as animals. No differences were found between the two groups on the STEBI-B, although pre- to post gains were made by all. Completing 'advanced' college science courses was not significantly related to science scores or science teaching efficacy beliefs. Implications of findings are discussed.

## Gail Richmond, Joyce Parker, Mark Urban-Lurain, Brett Merritt, John Merrill, Ronald Patterson

Assessment-Informed Instructional Design to Support Principled Reasoning in College-Level Biology

Standards documents call for students to systematically reason about scientific problems to better understand the world.. Teachers also must understand and use content in similar ways, and must have the opportunity to develop these skills in the context of the content they will teach. Our project was designed to facilitate development of reasoning about key processes and systems in biology. We constructed content-specific frameworks that define goal understanding and practices and serve as conceptual organizers for teacher and learners. With these frameworks as guides, we used an iterative process to develop assessment clusters, design instructional changes, and assess resulting changes in student understanding. We also developed a domain-specific taxonomy to evaluate students' ability to engage in principled reasoning (PR). We used stratified GPA to compare academic achievement across two sections of an undergraduate biology course, one section focusing on PR (Section1) and one without this focus (Section2). The strongest effect was for the middle GPA group in Section1, with 20% performing better on the PR questions (p 15.32% better on the non-PR questions (p fundamental problems in students' ability to engage in PR, we can design instructional interventions that make a difference.

## Eric Riggs, Russell Balliet, Christopher Lieder

Geologic Problem Solving in the Field: Insights into Student Problem Solving Strategies Through Analysis of Field Navigation

Field instruction is a critical piece of undergraduate geoscience majors' education, and fieldwork remains a major part of the work of professional geologists. Despite the central importance of field education, there exists relatively little educational research exploring how students learn to solve problems in geological fieldwork. This study adds tools and insight to the study of field problem solving. We used GPS tracking of students engaged in independent field examinations, and developed two parallel coding approaches for analyzing student navigational choices. Taken together, our coding enables correlation of navigational characteristics with performance and lends insight into problem solving by building on a conceptual framework modified from the cognitive science field of Naturalistic Problem Solving. Our results indicate that most advanced geology undergraduates are capable of recognizing



important features in the field, however lower-performing students fail to systematically test multiple interpretations of their data as reflected in poorly planned traverses across the examination field area. Specific track sequences, especially those involving reoccupation of locations, show particular difficulties in aspects of problem solving that are reflected in low quality interpretations on finished maps. Our study offers new tools and an independent approach to gauging student skills in geologic field problem solving.

## **Carol Rinke**

## Retention of Urban Science Teachers: Pathways Toward Integration or Participation

This paper addresses the issue of teacher retention in urban science classrooms, in which a revolving door of new teachers leads to an inexperienced teaching force and reduced academic attainment for students. Urban science teachers are particularly susceptible to attrition due to extensive professional opportunities outside the classroom. This study follows eight case study teachers in an urban school district in order to better understand how today's urban science teachers think about their careers and career moves. The experiences and perspectives of the eight case study teachers revealed that they followed two trajectories through the profession, those who aimed to integrate and were oriented toward the educational system and those who wanted to participate and oriented themselves away from the educational system. These professional directions were influential in shaping case study teachers' experiences in schools as well as their career directions. This finding suggests the centrality of urban science teachers' professional orientations for recruitment, preparation, and retention.

## Stephen Ritchie, Donna Rigano, Louisa Tomas, Andy Yeh

Writing for Learning Science: What Cognitive Tools Can Do to Structure Online Writing of Biostories

In response to international concerns about scientific literacy, students' waning interest in school science, and the underutilization of digital and networked technologies in science lessons, this study aimed to explore how an online science-writing project, using cognitive tools to structure the implemented activities, might improve students' interest and learning outcomes in science. A mixed methods design was employed by the study of the experiences of 101 6th-and 7th-grade children from five classes across two Australian schools. Students' Biostories about the selected contemporary socio-scientific problem of biosecurity merged scientific information with the narrative storylines. These were uploaded to a designated website where peers could read and comment on each other's stories. The results suggest that the cognitive tools helped the students become more familiar with biosecurity issues, develop a deeper understanding of related biological concepts, and improve their enjoyment of writing in science classes. Research, teaching and policy implications of these results for promoting scientific and digital literacies are discussed.

## Mraia Rivera Maulucci

Learning to Teaching Science: Negotiating Identity and Discursive Conflict in the Science Classroom

This qualitative study reports a subset of findings from a larger, ongoing study aimed at exploring interactions between teacher identity, learning, and classroom practices in a social justice teacher education program at a selective liberal arts college in New York. This case- study explores the journey of Elena, as an immigrant and a pre-service teacher candidate towards becoming a social justice educator. Elena reflects upon her learning in a social justice teacher education program, and during her student teaching experiences in a middle level science classroom. The analysis spans macro, meso, and microlevels to explore the intersections between language, identity, and power as they unfold in science classrooms. The findings show some of the ways language and scientific literacy verify and/ or deny aspects of Elena's core identity; specific instances where science discourse functions as power and privilege versus disadvantage according to ethnic, language, and gender categorizations; and the struggles Elena faces given the focus on high stakes accountability in science in her school.


#### Ann Rivet, Mary Petzoldt, Jenny Ingber, Jessica Riccio

Characterizations of Inquiry: Science Teachers' Descriptions of Curriculum Reform

Studies indicate that enactment of innovative science curricula can vary extensively across individual teachers and are not always "implemented with fidelity". Teachers' self-report of curriculum enactment has also been found to be less accurate when compared to observed actions in classrooms. Yet as new science reform programs move quickly to scale, it is realistic that teachers' primary face-to-face interaction with professional development support will be within the context of large workshop settings. Thus a key challenge facing reform efforts is how to support teachers through professional development that meets their needs when the only source of feedback is teachers' self-report in large workshops. We present a preliminary study of a new project-based curriculum pilot program in a large urban area, where we interviewed a sample of teachers and attempted to discern how they characterized inquiry based on their descriptions of their initial use of the new program. We found that teachers commonly characterized inquiry as "hands-on" or "discovery", articulated distinctions between inquiry processes and students' content learning, and recommended adaptations to fit students' needs without consideration for underlying design frameworks. These findings may lead to a better understanding of how to support teachers as part of large-scale reform efforts.

#### Tina Roberts, Marcelle Siegel, Linda Blockus

Examining the Impact of Critical Events on the Decisions of Science Undergraduates to Pursue Careers as Research Scientists

The purpose of this study was to examine the impact of critical events on the decisions of undergraduate summer science researchers to pursue careers as research scientists. The researchers used a modification of Flanagan's critical incident technique and sought to identify and explore categories of events that appeared to encourage or discourage undergraduates from pursuing a career in their field. Ninety-three undergraduates participated by filling out surveys about their career goals at the beginning and end of the summer, as well as a survey regarding a single critical event that occurred during the last four weeks of their experience. Findings indicated that 39% of students generally felt that their event was related to their research project and that the same event, experience by different undergraduates, could have differing impacts on career choice depending on whether the event was viewed positively or negatively. A majority of undergraduates also indicated that their self-confidence in and interest in becoming a research scientist were positively affected by their critical event. By identifying events that more positively or more negatively affect undergraduate career choices, faculty may be able to more effectively retain students to the academic track.

#### **Meredith Park Rogers**

Investigating "Life in a Square": An Examination of Elementary Preservice Teachers Understanding of Observation and Inference

The purpose of this study was to explore how a 6-week contextualized inquiry experience developed elementary preservice teachers understanding of observation, inference, and the relationship between the two for generating explanations. Three research questions guided my analysis of data collected from the preservice teachers' inquiry journals and end of the project interviews. Three key findings included: 1) simplistic descriptions given by the participants explanations for the changes, 2) an understanding of observation and inference but a lack of understanding in the relationship between the two with regards to formulating explanations, and 3) agreement that this type of inquiry activity is necessary for elementary students to learn about NOS and inquiry but with some modifications. Additional findings are elaborated on in the paper. From this study I learned that preservice teachers in their own learning practice. Implications for future research examining preservice and inservice teachers transfer from what they understand about observation and inference to their science teaching practice is discussed.



# Kathleen Roth, Karen Givvin, Catherine Chen, Leslie Atkins, Kathleen Schwille, Daniel Levin, Janet Coffey

Research Committee Sponsored Workshop: Using Video cases to Support and Study Preservice Teacher Learning: Two Approaches.

Extending the their findings from two major NSF research studies Case Studies of K-8 Student Inquiry in Physical Science (David Hammer and Emily van Zee) and the Video cases for Science Teaching Analysis (ViSTA) project (Kathleen Roth, Karen Givvin, Catherine Chen, Kathleen Schwille, Leslie Atkins), presenters will engage participants in the methods of building and using video cases to support preservice teacher learning. The approaches differ in their theoretical perspectives on teacher learning, in the kinds of structure provided to preservice teachers and their instructors, and in the degree to which science content knowledge development is an intended outcome of the use of the video cases. In this workshop, participants will first be engaged in watching and analyzing selections from one K-8 video case from each of the two projects. They will experience the video cases as preservice teachers might encounter them in a methods course. During the final part of the workshop, participants will reflect on this experience from a research perspective – comparing the two approaches, including the research base behind each of them, and discussing how the use of these video cases can contribute to a knowledge base about effective approaches for preparing science teachers.

#### Anita Roychoudhury

#### Intersection of Teacher and Student ZPDs: Instructional Implications

This study of preservice secondary teachers takes a microscopic view of the discourse practices they experienced in a methods course and that they attempted in their own teaching. The findings show that these teacher-candidates adopted several different discourse styles; these highlighted the specific areas of difficulties that they had in designing and implementing instructions that engaged students in the meaning-making processes.

#### Mollie Rudnick, Jeanne Century, Cassie Freeman, Debbie Leslie, Murat Kavheci, David Beer

Measuring Fidelity of Implementation: Understanding "Critical Components" of Science Instructional Materials

This paper describes a portion of the work of the "Applied Research on Science Materials Implementation: Bringing Measurement of Fidelity of Implementation (FOI) to Scale" project. This three-year, National Science Foundation-funded project has two main goals: 1) to measure the extent and nature of fidelity of implementation of K-8 science and mathematics instructional materials in a large urban school district and 2) the development of a suite of instruments to measure the fidelity of implementation of standards-based science and mathematics instructional materials (FOSS, STC, Science Companion, SEPUP, and Everyday Mathematics) at the K-8 level. In order to achieve these goals, our first step was the development of a conceptual framework for describing fidelity of implementation. The next step in the process was the identification of the "critical components", or essential elements, of the instructional materials programs, and determining where these critical components resided in the conceptual framework. The combination and extent of critical components a teacher enacts during instruction determine the "typology" of implementation and that typology is then analyzed for relationships to student outcomes. This paper will describe the process of identifying and categorizing the critical components to enable FOI measurement in enactment, efficacy, and effectiveness studies.

# Stephen Rybczynski, Elisabeth Schussler

Student Preconceptions of the Role of Pollination in the Plant Life Cycle

Many students display a surprising lack of knowledge about the processes involved in plant reproduction, which is an important component of the fourth grade life science curriculum. In this study, we present potential pollination misconceptions that were inferred from student predictions about the fate of plants that were not pollinated. Thematic analysis of the data found three incorrect ideas conveyed by students: non-pollination will result in death, un-pollinated plants will be less healthy or not grow as well as those that were pollinated, and a general confusion about the subject. A fourth theme was also identified that correctly linked pollination to the production of seeds.



These results demonstrate that the majority of students in this study harbored misconceptions regarding the role of pollination in the plant life cycle, a situation that may hinder their ability to fully comprehend plant reproduction. Teachers should be aware of the types of pollination preconceptions held by students in order to design lessons in a way that debunks misconceptions and fosters a clearer understanding of the role of pollen and pollination in plant life cycles.

#### Kihyun Ryoo

# Effects of Computer Simulation on English Language Learerns' Science

Although computer simulation has been widely used across science fields, such as biology and physics, and its effectiveness in science education has been examined, the role of computer simulation in improving English Language Learners (ELLs)' science learning have not been studied carefully to date. The purpose of this pilot study is to understand how the use of computer simulation helps ELLs develop conceptual understanding of scientific phenomena and provide stimuli for their use of scientific discourse in a collaborative learning environment. Twelve 5th-grade ELLs were randomly paired and participated in a series of computer-based interactive problem-solving activities. They were asked to solve problems related to photosynthesis by manipulating virtual objects in the computer simulation program. Collaborative dialogues and interactions of each pair were video taped, and individual interviews with students were collected. Preliminary results of videos and interviews reveal that the use of computer simulation enables ELLs to reflect on their thinking process, fosters their use of scientific discourse, and engages them in scientific inquiry process.

#### Saed Sabah, Xiufeng Liu

Developing a Two-Tiered Instrument with Confidence Levels for Assessing Students' Conceptions of Direct Current Circuits

The purpose of this study is to develop and validate a two-tier revised instrument (DIRECT-TTC) for diagnosing student understanding of Direct Current (DC) circuits. Another main purpose of this study is to investigate the relationship between students' understanding of DC circuits and their confidence in their answers. The revised instrument consists of 15 two-tier items with a confidence scale. Through a two-stage quantitative and qualitative validation process using both conventional statistics and Rasch modeling, the results indicate that the instrument is both valid and reliable. The results show a statistically significant association between students' answers to the first- tier questions and reasoning, r = .65 (p)

#### Jon Saderholm

#### A Study of the Science Inquiry Learning Environments Created by National Board Certified Teachers

This study attempted to uncover differences existing among the science inquiry learning environments created by National Board Certified Teachers (NBCTs) and non-NBCTs. This study was conducted in middle and high schools in Kentucky between October 2006 and January 2007. This was a multi-level mixed methodology study incorporating both quantitative and qualitative measures of classroom inquiry environment. It used a quasi-experimental design with non-random assignment and dependent pre- and post-tests (Shadish, Cook, & Campbell, 2002). Science inquiry environment was measured with the Elementary Science Inquiry Survey (ESIS) (Dunbar, 2002). Science inquiry environment measurements were triangulated with structured observations of a stratified random sub-sample of participating teachers. Analysis indicated that high school science NBCTs created learning environments in which students engaged in science NBCTs, on the other hand, did not create learning environments that differed in significant ways from those of middle school science non-NBCTs. The differences among the capacity of NBCTs and non-NBCTs, and among middle and high school teachers to enact science inquiry instruction are discussed. Implications for potential directions for science inquiry instruction research, teacher education, and NBPTS certification are provided.



#### Yavuz Saka, Sherry Southerland

Identities in a Community of Practice: The Role of Beginning Science Teachers' Identities in Becoming a Member of Their School Community and Implementing Science Education Reform

The first years of teaching are demanding as the novice works to gain a degree of familiarity in professional work, and a time when many teachers leave the teaching profession or move away from reform-minded practice. Using Cultural Historical Activity Theory, the goal of this multicase study was to understand how beginning science teachers' personal identities influence their involvement in communities of practice in their first year teaching and also to describe the impact of school context on shaping beginning science teachers' institutional identities, their involvement in the community of practice and their enactment of reform- based teaching practices. Data included a year of participant observations, surveys, questionnaires, interviews, observations, and mediating artifacts. Identities and dispositions of these teachers influenced their practices and their transition to become competent members of their school communities, transitions influenced by the social and professional structures of the schools and support to generate effective community of practice.

#### Sara Salloum, Saouma BouJaoude

Classroom Talk Analysis of A Science Teacher Balancing Teaching to the Test and for Conceptual Understandings

The purpose of the study was to present in-depth analysis of physical science classroom talk in which the teacher, Ms. Leila, was able to balance both commitments to teaching to the test and for conceptual science understandings. The study examined a science classroom's talk as an intersection between local talk and the global influence of grade 9 mandated exit exams. Classroom talk of 15 physics and chemistry sessions were analyzed. The science periods were videotaped and transcribed. Classroom talk (specifically the teacher's statements) was analyzed in terms of content knowledge types the teacher presented and how she shifted between them. Knowledge types were: factual, conceptual, procedural I: algorithms, and procedural II: inquiry methods. Shifts between different knowledge types were analyzed in terms of cognitive processes involved in the student-teacher interactions. It was found that shifts between factual/conceptual/ procedural (inquiry methods) were dialectical and implicit and dominated the body of concept explanation lessons. These shifts called for low adn medium level cognitive processes. Shifts between conceptual/procedural (inquiry methods)/ procedural (algorithms) were more explicit in terms of being related to test performance; they occurred mostly at the end of lessons. Ms. Leila's explicitness in dealing with exit exams built a constructive partnership with students towards a common goal of cracking 'exams.'

#### Victor Sampson, Jonathon Grooms

Science as Argument-Driven Inquiry: The Impact on Students' Conceptions of NOS

The overall objective of this study was to examine the impact of an innovative instructional model on students' conceptions of the nature of science (NOS). This model, which we call argument-driven inquiry, is designed to frame the goal of the inquiry process as an effort to explain natural phenomena, emphasize that individuals must be able to generate an argument that articulates and justifies an explanation as a result of the inquiry process, and make aspects of NOS a focal point of conversation inside the classroom. Findings suggest that placing these type of approach helps students develop a more informed understanding of NOS as a result of their experiences inside the classroom.

# Victor Sampson, Douglas Clark

Differences in the Ways More and Less Successful Groups Engage in Argumentation: A Case Study

To better understand how differences in group-level interactions can promote or constrain productive argumentation in science, this study examines and compares the interactive processes that took place within two more and two less successful groups. In order to capture both general features of the interactions and the particularities of individual groups, both quantitative summaries of conversation and qualitative description of events over time are included. This analysis identified five distinct differences in the ways these groups engaged in argumentation that



can be linked to the observed differences in the group outcomes. The number of unique ideas introduced into the conversation, how individuals responded to these ideas, how often individuals challenged ideas, the criteria individuals used to distinguish between ideas, and how groups members used the available materials were all notable differences in the ways these groups engaged in argumentation. These differences in the ways more and less successful groups engaged in argumentation highlight how interactions between individuals can influence group understanding and offer new insights for science educators interested in fostering productive group outcomes inside the classroom.

#### Jeff Saul, Lloyd Kramer, D. Jones, Eric Brewe, G. O Brian

Adapting to Modeling Instruction over Time

Intensive 3-4 week Physics Modeling Workshops can help high school teachers improve their content knowledge and pedagogical content knowledge, and learn to teach physics using modeling instruction, a guided-inquiry approach. The beginning workshop is designed to go through most of a one-year mechanics course. The curriculum is designed so that teachers can implement it in pieces or completely replace the curriculum for a year-long course. However, even with complete adoption, teachers may take years to master the modeling approach and help their students get the most out it. A selection of teachers who took at least one modeling workshop were observed teaching physics after completing the workshop and were interviewed about their teaching and implementing modeling over a one year period. Initially teachers face several challenges to adopting modeling. These challenges include accommodating state-wide and county-wide assessments and student discomfort with changes such as little or no lecturing and activities that make them think. As these teachers become more experienced, they continue adapting to become more proficient, more effective modelers. In this paper, we explore how beginning and more experienced high school physics modelers adapt their teaching to effectively implement modeling instruction.

#### Melissa Schen

# Scientific Reasoning Skills Development in an Introductory Biology Course Sequence for Undergraduates

Scientific reasoning is a skill of critical importance to those students who seek to become professional scientists. Yet, there is little research on the development of such reasoning in science majors, especially in biology. Using Lawson's Classroom Test of Scientific Reasoning (LCTSR) to assess hypothetico-deductive (HD) reasoning and Toulmin's argumentation pattern to assess argumentation abilities regarding a scientific scenario and data set, this study begins to establish a baseline of scientific reasoning development in undergraduate students enrolled in an introductory biology course sequence for majors. No significant trends of improvement were found in either HD reasoning or argumentation abilities over the two-quarter course sequence. However, specific difficulties in the control of variables and direct HD reasoning were found through analysis of LCTSR scores. Students were also found to have trouble identifying and rebutting counterarguments, compared to generating initial arguments. No difference was determined between biology majors and other students enrolled in the courses. Overall, little explicit attention was paid to scientific reasoning skills in the two-course sequence. These results suggest the need to develop direct explicit methods in order to improve the scientific reasoning skills of biology majors early in the curriculum.

# Sharon Schleigh, Douglas Clark, Cynthia DAngelo

The Impact of Gender on Conceptual Theoretical Framework and Cognition Across Cultures

This international comparative study addresses the debate surrounding gender and its impact on the way students think about science concepts related to force. Participants included 120 students from Mexico, Turkey, and the USA. Students in kindergarten, 3-4th, 7- 8th, and 11-12th grades were interviewed. Instruments designed by Ioannides and Vosniadou (2002) and diSessa et al. (2004), were employed to analyze conceptual frameworks and theoretical categorization. Analysis investigated the relationship of gender to (1) students' conceptual ideas, (2) the coherence of students' conceptual understandings, and (3) patterns of progression through conceptual categories by age and culture. Results suggest that girls express different conceptual ideas and progress through conceptual



categories in different patterns but exhibit similar levels of conceptual coherency in their understandings.

#### Heidi Schmoock, Shawn Rowe

Free-Choice Family Learning in a Bilingual Marine Science Program: A Qualitative Investigation of Interactions and Long-Term Impacts Among Mexican-Descent Families

Diversity in terms of ethnic, cultural, and socioeconomic status is not well represented in family learning research or in museum attendance. Thus, this study begins to address these needs by documenting evidence for learning and teaching during and after participation in a bilingual aquarium sponsored family learning program. Using a sociocultural framework for understanding learning, moment-to-moment interactions between participants while engaging in the program were observed. Long-term impacts were documented through interviews about participants' free-choice learning experiences subsequent to participation in the year-long program. Observation and interview data were coded and organized according to emergent themes that were ultimately used to construct claims about moment-to-moment and long-term learning and teaching behaviors of participants. Findings indicate that both parents and children were active in learning during the program, and they continued to learn and share knowledge about marine science in other free-choice experiences. Discussion focuses on specific patterns of interactions of children and parents. For the purposes of developing and implementing bilingual family learning programs, findings suggest the need to address cultural values and expectations pertaining to learning, with specific attention to literacy. Implications for research, including evidence for moment-to-moment and long-term learning, are discussed.

#### Christine Schnittka, Ian Binns, Randy Bell

Preservice Biology Teachers' Use of Interactive Display Systems: Reform-Based Teaching or Chalk and Talk?

Billions of dollars have been spent on computers and Internet access in American classrooms, and most classrooms now have at least one computer with an Internet connection. The investment has not been shown to have the desired effects on teaching and learning (Bull & Garofalo, 2004). Teachers resort to using the classroom computer primarily for administrative, rather than instructional purposes (Cuban, 2001). The purpose of this study is to learn whether an interactive display system (computer with Internet access connected to a digital projector and an interactive white board) facilitates successful, reforms-based teaching when it is given to a science teacher prepared to use the technology and committed to reforms-based instruction. Nine preservice biology teachers were given interactive display systems during student teaching. During the student teaching semester, researchers made classroom observations, conducted interviews, and collected lesson plans and written reflections. Analytic induction was used to analyze these various forms of qualitative data. Results indicate that teachers used the display systems in substantial ways to facilitate teaching reforms-based science, supporting the use of interactive display systems in a one-computer classroom. Implications of this study may help educators understand how teacher preparation with interactive display systems can encourage reform- based teaching.

#### Anita Schuchardt, Kathy Malone, Bill Diehl, Kamille Harless, Dudley Parr, Robert McGinnis

The Impact of a Modeling-Based Ninth Grade Physics Curriculum on Scientific Reasoning and Mathematics Concepts

The rationale behind teaching physics in ninth grade instead of biology has been reviewed by others (O'Brien, 2006; and Bardeen & Lederman, 1998). One motivation for this type of change in curriculum is to enhance students' understanding of scientific inquiry and reasoning. The ability to reason scientifically has been shown to be a predictor of student performance in both an introductory college level biology class (Johnson & Lawson, 1998) and an introductory college level physics course (Tfeily & Dancy, 2006). Improving students' scientific reasoning skills during their freshman year should therefore provide a better foundation for future science learning. However, under a biology first sequence the invisible nature of many biological processes and the difficulty in controlling variables in living systems pose obstacles to student practice and understanding of scientific reasoning. Switching to physics first, should enable students to benefit more from their initial exposure to scientific experimentation and



practice because the systems are more concrete and available to the students since experimental variables are more easily controlled. In addition, the use of an inquiry and model-based curriculum such as the instructional modeling approach (Wells, Hestenes, & Swackhammer, 1995) should further enhance the students' abilities.

#### **Elisabeth Schussler**

Plant Versus Animal Content in Elementary Science Textbooks

American culture tends to be more focused on animals than plants, resulting in students entering school with a preference to study animals. School appears to maintain this bias, as research has confirmed a student preference for studying about animals as compared to plants through high school. This study investigated the plant and animal content of elementary science textbooks to infer what students might learn about each, and whether the content for each group is equitable and reflective of state content standards. A coding system was developed that allowed the researcher to categorize units of plant or animal content in two textbook series and the associated state content standards. Both textbook series varied from the state-mandated content standards in ways that favored presentation of animal content. Each series focused on information about plant parts and plant needs (consistent with the state standards), while they had animal foci of needs, adaptations, parts, and types (state standards were focused on animal parts and needs). Textbooks appear to be partially influenced by culture rather than wholly influenced by content standards. This continued cultural bias towards animals maintains rather than dispels student preconceptions about plants not being as interesting as animals.

#### David Schuster, William Cobern, Brooks Applegate, Renee Schwartz, Adriana Undreiu, Paul Vellom

Design and Development of an Instrument to Assess Pedagogical Content Knowledge of Inquiry Science Teaching

Planning and implementing successful inquiry-based learning in the science classroom is a task demanding a combination of science content knowledge and inquiry pedagogy knowledge, a combination we might call 'pedagogical content knowledge of inquiry science teaching'. During their preparation, pre-service teachers take science content courses and teaching methods courses. Their science content knowledge is regularly assessed, but it is just as important to assess their knowledge of how to teach particular topics by inquiry. We describe the design and development of items for an instrument to assess such knowledge. Assessment items are case- based and problembased rather than about inquiry generally. A typical item presents a realistic teaching scenario for a science topic, poses a question about teaching strategy, and offers response options reflecting a spectrum of teaching orientations ranging from direct instruction through guided inquiry to discovery learning. Sets of tested and validated items form a Pedagogy of Science Inquiry Teaching Test, with versions covering K-8 science topics. Equally importantly, the assessment items can also be used formatively, by both pre- and in-service teachers, for problem-based learning of science inquiry pedagogy. Examples of assessment items will be provided and discussed.

#### Renee Schwartz, Norman Lederman, Judith Lederman

An Instrument to Assess Views of Scientific Inquiry: The VOSI Questionnaire

Because teachers and students are to develop sound epistemological views of science (NOS and nature of scientific inquiry [NOSI]), assessments are needed to understand these views and how they develop. Much attention has focused on developing knowledge and pedagogical expertise in teaching NOS. The VNOS instrument has been paramount in advancing our understanding and needs of teachers and students. Currently, we lack similar understanding about views and needs regarding NOSI. If teachers are to teach about SI, what is their knowledge base? What are students' views? How do we know if instruction is effective in advancing desired conceptions about what scientists do? In response to these questions, we have developed a valid, open-ended instrument that assesses views of scientific inquiry [VOSI]. The purpose of this paper is to describe the framework upon which the VOSI instrument is grounded, present a pool of items with rationale, describe administration and analysis procedures, and describe typical responses we have received that provide insights into views of NOSI.



# Christina Schwarz, David Fortus, Jo Ellen Roseman, Barbara Ladewski, Ted Willard, Joseph Krajcik

Designing and Testing the MoDeLS Progression

Modeling is a core component of scientific practice that should be appropriated to become scientifically literate. This paper defines modeling practice and the knowledge that undergirds the practice (meta-modeling knowledge) as well as justifies the importance of the practice and its associated knowledge. We incorporate the practice and knowledge components into an initial learning progression that is being implemented and tested across elementary and middle school grades. This paper illustrates and provides a rationale for elements of that progression. It also sets the context for the empirical studies testing the progression whose results are presented in the following papers.

#### Lea Segal, Dana Zeidler, Ariel Cohen

Teachers' Pedagogical Beliefs About SSI and Scientific Literacy in Israel

The purpose of this study was to investigate secondary science teachers' beliefs and attitudes towards teaching moral aspects of science in Israel as a part of the science curriculum. Additionally, we wanted to examine their perceptions of science education goals, and the extent to which they are willing to implement pedagogical actions consistent with successful implementation of moral-oriented components (SSI) in the science curriculum. The study employed a mixed method approach first with 152 teachers followed by a sub sample of 20 teachers to evaluate aspects of their pedagogical belief systems beyond what the surveys could reveal. Results suggested that science teachers in Israel see themselves primarily as content-educators. However, they identified in SSI education an opportunity to perform what they believed is an important educational task by advocated the integration of ethical issues related to science in the science curricula. Many participants expressed willingness to be active in promoting the SSI education by classroom practices, and many of them reported being involved in SSI instruction. However, all participants felt inadequately prepared to teach SSI competently lacking knowledge, resources, and time and also revealing misconceptions about scientific literacy. Classroom implications are discussed.

#### Hayati Seker, Aysegul Terzi

An Investigation of Factors Associated with Students' Interest in Physics

The purpose of this paper is to present results of the study conducted to explore factors associated with students' individual interest developed in the context of daily life. The concept of interest is the affective description of this connection between person and objects. Even though interest is assumed to be important for its role in learning concepts, studies are not sufficient to explain factors associated with individual interest. Person-Object Approach to Interest, as a theoretical approach underlying Self Determination Theory, explains interest as a relatively enduring relationship between a person and objects in his or her daily life contexts. For the purpose of the study tenth grade students were interviewed. The interview questions were semi structured and aimed to elucidate the categories that explain the relationship between students and interest objects from daily life related to physics lesson. The results suggest using other motivational constructs related to physics instruction to develop a new theoretical framework.

# Eulsun Seung, Lynn Bryan, Mark Haugan

The Process of Physics TAs' Knowledge Development for Teaching a New Physics Curriculum

Matter and Interaction (M&I) has recently adopted as a novel introductory physics course that focuses on the application of a small number of fundamental physical principles to the atomic and molecular nature of matter. In this study, we examined the process of four physics teaching assistants (TAs)?development of knowledge for implementing the M&I course—from the time they engaged in an M&I content and methods workshop through their first semester as teaching assistants for the course. Through a qualitative, multiple case study research design,



data was collected from multiple sources: non-participant observations, digitally recorded video, semi-structured interviews, TAs?written reflections, and researchers?field notes. Data analysis consisted of within and cross-case analyses. Data analyzed using the constant comparative method. TA training workshop and self reflection contributed in developing the participants?substantive knowledge of M&I. Pedagogical content knowledge related to instructional strategies, curriculum and students? learning was developed through the participants?teaching practice. The results of this study will contribute to not only the quest to identify the nature of professional knowledge for science teaching but also future preparation of the innovative introductory physics course as well as other college level science courses.

#### Ashraf Shady

Identity and Science Education: Sociocultural Approach

The study investigates how immigration and science education as a field of cultural production play a role in restructuring the identities of the participating stakeholders. As the teacher researcher in this study I experienced identity formation reformation as a result of being inscribed as other by my students and colleagues as "other". This experience led me to examine how the dialectical relation of agency passivity influences teaching and learning of science in urban science classroom. In this investigation I used authentic ethnography and cogenerative dialogue as research methodologies as well as tools to identify patterns of coherence and the associated contradictions. The findings of the study indicated that cogenerative dialogue maybe used as a tool to navigate cultural fields among the participating stakeholders.

#### Azza Sharkawy

Extending Grade One Student's Views of the Social Nature of Scientific Work Through the Use of Stories About Scientists

Students' "images of science" (Driver, Leach, Millar & Scott, 1996) including their images of the social nature of scientific work are widely accepted as important aspects of their scientific literacy (National Research Council, 1996). While studies have documented young children's (K-3) stereotypic images of scientists and scientific work (what scientists do, where they work and if they work alone or with others) few have examined instructional strategies effective in broadening these views. This paper presents the results of a qualitative study which examined how stories about scientists, presented over thirteen 40-50 min. lessons using an explicit and reflective approach (Kh-ishfe & Abd-El-Khalick, 2002), influence grade one students' images of the social nature of scientific work. Analysis of pre and post- interviews, draw-a-scientist-test (Chambers, 1983), classroom observation and student work indicate that the stories helped broaden students' views of the social nature of scientific work: 1) scientists working alone to an appreciation of three dimensions of the social nature of scientific work: 1) scientists working with others; 2) scientists communicating with the public; 3) scientists drawing on socially constructed forms of knowledge. The implications of the results for research and classroom practice will be discussed.

#### Rachel Shelton, Sybil Kelley, William Becker

Effects of Ethnicity and Gender on 6th Grade Students' Environmental Knowledge and Attitudes

Recently, studies focusing on the effectiveness of various environmental education programs have been common in educational and ecological literature. Despite this, however, little research has been done investigating the effectiveness of environmental programs across ethnic groups or gender. In this study, a mixed-methods design was used to address this issue by assessing the impacts of an environmental education program on students' knowledge and attitudes/intent to act in a highly-diverse urban middle school. Preliminary results suggest an increase in knowledge and little to no change in environmental attitudes/intent to act



#### **Daniel Shepardson**

Precipitation, Evaporation, and Condensation: Student Conceptions of the Hydrologic Cycle

The purpose of this study was to investigate students' conceptions of the hydrologic cycle and to examine whether these conceptions vary by grade level and community setting. The study was descriptive in nature and reflected a cross-age survey involving the collection of qualitative data from 1,298 students from the Midwest, USA. These data were analyzed for content in an inductive manner to identify student's conceptions, and statistical analysis was used to determine the significance in the frequency of the student conceptions. Four categories emerged that reflected different degrees of sophistication of students' conceptions of water transformation, movement, and storage. These Midwest students often portrayed the hydrologic cycle in the context of mountain or coastal landscapes that are common in textbooks but that are not representative of the environments where students live and where many of these students might apply their understanding of environmental systems as adults. Based on these findings we make curricular recommendations that build on the students' conceptions, the hydrologic concept, and the NRC (1996) science education standards.

#### **Robert Sherwood**

#### Recent Policy Documents with Implications for STEM Teacher Education and Research

Within the last two years several policy related documents have been released at the national level that may have a substantive impact on science education teacher education and research. These include; "Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future" from the National Research Council, the "American Competitiveness Initiative" by the Office of Science and Technology Policy, and the National Science Board's, "America's Pressing Challenge – Building a Strong Foundation". The research that will be reported in this session is; (1) an analysis of these various documents as they pertain to science education especially as they relate to science teacher preparation and new directions for research and development, (2) the impact of the reports on the "America Creating Opportunities to Meaningfully Promote Excellence in Technology, Education, and Science Act" that was recently passed by the US Congress, (3) indicators from the act about possible funding opportunities for science education and (4) how NARST members can be more active in influencing policy at the national level.

#### **Ruey Shieh**

#### Instructional Strategy Enhancing Learners' Sense toward Online Classroom Community

An earlier study examining a hybrid online course indicated that non-degree pursuing adult learners (mainly composed of in-service teachers) considered an interactive classroom community helped them learn the course content. In order to strengthen the collaborative, learner-centered learning community, an instructional strategy requiring the learners to take responsibility for their learning was deliberately implemented in the following course offering. The purpose of this study is to investigate to what extent the designed instructional strategy enhanced the learners' perceptions of connectedness and learning toward the online classroom community. The preliminary findings show that the instructional approach not only helped increase the learners' sense of connectedness toward the classroom community, but it also helped learners improve their learning habits. It is hoped that the concept of instructional design emphasizing active, responsible online learning as described in this study would provide instructors and educators some insights into designing online instruction.

# M. Gail Shroyer, Amanda Morales, Cecilia Hernandez, Kimberly Staples, David Allen

Science and Mathematics Persistence of First-Generation Mexican American Non-Traditional Students in Teacher Education.

This paper discusses the findings of a qualitative, microethnographic case study of the science and mathematics educational experiences of 15 non-traditional, Mexican American, paraprofessionals as they completed their tenure in a 2+2 distance-delivered teacher education program in the Midwest. The theoretical frameworks that serve as



the basis of this study are Tinto's Model of Student Integration (Tinto, 1975, 1993) and Bean's causal model of college student attrition (1980, 1982). This integrated framework addresses the complex factors that enhance the retention of non-traditional, diverse students in teacher education. The researchers identify individual characteristics of those students who have persisted on to graduation and it suggests effective strategies for the science and mathematics teacher preparation of Mexican American, non-traditional, English learners.

#### Yael Shwartz, Ayelet Weizmann, David Fortus, Joseph Krajcik, Brian Reiser

Middle School Science Curriculum: Coherence as a Design Principle

Coherent curricula are needed to help students develop deep understanding of important ideas in science. Too often students experience curriculum that is piecemeal and lacks coordination and consistency across time, topics, and disciplines. Investigating and Questioning our World through Science and Technology (IQWST) is a middle school science curriculum project that attempts to address these problems. This paper illustrates some of the challenges and trade-offs related to three aspects of coherence and the ways we have chosen to deal with them: 1) learning goal coherence, 2) intra-unit coherence between content learning goals, scientific practices, and curricular activities, and 3) inter-unit coherence supporting multidisciplinary connections and dependencies. Preliminary results regarding the effectiveness of IQWST's approach to these challenges are presented.

#### James Shymansky, Leonard Annetta, Susan Everett, Larry Yore

The Impact Of A Five-Year, K-6 Systemic Reform Effort On Elementary School Students' Achievement in Science

The research reported here focuses on the impact on student achievement of a 5-year, two- state, multi-school district professional development (PD) project called, "Science Cooperatives: Effecting Local Systemic Change in Rural Missouri and Iowa" (Science Co-op). Specifically, this report addresses two research questions: (1) What impact did the Science Co-op PD have on student achievement across participating school districts? and (2) what is the relationship between the level of teacher participation in Science Co-op and the science achievement of students? Unique to the PD were its focus on science unit adaptation in place of traditional, wholesale unit adoption and its use of interactive television to sustain ongoing, year-round communities of practice. Our data suggest that a sustained involvement in PD for K-6 teachers that is focused on adapting science kits and encourages a de-emphasis on rote memorization and a greater emphasis on inquiry, critical thinking and problem solving will result in lowered student achievement as measured by multiple choice items but higher achievement when measured by constructed response items, especially for female students.

#### Eli Silk, Christian Schunn

Utilizing Contrasting Cases to Target Science Reasoning and Content in a Design-for-Science Unit

A quasi-experimental design to test the use of contrasting cases as an instructional tool to support science learning in a design-for-science classroom was conducted. Five eighth grade science sections from one teacher were assigned to one of two conditions, Contrasting Cases (N=54 students) or Sequential Cases (N=30 students). The influence of contrasting cases on domain-general science reasoning knowledge, domain-specific differentiated knowledge, and domain-specific content knowledge was investigated. The exposure to contrasting cases was effective only at increasing domain-general science reasoning. In addition, science reasoning was a significant predictor of content knowledge, but differentiated knowledge was not. Thus, the mediated effect of contrasting cases on content knowledge through reasoning knowledge, if it exists at all, was not strong enough to be observed in these data. Improvements to the implementation of contrasting cases in the unit, and in design-for-science curriculum in general, are considered.



#### Patricia Simmons, Vincent Lunetta, John Penick

Sponsored Workshop: Research Agenda In Science Education: An Examination of Three Domains of Inquiry

The Research in Science Education (RAISE) Workshop is an intensive session focused on how the science education research community can move toward building a 'progress model' for science education research. The goal of this session is to facilitate in-depth discussions of three domains of research in science--science teaching and science teacher education, science teaching and the nature of the scientific enterprise, and science learning and technology environments. Participants will engage in small and large group discussions with opportunities to review and critique research hypotheses and questions in these two areas, provide input into areas of needed research, and extrapolate how the research community can lead more systematic, scientific research and respond to instructional needs, practices, and policies for science education.

#### Shirley Simon, Stuart Naylor, Brenda Keogh, Jane Maloney, Brigid Downing

Puppets Promoting Reasoning and Argument Science

Research into classroom interactions has shown that talk that promotes reasoning can help children in their learning of science. Such talk can only be generated when teachers are willing to take a dialogic approach that is stimulating and provides opportunities for children to articulate their ideas. This research set out to determine whether the use of large puppets would help teachers to change the nature of their whole class discourse to enhance children's talk and engagement in science. The study was carried out with 16 teachers of children aged 7 to 11 years in schools in London and Manchester, UK. Through adopting a mixture of research methods, including classroom observation and teacher and child interviews, the research provides evidence that the use of puppets significantly increases the amount of teacher discourse oriented towards reasoning and argument, and decreases the amount of talk that focuses on recall. Interview data also show the positive effects of puppets on children's motivation and engagement in science. The findings have led to further major funding for professional development in the use of puppets in the UK, and research into the reasons why the use of puppets is so effective.

#### Jamila Simpson, Eileen Parsons

African American Parents' Perspectives of Informal Science: A Cultural Dimension

The purpose of this study was to determine African American parents' opinions of a program called Jordan Academy in which they enrolled their children and the alignment of the parents' perspectives with Black Cultural Ethos (BCE). BCE refers to nine dimensions posited by Wade Boykin, a psychologist, as comprising African American culture. Participants were parents of students that attended Jordan Academy, an informal science enrichment program designed for third through sixth grade students from underserved populations. Qualitative methodologies were utilized to perform a thorough assessment of parents' perspectives. Data sources included classroom observations, student surveys, academy curriculum, photos and video-taped class sessions. Data included parents' responses to semi-structured, audio recorded interviews and students' written responses to open-ended items on the program's evaluation instrument. The data were analyzed for themes and the findings compared to Black Cultural Ethos. Findings revealed that the participants believed that informal science education offered their children opportunities not realized in the formal school setting - a means of impacting their children holistically. Overall, the parents' views emphasized the BCE values of harmony, affect, verve, orality and communalism. The study has important implications for practices within and research on informal science education.

# Wendy Sink, Jennifer Cartier

A Professional Development Program for In-Service Elementary Teachers: Supporting Curriculum Planning and Enactment Grounded in the Psychological Tools of Science

In this study, we examined how teachers used instructional materials to mediate students' developing psychological tools (central disciplinary practices). We created a year-long professional development program that paired



elementary teachers with doctoral students in the natural sciences and mathematics. Their work was guided by an instructional framework that grounded planning in instructional materials and emphasized the need for participants to identify key disciplinary ideas and design supporting tools to scaffold students' learning. Here we present four case studies that describe how elementary teachers used supporting tools to mediate students' appropriation of psychological tools. Teachers and fellows indicated that, while they tended to use activity structures provided by the commercial curriculum, they usually collaborated to develop the tools for supporting students' engagement in those activities. All four teachers reported that these instructional approaches were new to them, particularly the strategy of explicitly grounding lessons using an overarching psychological tool. They also noted the key role that fellows played in articulating the psychological tools and supporting teachers' growing understanding of how they connected to scientific practices.

#### Stephanie Slater, Timothy Slater, Cherilyn Morrow

The Impact of a Kinesthetic Astronomy Curriculum on the Content Knowledge of At-Risk Students

This paper reports on the impact on understanding of at-risk ninth grade students using kinesthetic approach to instruction for the traditionally challenging topic of Earth's seasons. The guiding research question was: To what extent does the kinesthetic astronomy instructional approach assist at-risk students in correcting common and widespread misconceptions about the cause of the seasons? All students in the intervention classes were taught seasons using a kinesthetic approach, and the research design was intended to determine if at-risk students had similar gains in achievement. This was done by developing a two-group, multiple measures quasi-experimental study design, data was collected pre- and post-instruction using written, student-supplied-response assessments. Additionally, a third assessment was conducted 8 weeks after instruction in an attempt to measure durability. The results showed that statistically significant conceptual change occurred across three subtopics supporting seasons and were stable over 8 following weeks, suggesting that students' content knowledge did not substantially diminish over time and that the at-risk students' conceptual understanding has durability.

#### Adriane Slaton, Howard Glasser, Angela Calabrese-Barton

Negotiating Respect and Learning in a Middle School Science Classroom

Troubling traditional notions of respect focused on absolute power and authority (e.g. respect for elders, money) we construct a working framework for understanding respect as well as to highlight student voice. We put forth the idea of a "practice of respect", or actions individuals take to publicly appreciate or develop understandings of others and their value. To document and describe the relationship between practices of respect and negotiating learning in urban middle school science we draw upon classroom ethnography and to better understand student voice and perspective, target case studies. When examined through the lenses of identity and participation, we concentrate on how the learning community, could be thought about as being made up of groups that engage in practices of respect differently. We describe how these practices of respect position individuals in these groupings for differential access to science, and therefore opportunities to succeed in school science and/or to develop positive identities in science. These findings, demonstrate two important points about respect: (1) A practice of respect links participant identities and their access to science. (2) When respect is mutually enacted, both students and teachers engage in the science class.

#### Leigh Smith, Kendra Hall, Janet Losser

Integrating Science and Literacy: Does One Size Fit All?

Using a pre/post multi-group comparison design, this study explored the effectiveness of integrated science and literacy lessons. Two instructional units (Matter and Heredity) designed to use text structure awareness to enhance science content learning were developed and implemented in Grade 5 classrooms. A specific text structure (comparison) was used as a focus of the literacy instruction. Control classrooms received regular instruction on the same science content as planned by their teachers. Items on pre and posttests were combined to create 4 measures:



explanations, content knowledge, summary, and recall of key words. Results indicate that students who received integrated science and literacy lessons in connection with the Matter Unit outperformed students in the control group on all measures. However, students performed differently on the Heredity Unit; children in the treatment group scored significantly better than those in the control group on only one of the components of the summary measure and recall of key words. There was no significant difference on any of the other measures. These results suggest that certain literacy strategies may be beneficial in teaching/learning some science topics, but not as effective for others.

#### Jan Solberg

Sustainable Improvements of Science Teaching Through the Development of Local School Science Cultures

Many projects are launched every year aimed at improving science teaching. However, many of them fail to produce sustainable improvements or significant dissemination of successful developments to other teachers or schools. Developing Local School Science Cultures (LSSC) can be seen as a long term strategy for cultivating developments in science teaching. LSSC can be defined as the emerging result of the ongoing negotiation of meaning through participation in practice between key actors of relevance to science teaching in schools. Through empirical investigations into a three year development project aimed at improving science education in 17 secondary schools valuable insights into the complexity of educational change was achieved and a theoretical model was developed. Based on these insights and the model presented the article argues that investigating LSSC may point to local unutilized resources in individual schools that need to be accessed and significant hindrances that need to be addressed before any profound educational change can occur.

#### Jan Solberg

Danish Science Municipalities - a Convergence of Science Education Research and Political Trends

Approximately 40% of Denmark's municipalities have shown an interest in branding themselves as "science municipalities" following the success of a regional project aimed at increasing student interest in science (see http:// www.formidling.dk/sw12217.asp). One project outcome was a model for facilitating sustainable development in science education based on coordination and ongoing progression of local school initiatives within a regional frame involving actors such as local enterprises and politicians. The effect of a closer relationship between local and regional efforts has been documented to be very effective, if rather difficult to initiate and maintain. Such regional anchoring is also consistent with national policy wishes to increase the quality of science education through the fortification of local efforts. Thus, we see a merger of policy and research, which may prove to be a fruitful model for science education development in Denmark as well as other countries.

#### Toni Sondergeld, Charles Rop, Andrea Milner

Environmental Education Professional Development Programs: Characteristics That Bring Positive Impacts

Building teachers' confidence in their understanding of nature and encouraging the use of field experiences with students are important factors in increasing environmental awareness in students. A River Runs Through It (ARRT), an integrated environmental education professional development program, immersed practicing teachers in hands-on field inquiry while providing them with valuable experiences, tools, and support necessary for raising teacher enthusiasm and self-confidence. Our work begins by taking a broad look at environmental education and professional development programs focusing on environmental education. We then narrow the focus to our environmental education professional development program—ARRT—and the positive impacts found from allowing teachers to explore local outdoor environments with a support system that aided them in bringing their ARRT experiences into their own classrooms.



#### Helga Stadler, Konrad Krainer, Helmut Khnelt

Raising the Quality of Science Teaching in Austria - The project IMST2

The project IMST2 (Innovations in Mathematics, Science and Technology Teaching, 2000- 2004) was built on the research project IMST1 (1998-99) analyzing the poor results of Austrian upper secondary students in TIMSS. IMST combined a bottom-up approach of teacher initiated projects with a top-down approach by offering such projects financial support and mentoring. The project reached from 34 (2000/01) up to 62 (2003/04) upper secondary schools (10% of the target group in the last year). Teachers could apply for participation as individuals or as school teams and have been supported in five subprojects (Basic education, School development, Teaching and learning processes, Practice-oriented research, Gender Sensitivity and Gender Mainstreaming). Frameworks for good practice were identified and evaluated. At system level, recommendations have been incorporated into the new national curriculum for upper secondary general education and led to IMST3 (2004- 2006) which continually covers all school levels. Among others, IMST3 initiated the setting up of science education research centres at universities, the establishment of regional science teacher networks and gradual implementation of science, mathematics and German language teacher advisors. The funding of teacher initiated educational research and development by the so called IMST-Fund has been secured at least until the end of 2009.

#### Helga Stadler

How Girls and Boys Use Computers in Physics Classes

How girls and boys use computers in physics classes Helga Stadler, Faculty of Physics, University of Vienna When school managers started introducing computers into various school subjects, they hoped this would improve student motivation and learning results. Research indicated that in physics this is not always the case; the computer does not necessarily improve students' motivation nor do we obtain any significant increase in knowledge and competences. In order to gain more knowledge about the learning and teaching processes we videotaped and analyzed about twenty computer-aided physics lessons. We explored how computers are used in the average physics class, how students interact with computers and in which ways work with computers influences collaborative learning processes of the students. We found that only very rarely does the computer seem to support understanding of physical concepts and that learning processes and collaborative work was not fostered but hampered by the media. Moreover, as computer programs in physics rarely provide learning within contexts that are relevant for girls and as interaction in class – mainly in mixed groups – does not support the development of self-confidence in respect to the subject, we concluded that computers – in the ways they are used in our physics classes – do not contribute to narrowing the gender gap in physics, but to widening it.

#### Marilyne Stains, Vicente Talanquer

Analysis of Learning Progressions Using Classification Tasks: Application to the Intermolecular Forces Concept

We investigated the learning progression for the intermolecular forces concept by exploring undergraduate and graduate chemistry students' reasoning strategies when classifying chemical substances based on the nature of their intermolecular interactions. We were specifically interested in the identification of categories that students with different levels of preparation create when classifying substances at the symbolic and microscopic levels, character-izing possible learning progressions for the intermolecular forces concept, and analyzing the relationship between expertise and students' level of preparation. Understanding student thinking in this area is crucial since a large percentage of chemistry problems rely on the application of appropriate classification schemes and little is known about the development of expertise in understanding and applying these schemes. Research data has been collected in the form of clinical interviews with students enrolled in general chemistry, organic chemistry, senior and graduate level chemistry courses. Our results show that undergraduate students, regardless of their level of preparation, have difficulties applying classification schemes typically used in the field. Our analysis also indicates that the understanding of the intermolecular forces concept is developed through stages that conceptually build upon each other. However, this continuous learning progression does not seem to be related to students' level of preparation.



#### **Kimberly Staples**

Persistent Misconceptions of Biological Concepts Among Preservice Teachers and 2nd Grade Students: The Power of Probing

This study compared the classification systems of living versus non-living things between 2nd grade and college level students. The research focused on identifying the effects of using illustrative diagrams to scaffold students' [re] construction of the characteristics of living things. Preservice elementary teachers (42) experienced and implemented three probing activities to identify misconceptions of living things during the science methods course. During clinical science instruction twenty 2nd grade students experienced similar probing activities in a learning cycle format. Common misconceptions were identified between both groups of students. Quantitative analysis of the STEBI-B posttest mean scores using the ANOVA test revealed a significant difference in posttest mean scores of preservice teachers based on level of illustrative [diagrammatic] representations of mental frameworks for biological concepts. A qualitative analysis of students' classification systems. Results of using a illustrative diagrams imbedded in a learning cycle approach to science instruction produced changes in conceptions of living things beyond people, plants, and commonly encountered animals. The results of the study reveal a change and increase in the understanding of biological concepts consistent with accurate scientific explanations.

#### A. Lynn Stephens, John Clement

#### Anchoring Student Reasoning in Prior Knowledge: Characteristics of Anchoring Cases in a Curriculum

We analyze strategies for selecting and honing Anchoring Cases, which are used to elicit usefulóbut often implicitly heldóprior knowledge possessed by most students. In an innovative model-based high school mechanics curriculum, each unit presents a Target Case, designed to elicit a persistent misconception, and an Anchoring Case. These are connected by a set of Bridging Analogies that enable the students to transfer a conception from Anchor to Target in a series of gradual steps. The curriculum has produced significant gain differences over traditional instruction on measures of understanding. This suggests the usefulness of the pedagogical strategies; however, experience has shown that it is no easy matter to create successful Anchoring Cases. We analyzed these Anchoring Cases in terms of their consistency with previously identified expert design strategies and identified new strategies. We have organized and honed the strategies into a coherent framework (part of a much larger framework presented in this related paper set), designed to help with 1) predicting which Anchoring Cases are likely to be effective; 2) developing new Anchoring Cases; 3) forming an initial theory about how and why Anchors work. These findings have implications for lesson design, teaching strategies, and pedagogical theories of conceptual change.

#### Trish Stoddart, Sara Tolbert

Preparing Elementary School Teachers to Integrate Inquiry Science Instruction and Language Development for English Language Learners

This paper focuses on the preparation of experienced elementary teachers to integrate the teaching of inquiry science with English Language development for students who are limited English proficient. It is based on the principle that the teaching of science and language are reciprocal processes and that integration enhances learning in both domains. However, many teachers feel inadequately prepared to teach science to English Language Learners (ELL). This paper presents the findings of a study of ten grade 3-5 teachers who participated in an innovative Summer School Academy (SSA) that integrated teacher professional development with teaching science to ELL. Pre- and post-interviews, Likert scales and a Science-Language Integration rubric were used to analyze change in teachers' understanding of science-language integration and their level of confidence in teaching science to ELL. The results demonstrate a significant shift in teachers' knowledge and beliefs. When they entered the SSA, the majority of teachers had a simplistic, global view of integration that is typical of novices in a domain. At the end of the SSA, however, the majority of teachers had a more elaborated view of integration. Teachers also significantly improved in their confidence in their ability to teach science to ELL.



#### Martin Storksdieck

Building a Quality Field Trip Teacher Survey Instrument

Field trips are increasingly pressured to demonstrate their efficacy in light of testing demands in schools. This paper describes the development, validation and utilization of a Quality Field Trip Assessment Instrument that can be used to determine whether conditions for learning are likely present during a field trip experience to an informal setting. Data was gathered over the course of three years from a variety of sources using multiple methods. A comprehensive literature review was followed by a series of focus groups with major stakeholders (teachers, principals, educators from various cultural institutions, program directors from these institutions, and researchers) to develop criteria for quality field trips. The resulting quality field trip model formed the basis for a pre/post, closed-ended teacher questionnaire. In addition, a similar instrument was designed for educators from cultural institutions to assess their field trip offerings. Two independent observers validated teacher and educator self-reported data for a triangulated data set. Based on the results of pilot-testing and reliability analysis, an abbreviated, post-only teacher questionnaire was developed and used to assess more than 180 field trips to 14 cultural institutions in Cleveland. The results of the study had implications for field trip practice in a variety of settings.

#### Nicholas Stroud, Megan Roberts, Jenny Ingber, Katherine Brown

Involving Elementary Teachers in Informal Learning Experiences

Teachers are centrally important for their students' academic achievement, but their effect on students' learning in informal settings is less well studied. Most studies of teachers and school trips are on the "best practices" in field trip preparation and conduct, and these practices are often contrary to the task-oriented practices enacted by teachers during school trips. In addition, teachers' instructional practices during school trips are just now being investigated. The broad goal of this research is to involve teachers in their students' learning during informal learning experiences. More narrowly, this poster reports on the process of designing a set of strategies for teachers to assess student learning during school trips to an informal science institution.

#### Carol Stuessy, Dane Bozeman, Toni Ivey, Jane Metty, Rasheedah Richardson, Susan Skidmore

A Model for Preparing Policy Researchers in Science Education: SERGE

This Special Colloquium describes an emerging model of graduate science education, Science Education Research and Graduate Education (SERGE), originating from research group activities at a large Research I university. Research group activities, which were sponsored by the National Science Foundation, were to complete two objectives: 1) to do policy research in the area of the high school science teacher professional continuum (TPC), and (2) to prepare a cadre of new-generation science education policy researchers. In the process of intertwining these two objectives, SERGE emerged as an efficient and effective approach to address both research and graduate education objectives. The purposes of this colloquium are (1) to describe the emergent model of graduate science education, SERGE (Science Education Research and Graduate Education); and (2) to present evidence that the use of this model enhances the individual and group policy research identities of the graduate student members of the TPC Research Group. Evidence is presented in the form of five graduate students' experiences, initially written as reflective papers, which describe the emergence of their individual research identities and interests from within the TPC group policy research context.

#### Karthigeyan Subramaniam

Constructing Classroom Meaning with the Integration of Computer Technology into Science Teaching

The purpose of this study was to investigate the teaching and learning images that science teachers use to construct classroom meaning when they integrate computer technology into their teaching. It is proposed that science teachers construct classroom meaning with the integration of computer technology into their teaching by establishing



microcosms. Within these microcosms, the social interactions between students and science teachers are framed by the science teachers' images of teaching actions with the computer technology. Image is proposed as a construct to understand science teachers' knowledge in the context of teaching with computer technology. The framework used to map participants' science teaching lessons with computer technology used constructs from four theories: the curriculum enactment theory, the social interaction theory, the sociocultural theory, and the social practice theory. Data were collected using a variety of qualitative methods: participant observations; interviews; focus group interviews; and, participant's metaphorical statements and accompanying narratives. Findings revealed that participants constructed classroom meaning through a number of images: images of lessons as moving objects; images of facilitator, and guide roles; and images of mutual investment. All these images contributed to the participants' establishment of teaching microcosms: the construction of classroom meaning.

#### Dennis Sunal, Cynthia Sunal, Cheryl Mason, Dean Zollman, Corinne Lardy, Erika Steele

Impact of Undergraduate Science Course Reform on Student Outcomes

This study examined students' learning outcomes in reform and non-reform entry-level undergraduate science courses and how differences within and between courses at different universities affected these students short- and long-term. Three institutions were selected with one reform matched with one non-reform undergraduate science course each, six courses, with about 400 students. The sample was the six courses' faculty, students, and a subgroup of student graduates of the courses who were in-service elementary teachers. Multiple quantitative and qualitative instruments were analyzed using comparative and relational studies at multiple points. Results included significant differences in short-term impacts on students and long-term effects on graduated in-service teachers; identification of reform courses characteristics producing significant impacts; and identification of characteristics of effective faculty. Concerns affecting change vary according to the beliefs of faculty about student learning and teaching, extent of reform characteristics effectively utilized in the undergraduate science course, and other factors.

# Alan Szeto, Lynn Bryan, Nicholas Giordano, George Bodner, Emily Wischow, Shanna Daly

Development of a Concept-Inventory-Based Test in Nanoscale Science and Engineering and Its Use at a Professional Development Institute

Concept inventory (or CI) has been described as a "multiple-choice test" for the determination of whether students have "an accurate and working knowledge of a specific set of concepts." Another view of the term "concept inventory" would be that it is a list of key concepts we want students to learn. This study intended to: 1. provide a brief discussion of the recent development and use of CI's in science and engineering, and 2. describe our group's effort to prepare a test in nanoscale science and engineering (NSE) compiled based on an inventory of essential facts and concepts (i.e., the alternative view of concept inventory) identified from the lesson plans for an NSE professional development institute in the summer of 2007 at Purdue University. A final set of 16 test items was used as pre- and post-instruction assessment of 12 middle and high school teachers' knowledge of NSE, focusing primarily on their conceptions of nanoscience. Our method of analysis and various findings were described to illustrate ways that the data collected with this 16-item instrument could be analyzed. This study was supported by the National Center for Learning and Teaching in Nanoscale Science and Engineering (NCLT).

# Robert Tai, Geoff Potvin, John Loehr, Scott Lloyd

The Doctoral Experiences of Students and Their Advisors in Chemistry and Physics: A Qualitative Examination

This exploratory study examines the various processes and challenges facing graduate students over the course of their graduate education as they transition from novices to independent researchers. The participants are drawn from an interdisciplinary research laboratory which has members from a chemistry and a physics department. The experiences of the graduate student participants and their respective advisors are studied by comparing and contrasting the formal and informal aspects to earning doctorates in this laboratory. Using participant interviews, researcher observations, and document analysis, it is found that there is significant variation between the two departments in both the



formal and informal standards for the granting of doctoral degrees as well as significant variability amongst the faculty advisors' standards and expectations of graduate students. The results also indicate that approaches to advising can be grouped into the categories icollaborative- focusedî and iautonomy-focusedî, and that graduate advisors often mimic the approach that was taken by their own graduate research advisors. Graduate student responses to these differing approaches are varied and likely depend on students' expectations and experiences prior to entering graduate school.

#### Vicente Talanquer

On Constraints and Learning Progressions: The Case of "Structure of Matter"

Based on the analysis of published students' alternative conceptions about the structure of matter, we identify a small number of presuppositions that seem to constrain students' ideas and reasoning in this domain at various learning stages. These sets of presuppositions are not static; they evolve with learning and development by addition, modification, coalescence, differentiation, and reorganization of the core elements. Although many presuppositions seem to be interrelated, some of them change or lose/gain strength independently from one another. Overlapping or competing presuppositions about the structure, properties, and behavior of matter are able to coexist at any given time, particularly at intermediate stages of expertise. The activation or instantiation of certain presuppositions seem to be highly dependent on judgments of similarity among systems or tasks, cognitive availability, and task framing based on contextual features, salient cues, and perceived goals. The identification of these constrains provides a useful framework that teachers can use to better understand and even predict many of their students' learning difficulties. It can also help in the design and organization of learning experiences and assessment tools that recognize and take advantage of the most likely trajectories towards expertise (learning progressions) followed by many students.

#### Amy Taylor, Gail Jones

Crossroads of Science and Mathematics: The Intersection of Scale and Proportional Reasoning

National Science Education Standards emphasize teaching unifying concepts and processes such as basic functions of living organisms, the living environment, and scale (NRC, 1996). This study explored whether or not there is a correlation between proportional reasoning ability and a student's ability to understand surface area to volume relationships. Proportional reasoning scores of middle school students (N = 19) were correlated to pretest and posttest scores of an assessment which measured students' understandings of surface area to volume relationships. The instructional intervention included five consecutive days of investigations of surface area to volume relationships and applications of surface area to volume as a limiting factor. There were significant differences in a paired sample t-test from pretest to posttest for the surface area to volume assessment (t = -4.66, p = 0.000). A statistically significant correlation was found for the proportional reasoning scores and the surface area to volume posttest scores (r = 0.73, p < 0.000). Relationships between proportional reasoning, estimation skills, visualization abilities and success in solving surface to volume problems are discussed. The implications of the results of this study for learning concepts such as limits to size and properties of systems that change depending on volume and surface are explored.

# Gaye Teksoz Tuncer, Ceren Tekkaya, Semra Sungur, Jale Cakiroglu, Hamide Ertepinar

Environmental Knowledge: What It Tells to Create Environmental Learning of Pre-Service Teachers in Turkey

Many environmental problems require the efforts, individually and collectively, of skilled and properly educated individuals, comprehensive and meaningful environmental education is one promising response for precious resources and a major challenges facing environmental education today is the strengthening of the professional development of teachers. Given the above facts, this study investigates the environmental knowledge of pre-service teachers in a developing country (Turkey). Six hundred eighty four respondents answered the 11 environmental knowledge questions. The results showed that slightly less than half (48.7%) of pre-service teachers appear to have a passing or acceptable level of environmental knowledge. The findings may suggest that individual pre-service



teachers may be more concerned about environmental problems and had positive attitudes towards the environment if they had sufficient environmental knowledge. Thus, begging the question of what it would take to create a critical mass for increased environmental learning throughout the educational system.

#### **Gregory Thomas**

# Developing Students' Metacognition Through Realigning Their Views of the Nature of Chemistry Learning: An Activity Theory Perspective

Concerns in relation to students' learning and reasoning in chemistry classrooms are well documented and persistent. One way to overcome students' learning difficulties is to develop their use of processes and discourse in classrooms that facilitate their views of the science they are to learn becoming explicit to themselves and others, and the object of peer scrutiny and potential debate. This paper reports on, (a) students' increased use of students' consideration of chemical phenomena at molecular, symbolic and macroscopic levels and the processes and discourse they employed and (b) the metacognitive changes and processes that accompanied their learning strategy modifications. Activity theory is used to position changes to students' learning processes and metacognition within their social context/s so that the impact of changes to the rules/customs and tools of the activity system, brought about by the introduction of new means of considering chemical phenomena, can be understood in relation to the dynamic and multi-faceted nature of their classroom learning learning environment. The results suggest that the enhancement of students' chemistry learning processes is metacognitive process that is highly socially situated.

#### Julie Thomas, Ratna Narayan

One-to-One Field Experiences: How Do Child-Interactions Influence Elementary Preservice Teachers' Science Confidence and Content Knowledge?

Earlier research on unique one-to-one field experiences (where elementary preservice teachers designed science lessons to match the conceptual learning needs of one elementary student), reported increases in participant's science content knowledge and science-teaching self-efficacy. The current study asks: How does the child, in one-to-one paired clinical field experiences, influence preservice teachers' science confidence and content knowledge? Research data included participants' own transcriptions of their clinical-field interviews, lesson plans, and personal reflections; final exam papers; and probing interviews with some participants to gather more detailed data about the clinical field interactions with children. Participating preservice teachers reported increased content knowledge, enhanced confidence, and new-found enthusiasm for science and science teaching. Narrative data shows how participants' new interest in, and deeper understanding of, science content resulted from preparing children's lessons; the opportunity to experiment with different instructional methods generated new science teaching. These results align with Bandura's (1977) theory of self-efficacy where the one-to-one clinical field experiences provided important mastery experiences. Perhaps there are implications here about how and when elementary preservice teachers learn necessary science content and how to focus clinical field experiences.

# Norman Thomson, Jennifer Adams, Sam ODell, Seri Chapman, David Jackson, Jacque Magner

Hominid Evolution: Theory, Facts, and 'Tales' From the Field

We would like to describe activities that we are using to enhance the teaching and understanding of human evolution through a national natural history museum recognized for its outstanding contributions to understanding human origins, a zoo with the largest breeding program of lowland gorillas in the world, and a major university with a top ranked secondary teacher education program - all involved with dedicated science teachers who are making a difference. We (scientists, science educators, and teachers) will describe our innovative professional learning programs and outcomes, classroom activities, and what the students learn. Our italesî from the field, extant and extinct, focus on hominid evolution: theory and fact.



#### Andree Tiberghien

Relations Between Public Policy and the Research-Based-design of Instructional Materials: Their Mutual Influences

This presentation will focus on the analysis of possible influences of teachers' use of instructional materials on local, regional, country, international levels of public policy. In our study, instructional materials (including process of their implementation) are research-based design for the improvement of student learning, teacher professional activity. For the first time our analysis, based on the productions carried out in our research team, will distinguish two "places" where research intervenes - the design and/or the evaluation of the objectives achievement. Then we will present our theoretical framework, which combines (1) components of activity theory to analyse how teachers' use of new instructional materials can modify their practice, and (2) an institutional approach taking into account the complexity of interactions between the institutional levels. In conclusion we will propose a tentative frame for analysing the influence of teachers' use of research-based instructional materials on the different levels of public policy.

#### John Tillotson, Monica Young

The Impact of Pre-service Program Experiences on Early-Induction and Post-Induction Science Teachers' Epistemological Beliefs

Prior teacher education research studies have paid little attention to how teachers' knowledge and practices are influenced by what they experience in teacher education programs and even less attention to how teachers are affected over time by their preparation. The purpose of this study was to examine the perceptions of early induction and post-induction science teachers (N=88 total) participating in the NSF-sponsored IMPPACT Project researching the impact of specific preservice program learning experiences on the development of their epistemological beliefs about effective science teaching and learning and their classroom practices. Graduates from three science teacher education programs representing geographically diverse regions of the United States were surveyed using the National Survey of Teacher Education Program Graduates (NSTEPG) to determine the perceived role that each of these three teacher education programs played in providing them with the requisite knowledge and skills to be successful as a science teacher. Graduates rated their preservice program experiences as strong (Mean 5.34 on a 7-point scale). They rated the adequacy of their skills as more than adequate (Mean 2.146 on a 3-point scale) and adequacy of pedagogical knowledge and understanding similarly (Mean 2.372 on a 3-point scale). Early results show no significant differences between sites.

Kenneth Tobin, Alberto Rodriguez, Deborah Tippins, Wolff-Michael, Roth Cathy Zozakiewicz, Nancy Brickhouse How Far We Have Come After Two Decades of Progress: A Re-visitation to the Challenge of "Science For All Americans."

It's been nearly two decades since the 1989 call of science for iAll Americans.î This research panel will discuss observations of progress across a variety of under-represented groups in science education from a variety of research perspectives as well. Presenters will discuss their findings from urban and rural settings as well as identifying obstacles to future progress in diversity and equity in science education. Implications for future research methodologies will be discussed as well.

#### Kenneth Tobin

Synchronizing Face-to-Face Encounters to Produce Success in Urban Science

This multi-method study explores the emergence of synchrony in the enacted culture in diverse urban high school science classes. Students and teachers with diverse ethnic histories learned to transact successfully in cogenerative dialogues and the interstitial culture created there was transferred to the classroom to support participation in science. Meso-level ethnography and micro-analyses of videotape converged to provide insights into the production and appropriation of prosody as teachers and students collaborated to create plans to improve science education. Micro-analyses show that successive speakers aligned the frequency, amplitude and frequency contours of utter-



ances as they showed one another respect and shared out opportunities to participate. Subsequently, teachers and students enacted similar forms of culture as they collaborated in science classes.

#### Regina Toolin

Smaller is Smarter: Technology Enriched Project-Based Inquiry at a Public Urban Academy

This study examines the practices by which math and science teachers infuse technology into project-based curriculum and instruction in a middle school math and science classroom. The study was conducted over a six month period involving approximately 45 middle school students, a math and science teacher and 2 administrators. The researcher assumed the role of participant observer as she mentored, co-developed and researched the development and implementation of a project-based unit on urban ecology with middle school math and science teachers. Data was collected through qualitative methodologies including student achievement data, classroom observation notes, anecdotal notes, project/lesson plans, and student investigative journals and projects. Many factors influenced the infusion of technology into this school including prior knowledge and experience of project-based inquiry; influence of school vision, mission and philosophy; technological availability and ongoing one-on-one professional development.

#### Iris Totten, Mo Morse

Using Geologic Time Inquiry-Based Activities to Enhance Student Learning in the Introductory Geoscience Labs

An experimental study was conducted that examined the impact of introducing inquiry-based activities into introductory geology labs. Graduate teaching assistants (GTAs) taught six sections of a geologic time lab using a traditional, expository method of instruction during the fall 2006 semester and returned in the spring to teach the same lab, with the addition of two inquiry-based activities. Three different instruments were used to measure differences in attitudes and content gain/retention between the control and experimental groups. Instruments included an attitude survey, the Geoscience Concept Inventory (GCI), and a retention quiz. The pre-post attitude survey revealed an overall gain in positive student responses during the experimental inquiry- based labs compared to the control traditional classroom, which experienced negative gains in attitude. The GCI pre-post instrument demonstrated an increase in correct responses during the traditional instruction and a decrease in correct responses during the traditional instruction and a decrease in correct responses during the inquiry-based on the results from these instruments inquiry-based instruction. The retention quiz revealed on the results from these instruments inquiry-based instruction had a more positive effect on student attitudes and retention of content but was not as effective at increasing content gain as measured by the GCI.

# Lynn Tran, Paola Rodari

Training for the Museum Educators: Implications for Science Education

This investigation seeks to understand the professional education that is available and needed for educators who teach science in museums, and contributes to our growing understanding of science teaching in contexts beyond school. The specific intent is to consider the professional education needed for practitioners in this field by first examining the practices that are currently in place; and inquires (1) what knowledge and skills are valued by the practitioners in the field, (2) how does the knowledge valued by the institution compare with that proposed for the field in general, and (3) what knowledge is shared across the occupation, and what is institution specific? Preliminary findings report that more than just talking—traditionally examined within studies of questions and explanations—there were also theatre-based skills, which taught the educators to engage non-verbally and through their body language. While practitioners appreciated the need to teach in a manner that took the needs, interests, and abilities of the learners into account, how and why this understanding was related to their beliefs on learning and important to their practice was not part of their training program. These findings have implications for the field of science education.



#### Karen Travers, Christopher Harris

Contributions of the Mentor Teacher: Opportunities for Pre-service Science Teacher Learning During the Methods Semester

The purpose of this study was to explore the contribution of the mentor teacher in helping pre-service teachers (PSTs) learn to teach science during the methods semester of a field-based elementary teacher preparation program. In addition, the perceptions of the PSTs were examined regarding the quality of the mentorship that they received for the teaching of elementary science. Participants were 59 PSTs from four field-based elementary methods sites in a large urban area. Of interest in this study was examining the extent to which PSTs actually observed science teaching in their practicum classrooms during the methods semester. Analysis of an end-of-semester survey revealed that more than one-third of the PSTs never observed their mentor elementary teachers teach science. While nearly two-thirds of the PSTs reported observing their mentor teachers enact science instruction in the elementary classroom, more than half (55%) of these PSTs reported observing lessons infrequently or only once. On a positive note, 61% of PSTs who observed at least some science teaching reported that they perceived their teachers as modeling inquiry science teaching strategies.

#### David Treagust

#### Challenges in Australian Science Education

Four currently recurring themes in Australian science education are 1) the decline in science subjects taken by students in upper secondary school, 2) an inadequate number of qualified science teachers, particularly outside metropolitan areas, 3) debate about the merits of standards-based education as opposed to outcomes-based education, and 4) consideration of a national curriculum in science.

Recent national research has demonstrated that science in primary schools is generally student-centred and activity-based, and a new curriculum Primary Connections is having a substantial impact on engaging primary teachers to teach more science in an effective way. This research also has shown that high school students do not consider science to be relevant and does not connect with students<sup>1</sup> interests and experiences. Furthermore, in the current educational climate, science teachers feel undervalued, under-resourced and overloaded with non-teaching duties.

To address the above issues, a National Curriculum in Science (as well as Mathematics English and History) has been suggested and has received broad support from the States and Territories and a number of key education groups.

Set against these rather negative themes is the positive one that Australian students generally do well in international science education comparison tests so there is no major political will to provide funds of a magnitude that can address the four themes discussed above.

#### David Treagust, Uri Zoller, Christine Chin, Rachel Mamlok-Naaman, Avi Hofstein, Gilberto Alfaro-Varela Reforms in Science Education in Different Countries

This seminar discusses reforms in science education in four different countries: Australia, Israel, Singapore, and Costa Rica. David Treagust reflects problems and challenges on Australian science education. Israeli Uri Zoller contributes his reflections on whether or not the science education reforms, worldwide, are compatible with this paradigm shift. Christine Chin, Kim-Chwee Daniel Tan, and Thiam-Seng Koh elaborate their discussions on science education programs and policy changes currently in Singapore. Avi Hofstein discusses science education reform in Israel, as influenced by National Science Education Standards in the USA (NRC, 1996). Gilberto Alfaro-Varela from Costa Rica describes alternative ways of providing in-service teacher programs for promoting education.



#### Thomas Tretter, Gail Jones, Jennifer Wolf

Nanoscience Instruction in Physics

The impact of a 5-day sequence of nanoscience instruction for 207 high school physics students in 8 classrooms and 3 schools was investigated. The instructional sequence was organized around key big ideas in nanoscience that were identified by a panel of 39 national experts in nanoscience and nanoscience education. Pretest and posttest measures included measures of conceptions of scale boundary distinctions (particularly nanoscale) and a new instrument (Conceptions of Nanoscale Instrument – CNI, with Cronbach alpha = 0.79) designed to specifically measure the targeted big ideas in nanoscience. Results for scale conceptions showed that students developed a clear distinction of a scale difference between microscale and nanoscale worlds, including accurate knowledge of which objects are representative of each scale world. Conceptions across the breadth of big ideas in nanoscience were significantly enhanced by the instruction. Analysis of subscores within the CNI showed differential impacts on particular nanoscience concepts. Implications for potential challenges and successes for impacting high school students' conceptions of nanoscience are addressed.

#### Meng-Jung Tsai, Chien Chou, Ying-Shao Hsu, Fang-Ying Yang

Developing an Instrument to Assess Students' Online Information Anxiety in Inquiry-Based Science Learning

This paper presented the development of the Information Anxiety Rating Scale which was designed to evaluate students' anxiety toward online information due to cognitive overloading in inquiry-based science learning. An initial version of the instrument contained 36 candidate items provided by science educators, computer educators, science teachers and high school students. A survey with the initial version of IARS was then administered to 296 high school students and a total of 287 valid questionnaires were received and used for data analyses. A factor analysis and reliability analyses were used to examine the construct validity and reliability of the scale. Finally, a total of 22 items were extracted under six dimensions: fear, fashion, dependence, value, confidence and uncertainty. And the reliability was 0.78 for the total scale. This scale can be used in future study to examine the role of information anxiety played in students' online inquiry-based science learning. It may also be used to design and evaluate a science curriculum that aims at providing scaffoldings for minimizing students' online cognitive overloading and online information anxiety.

# Chung-Hsien Tseng, Hsiao-Lin Tuan, Chi-Chin Chin

Investigating the Relationship Between Students' Motivation and Concept Learning in a Digital Learning Context

This study examines the relationship between conceptual change and learning motivation of 87 junior high school students after experienced a digital learning context for ¡§Acid, Base and Salt;" concepts, designed from the Dual Situated Learning Model (She, 2003, 2004). Two instruments: Students' Motivation Towards Science Learning (SMTSL) questionnaire (Tuan, Chin & Shieh, 2005) and students' Concept Diagnostic Test (CDT) for ¡§Acid, Base and Salt;" were implemented before and after the digital learning. Results showed that, after experienced digital learning, students' score in post-CDT was significantly higher than in pre-CDT (p< 0.05). In addition, students with high motivation performed better than students with low motivation (F<sub>1</sub>×4.884;Ap<sub>1</sub>×.03). Stepwise regression analysis indicated that students' self-efficacy, active learning strategies, and learning environment stimulation played an important role in conceptual change, with the total explanation power 31.7%. This study proved the effectiveness of DSLM for conceptual change and revealed the relationship between students' motivation and conceptual change in DSLM.



### Jen Tsung-Hau, Lee Che-Di, Chang Chun-Yen

The Effects of Different Science-Subject Achievements on Self-Concept in Science Learning - Are They Same for 8th Graders in Taiwan?

The difference among the effects of achievements in four science subjects (physics. chemistry, life science and earth science) on self-concept in science learning (SCS) for Taiwanese 8th graders are investigated through secondary analysis approach. The data of 5772 valid sample-subjects in TIMSS 1999 was analyzed by structural equation modeling techniques. The main findings are (1) different science-subjects seem have the same effects on SCS for all the 8th graders, but different effects on SCS for both high science- achievement students (HSASs) and low science-achievement students (LSASs); (2) all the four science-subject achievements have significant direct effect and almost same total effect (about 0.3) on SCS; (3) all the science on SCS is much smaller than the other three subjects for the HSASs; (5) only the earth science has significant direct effect on SCS for LSASs, and (6) earth science has the same total effect on SCS for both HSASs and LSASs.

#### Blakely Tsurusaki, Beth Covitt, Edna Tan, Charles Anderson

Developing a Learning Progression for Environmental Science Citizenship,

Socio-ecological issues confront us with a need to make decisions associated with arguments from evidence under circumstances where both the decision and the evidence are contested. This poster describes work investigating how students make socio-ecological decisions.1We developed two interview protocols concerning how students reason about environmental issues: a strawberry interview that asked students to activate their role as consumers of food, and a water interview that presented a scenario about a company interested in drilling a well that asked students to make a decision as a voter.1We conducted 22 interviews with elementary, middle, and high school students and used a decision-making framework to investigate how students' identities, roles, funds of knowledge, practices, and understanding of the science affected their framing of the socio-ecological issues and decision-making.1We found that family and individual values and practices played an important role in how students used their understanding of the science and how students made decisions, including the sources of information they trusted and the evidence they used to support their decisions.1We describe the implications for how and what we teach students in science class if we want students to be environmentally literate citizens.

#### Eli Tucker-Raymond, Christine Pappas, Maria Varelas, Ibett Ortiz

Distinctive Interactions: Young Children's Language Acts in Dialogic Curriculum Genres

Using data from 16 children in 4 urban classrooms (one 1st grade, one 2nd grade, and two 3rd grade), we explore how individual children were both consistent and idiosyncratic in their use of language in a set of activities over the course of two integrated science-literacy units. We examine these children's "ways with words" or language acts, as well as the semiotic contributions they made within dialogic routines or curriculum genres over time that created a progressive discourse which supported opportunities for student inquiry and learning in the classroom. The dialogic curriculum genres allowed for school, science, and students' everyday registers to intermingle within students' language acts. Some curriculum genres, as they were enacted by different teachers, enabled students to use a wider or narrower range of language acts. Nevertheless students tried out different configurations of this hybridity in distinctive ways, ones that had consequences for the discourse in the classroom. That is, individual and classroom community goals and resources worked together and realized a dialectical relationship, shaping each other.

# Steven Tuckey, Charles Anderson, Kelly Merritt, Hosun Kang, Mark Conley

Framing Future Discussions and Research on Science Literacy

This paper presents a theoretical framework relating research traditions in literacy and science education through commonplaces for discussion, and proposes strong sites for future research. Three major research orientations (tra-



ditions) are described in light of their perspectives on four commonplace themes: the nature of "texts" in science, the role of the teacher in science classrooms, ideas about how students learn science, and what is meant by the term "scientifically literate." The three traditions, categorized broadly by their research foci, are further illuminated by examining the perspectives of each on the case of a typical pre-service teacher experience. By examining existing literature about science and literacy, and considering the ways in which science education can both benefit from and contribute to a broader literacy education research field, this paper will provide a scaffold for ongoing conversations both within and across these communities.

#### **Russell Tytler**

School Innovation in Science: A Viable Model for System Change?

School Innovation in Science is a major initiative which developed and validated a model whereby schools can improve their science teaching and learning, based on a pedagogical framework and strategic support. The initiative was developed and rolled out to more than 400 schools over the period, 2000-2004. The research effort underpinning the development phase included the development and validation of a framework describing effective teaching, the refinement of a school and teacher change strategy, the development of instruments to monitor teacher classroom practice and a variety of student outcomes, and the development of insights into the change process. This paper uses research data from the project to examine the effectiveness of this approach to school improvement, and raise questions about the nature of school and teacher change, and factors affecting innovation in teaching and learning. Interviews held in 2004 and 2006 with school coordinators and regional consultants, concerning the ongoing legacy of SIS. This data, and evidence from related developments in school change strategies in Victoria, will be used to interrogate how we might think about the sustainability of the innovation.

#### Bhaskar Upadhyay

Culturally-Sensitive Pedagogy in an Elementary Science Classroom: A Case Study of a Hmong Elementary Teacher

This qualitative study explores how a Hmong female elementary teacher enacts culturally-sensitive pedagogy to teach science to empower students from minority groups. I further emphasize specific aspects of Vang's curriculum and pedagogy, as well as evidence of her reflectiveness while teaching science. In addition, I also emphasize the empowering role of minority parents as they bring their experiences to enhance culturally-sensitive pedagogy in science classrooms. In this regard how Vang utilizes a Hmong parent to be a part of valuable resource to science teaching. I use the theoretical frameworks of funds of knowledge (Moll & Greenberg 1998); Banks (1991) notion of multicultural teaching and learning, and Greene's (1993) idea of empowerment.

# Sibel Uysal, Senay Yasar-Purzer, Dale Baker, Elizabeth Lewis, Michael Lang

Teachers' Meaning-Making During Professional Development of Scientific Classroom Discourse Communities

Teachers' Meaning-Making During Professional Development of Scientific Classroom Discourse Communities Abstract This study describes school-based teams of secondary science and English/ELL teachers' progress on their definition of scientific classroom discourse communities (SCDC) through activities in the summer institutes of the Communication in Science Inquiry Project (CISIP). Data were collected at the beginning, middle, and end of the institute using three different activities. The cross-case study method was used to compare and contrast the high school and middle school teachers' negotiation of meaning individually and in small groups. Both groups of teachers showed improvement in their understanding the CISIP model of SCDC components through the institute activities. Middle school teachers expressed interdisciplinary support for each other's classrooms as they explored the CISIP model. High school teachers wanted to work with their team members, but they saw their role primarily as applying CISIP' components and being successful in their own classrooms. At the end of the summer institutes, most groups appreciated and understood the CISIP model for SCDCs. In the end academic language development, written discourse and the learning principles (NRC, 2000, 2005) were the most frequently mentioned CISIP components.



#### Doug Vallette, Nanette Dietrich

How Mathematical Literacy Impacts Inquiry in Physics

The purpose of this study is to consider the extent to which students' understanding of the language of mathematics enables them to enter into scientific conversation in the secondary physics classroom. Specifically we investigate the following questions: How do secondary physics students use the language of mathematics in their explanation of physics concepts in the context of mathematical modeling? What level of mathematical fluency is necessary for secondary physics students to enter into meaningful dialogue? What is the impact of secondary physics students' current level of mathematical fluency on their understanding of physics concepts in the context of mathematical modeling?

#### Roeland Van der Rijst, Jan Van Driel, Jan Kijne, Nico Verloop

Exploring Scientific Research Disposition from the Perspective of Academic Professors

Many universities are searching for ways to strengthen linkages between research, teaching and learning. However, at universities intangible elements of research practice, like scientific research disposition, often remain implicit. Explicating these elements might improve both university science teaching as well as student learning. In particular, understanding differences and similarities of academics' scientific research dispositions can help to enhance these links. Aim of present study is to explore variations of aspects of scientific research disposition and the weights academics put on these aspects. First, a phenomenological study into academics' conceptions about research dispositions was completed to analyze full qualitative variation. Second, an interactive cognitive mapping task was analyzed to quantify properties of academics' cognitive maps about aspects of their scientific research disposition. Through the analysis of both transcripts and cognitive maps, six qualitatively different aspects of scientific research dispositions were distinguished; (i) inclination 'to know', (ii) 'to be critical', (iii) 'to share' knowledge, (iv) 'to understand', (v) 'to achieve', and (vi) 'to be innovative'. The results of this study provide academics with extra knowledge of aspects of scientific research disposition which can help to support students to become proficient in scientific research.

#### Michiel van Eijck, Wolff-Michael Roth

Improving Science Education for Sustainable Development

The increasing awareness that the quality of education is critical for a sustainable future has led authors in high quality science and science education journals to call for the improvement of science education. Yet, the different often-simultaneously proposed educational approaches that can be found in science journals commonly are grounded in reductionism and behaviorism, epistemologies that mitigate against the very attitudes that are to be propagated. To overcome such inner contradictions, we present a holistic epistemology that is grounded in human evolution and the notion of collective human activity as the pivotal unit of individuals' transaction with the natural world. Drawing on data from an environmental education project, we exemplify how this epistemology allows a dual contribution to both to the improvement of science education and sustainable development.

#### Michiel van Eijck, Pei-Ling Hsu, Wolff-Michael Roth

Translations of Scientific Practice to High School Students

In the science education research literature, it often appears to be assumed that students "possess" more or less stable "images of science" that directly correspond to their experiences with scientific practice in science curricula. From cultural-historical and socio- cultural perspectives, this assumption is problematic because scientific practices are collective human activities and are therefore neither identical with students' experiences nor with the accounts of these experiences that students make available to researchers. Drawing on data collected before, during, and af-



ter pre-university biology students' internships in a scientific laboratory we show how students' "images of science" are co-produced along a trajectory of translations that was determined by the use of particular actions and tools, and a particular division of labor in scientific practice.

#### Rick Vanosdall, Michael Klentschy, Laurie Thompson, Kathryn Weisbaum, Larry Hedges

Effects of Scaffolded Guided Instruction on Student Achievement in Elementary Science

The use of inquiry-based teaching strategies has long been emphasized as the foundation of systemic reform initiatives in elementary science education. The ultimate aim of these reforms is to improve student learning and achievement in science. However, the research on the effectiveness of these reform effortsóat least in terms of student achievementóhas been spotty and inconclusive. In recent years, there has been a call for carefully designed experimental research to provide stronger tests of the causal effects of reform strategies on student achievement. In this symposium, we report on a new instructional reform effort and present empirical results from experimental studies on the efficacy and effectiveness of this approach. This approach, Scaffolded Guided Inquiry (SGI), was developed to: a) allow better alignment between what is taught and what will be assessed in a standards-based accountability system, b) facilitate deeper conceptual understanding through more effective participation in classroom inquiry activities; and c) develop metacognitive approaches to learning. We describe the conceptual framework of this approach and present examples of classroom implementation. We then present results from a series of experimental and quasi-experimental studies to test its effects on student achievement across a diverse groups of students and teachers.

#### Maria Varelas, Christine Pappas, Angela Calabrese Barton

Integrated Science Literacy Enactments: Spaces for Production of Scientific Knowledge

This is the introductory paper to a related paper set that explores theoretically and empirically science learning and teaching in primary-grade urban classrooms where teachers have designed, implemented, and studied curriculum and instruction that offer children various encounters with science and literacy in two extended unitsóMatter and Forest. In this paper we present the theoretical and research framework that underlies the collaborative action research model that we have employed. Considering each classroom as a specific ecology of "learnerhood" leads us to be concerned with and study how individuals (children and teacher) work together to engage with materials, ideas, and each other to achieve learning goals. Various dialectical relationships are important in the ecologies of learnerhood. As the inhabitants of these ecologies interact with each other, they share perspectives, as well as have and maintain distinct voices. As researchers we capture and explore young children's developing understandings of scientific ideas, their interactional forms of participation, and the mediational tools they use in the midst of learning to write, read, draw, think, talk, do science with their peers and their teacher.

#### Keisha Varma, Marcia Linn, Freda Husic

Examining the Role of Teacher Partnerships in Science Education Research, Professional Development, and Teacher Learning

The work reported in this paper is part of the research conducted by a large-scale research center that supports teachers to use technology based curriculum modules to enhance their inquiry instruction. In our work, we focus on partnerships that teachers form with researchers, mentors, and other teachers. We make an important distinction between community and partnership. We define community as the group of individuals participating in the research center who have a shared interest in using technology to increase science inquiry teaching and learning (teachers, students, researchers, designers, mentors, principals). Partnerships focus on the relationships between individuals in the community. This paper examines three types of teacher partnerships: teacher- researcher partnerships, teacher-mentor partnerships, and teacher-teacher partnerships. The results reported in this paper focus on the teachers' roles and how the partnerships impact their pedagogical practices and influence their knowledge development.



#### Richard Vath, Anna Switzer

Understanding First-Time Enactment of Environmental Decision-Making: Lessons for the Support of Teachers and Design of Professional Development

A "disconnect" exists in the minds of many Americans between our behavior and how it may contribute to the nature of environmental problems. Many environmental science textbooks are written with an explicit goal of giving students the knowledge they need to make more responsible decisions regarding the environment. However, most of them do not provide explicit instruction on making decisions. Little research has been conducted on the teaching of decision making in the context of environmental science. In this paper, we describe a study of two inner-city, high-school teachers teaching environmental decision-making (using a process called SCDM) as part of a reform-oriented environmental science curriculum for the first time. Research questions include: (1) What kinds of variations do the teachers demonstrate in terms of their characterization of SCDM and its steps, their use of examples, and their discussion of values? (2) In what ways do these instructional variations relate to student decision-making in terms of the use of SCDM and the consideration of values? (3) What examples and teaching issues from their first-time enactment can be used to inform subsequent professional development?

#### Bruce Waldrip, Vaughan Prain, James Carolan, Stephen Norris

Using Multi-Modal Representations to Improve Learning in Junior Secondary Science

There is growing recognition that learning science in school entails understanding and linking verbal, visual and mathematical modes to develop knowledge of scientific concepts and processes. However, teachers face various challenges in developing students' capacities to use these literacies of science to interpret and construct scientific texts. Our paper reports on two case studies on the topics of the particle theory of matter in Year 7, and force in Year 8. We aimed to identify teachers' perceptions of, and strategies to support, learning through this interlocking modal focus. Analysed qualitative data included focus-group and individual interviews with teachers, as well as observations of classroom lessons. The findings indicated that this explicit multi-modal focus posed significant demands on teachers and students, but had the potential to enable effective learning.

#### Alison Wallace, Meena Balgopal

Decisions and Dilemmas: Using WTL Activities to Increase Ecological Literacy

Our objective was to determine whether the Cognitive-Affective-Behavior Writing to Learn model increases ecological literacy in undergraduate elementary education students by enabling them to identify and propose solutions to ecological dilemmas. We tested our teaching heuristic by having students write three guided essays addressing the cognitive, affective, and behavioral domains in response to news articles on the issue of hypoxia. 64% of the students (14/22) in this study improved their ecological literacy from the first to the third essay. Students who improved the most did not necessarily demonstrate a complete understanding of hypoxia. However, these students were the only ones who broadened their conceptual framework of ecology during the guided writing activities as shown by their continued improvement in their pre-post ecological concept maps. We conclude that ecological literacy is not a discrete state of mind but rather a continuum. Authentic learners who can recognize dilemmas and potential decisions (and their ecological consequences) are on one end of this continuum. The goal of biology educators should be to encourage each student to move along the continuum towards ecological literacy, and as our findings illustrate, guided writing activities have enabled 2/3 of the students in this study to do so.

# James Wandersee, Renee Clary

An Interaction Analysis of College Biology Laboratory Students' Discussion Board Contributions

A common feature of course management systems used in teaching college science on campus is the class discussion board. Although the majority of discussion boards described in the literature were used in conjunction with face-to-face learning (e.g., Berge, 1998; Hara et. al., 1998; Love, 2002; Schrum & Hong, 2002), Kay concluded



that "there is no research on how much discussion actually goes on outside of the school environment [and] while the assumption may be that students are spending time reflecting and posting messages at home, there is no data to support this supposition" (2006). In an effort to address this gap, the purpose of the current study was to examine the quantitative and qualitative nature of an entire semester of student postings on a college biology laboratory discussion board at a research university. Twenty students, including both females and males, comprising an intact section, participated in multi-threaded online discussions initiated by the instructor using the Leonardo discussion board strategy that was previously developed and tested by the researchers. Quantitatively, the number, length, and degree of interactivity reflected by the students' postings for the 41 strands were impressive. Particular categories of issues were identified that provoked the most discussion--fostering "community."

#### Tzu-Hua Wang, Kai-Ti Yang

Pre-service Teachers' Perspectives towards Integrating Interactive Whiteboard into Elementary School Natural Science Course

In recent years, some researchers try to integrate the Interactive Whiteboard (IWB) into teaching, and the governments of many countries also begin investing funds in introducing the IWB to schools. Since 2006, Taiwan has started to implement the policy; however, the international and local researches on integrating the IWB into teaching are obviously inadequate. This study aims to investigate and compare per-service teachers' perspectives towards the integration of the IWB and other multimedia software into elementary school Natural Science course. It adopts Constructivist Multimedia Learning Environment Survey (CMLES) (Maor, 2000) to survey 90 pre-service teachers in college. It is found that in comparison with other multimedia software, the pre-service teachers tend to believe that integrating the IWB into the elementary school Natural Science course can better promote students' interactive discussions and reflective thinking in class and assist them to do inquiry learning. Moreover, the IWB-based digital teaching materials can familiarize students with real-life situations. The major disadvantage the pre-service teachers find is that students may encounter more difficulties in operating the IWB.

#### Chia-Yu Wang, Lloyd Barrow

The Role of Content Knowledge in General Chemistry Students' Understanding About Molecular Polarity

This study employed a mixed-method design to reveal how general chemistry students use their conceptual frameworks to solve problems about molecular polarity. The quantitative phase explored students' understanding and misconceptions about concepts of molecular geometry, polarity, and prerequisite concepts for a large sample size. The qualitative phase employed a case study approach including eight student interviews to portray students' conceptual frameworks regarding molecular polarity and prerequisite concepts in high, moderate, and low content knowledge groups. The quantitative findings identified students' misconceptions associated with concepts of electronegativity, chemical bonding, bond polarity, molecular shape, polarity of molecules, intermolecular force, and ionic lattices. The major findings of the qualitative phase revealed that levels of students' content knowledge can be considered as a continuum. Along the continuum from high level to low level of content knowledge, the quality of students' explanations declined, as did their ability to reconcile new information to their existing knowledge framework. Three prerequisite concepts were also identified that may explain students' failure for learning about molecular geometry and polarity. This study provides empirical evidence for how students' content knowledge influences their understanding about molecular polarity. The findings have implications for college chemistry education for teaching concepts of molecular polarity.

#### Annmarie Ward, Carla Zembal-Saul

Classroom Inquiry Style and Its Influence on Preservice Elementary Teachers' Science Teaching Practice

This comparative case study investigates the idea of Classroom Inquiry Style (CIS) as a way to characterize variations in how preservice elementary teachers implement inquiry-based teaching strategies into their own student teaching after participating in a science methods course focusing on inquiry practices that emphasized evidence and explanation. This study represents the second component of a broader research agenda investigating the



interface between preservice elementary teachers' substantive content knowledge and development of pedagogical content knowledge (PCK) for inquiry-based science teaching. Findings include: 1) Patterns in aspects of CIS were unique to each participant, allowing us to differentiate among them; 2) For the three student teachers, certain aspects of CIS tended to cluster, indicating possible interrelationships among aspects comprising the clusters; and 3) Although issues regarding participants' inquiry teaching could be explained by limitations in the three student teachers' content knowledge, CIS provided an alternative explanation for the problematic nature of many of the events. Information from this study will inform elementary teacher preparation programs and professional development programs in understanding factors important for teaching science using inquiry-based strategies, and subsequent research on the influence of depth of content knowledge and aspects of Classroom Inquiry Style on elementary teachers' PCK development.

#### William Watson

#### A Review of Measures of Student Concept Learning From Field trips to Informal Science Institutions

This paper presents results from a systematic review of measures used in 40 studies of K-12 student concept learning from field trips to informal science institutions (ISIs). Results suggest that research that reports instrument development, structure, type of knowledge assessed, validity, and reliability might provide the best evidence of learning from field trip experiences. A negative relationship between the number of characteristics reported and effect size leaves unanswered questions about the quality of measures used in studies that report few characteristics, and therefore about conclusions drawn from the data they provide. Attention to reporting instrument characteristics could lead to increased confidence in findings that identify the many positive impacts of field trips to ISIs on student understanding of science concepts.

#### William Watson, Curtis Pyke, Sharon Lynch, Robert Ochsendorf

# Scaling-Up a Middle School Motion and Forces Unit in a Large, Diverse School District: Results and Implications of a Quasi-Experiment

The evidence-based scale-up of educational interventions ushers in a new era of unit-centered curriculum change in science education. In this paper, we ask if small scale efficacy trials for individual units, followed by small-scale implementation studies and then incremental scaling-up, can serve the goals of improving student science achievement and equity. Results of a four-year study of the scale up of a middle school motion and forces unit in a large, diverse, suburban school system are presented. Findings show statistically significant treatment effects at small scale, F(1, 1759) = 24.26, p < .05, Cohen's d = .23. Interactions of curriculum condition with student characteristics showed benefits for all students with few exceptions. However, despite statistically significant treatment effects at small scale, a positive effect at large scale was not attained. This empirical study situates a discussion of the potential impact of policy that attempts to drive curriculum reform through evidence-based materials selection coupled with a scale-up agenda.

#### Scott Watson, Glenna Dunn

Conflict in Cooperative Learning Groups in an Elementary Science Methods Course

The purpose of this research was to determine if minimal training on the concepts and effects of relational, task, and process conflict would have an effect on proportional process conflict in undergraduate cooperative learning groups of elementary science methods students. Proportional process conflict is explained as the amount of process conflict in proportion to relational and task conflict and to the overall amount of conflict within the group. The sample consisted of 68 undergraduate students from four classes of the same course. Two classes were given conflict training and two classes were not. A Likert-type scale conflict scale was formed by combining questions from the refined Intragroup Conflict Scale (Pearson, Ensley & Amason, 2002) with questions from Shah and Jehn's survey (1993). The Conflict Survey was administered at the beginning, middle and end of the semesters. The Bales Interaction Process Analysis (Forsyth, 1983), interviews, and conversations were used to gather additional infor-



mation. Results of the t-tests showed no significant differences in the proportional process conflict between the undergraduate cooperative learning groups. The analyses of the Conflict Survey and the Bales Interaction Process Analysis indicated low amounts of relational, task, and process conflict in all of the cooperative learning groups.

#### Matthew Weinstein

Critical Science Literacy: Identifying Scientific Inscription in Lives of Resistance

This paper uses discourse analysis to analyze the role and form of science literacy in three examples of writings linked to social justice struggles over socioscientific issues. The purpose of this analysis is to better understand the nature of scientific literacy in the context of radical social movements and to reconsider what is necessary for a science literacy for social justice. The first example consists of the writings including training manuals, magazines, websites, and coordination plans of medics serving the anti-globalization struggle. The second consists of the writings of Wilmette Brown, a Black, Lesbian Activist, and her analysis of her cancer and the health care system. Finally, I look at the writings of human research subjects in the magazine Guinea Pig Zero. The paper concludes by noting that while literacy as defined in the National Science Standards is evident in these writings, more important is an institutional analysis of science and health care. The paper also notes that the analyses of these activists combine multiple disciplines, genres and media suggesting that œscience literacy separated from œsocial analysis is disempowering to those working for social justice.

#### Ayelet Weizman, Nir Orion

The Planetarium as an Outdoor Learning Environment

The purpose of this study was to investigate the effect of learning conducted in the planetarium, as part of a complete unit, on Elementary-School students' basic Astronomy concepts. We developed a model for combining planetarium lessons over the course of school teaching, based on the principles of teaching in Outdoor Learning Environments (Orion, 2003). Three 4th grade classes participated in the study- The first class participated in the whole unit, including preparation lessons, a planetarium lesson, and a summarizing lesson. The second class participated only in a planetarium lesson, without the other elements of the unit. Another class participated in the unit, but not in a planetarium lesson. Learning was measured by Pre and Post tests, students' essays, and interviews. Results indicate significant difference between the first group (whole unit with a planetarium lesson) and the two others, with regards to understanding basic Astronomy concepts.

# Ayelet Weizman, Yael Shwartz, David Fortus, Joe Krajcik

Developing the Practice of Scientific Modeling through Classroom Discussions

We examine the contribution of whole-class discussions to students' development of modeling practices in two modeling-driven units from a coordinated middle school science curriculum. The units, in physics and chemistry, include embedded supports for discussions involving the scientific practice of modeling. Video analysis showed that whole-class discussions contributed to students' construction, communication and evaluation of models. Focused interviews indicate that students acknowledge the role of discussions and think they helped them learn about models.

#### Andrew West, Mark Volkmann

What Misconceptions Do US Teachers Have About Lesson Study?

Lesson study is a professional development strategy where teachers have the opportunity to grapple with authentic issues encountered in classrooms and schools. A brief definition of lesson study is when a small group of teachers work together to design a single lesson on a topic that students find difficult. These efforts result in a better lesson, and with teachers who are more knowledgeable about teaching. This PD strategy has been practiced in Japan over the past 50 years. A handful of researchers are credited with introducing this strategy to US schools. However, US



teachers have encountered difficulties implementing lesson study. Lewis (2002) described these difficulties as misconceptions. However, her list is anecdotal. Our study represents an attempt to provide research evidence that tests her anecdotal list. In addition to the 6 misconceptions described by Lewis, we found 3 more. We describe these 3 misconceptions and discuss their implications for the use of lesson study with US teachers.

#### Anne Fiona White, Sheliza Ibrahim, Steve Alsop

Science Teacher Education in Place: A Participatory Action Research Approach

This paper will report on the use of place referenced participatory action research as a model of science teacher education (drawing on the recent literature on critical pedagogy of place). Our model of science teacher education utilises videoethnography and student documentary photography as a means of provoking discussions of science within local contexts. This collaboration of middle school teachers and researchers in two inner city schools blended the roles of teacher/researcher and promoted conversations on the nature of science, science pedagogy and science curriculum, placed in the context of discussions on agency, learners, locations and communities. Results will be reported on how the linking of this context-specific professional learning approach to a place-specific approach to pedagogy shaped the discourses, nature and culture of science teacher education that emerged.

#### Nicole Wickler, Meike Lemmens, Kathy Roth, Kathleen Schwille, Cathy Chen, Sharon Lynch

Elementary Teachers Learning Science Content Through Video Analysis of Practice: Impact of the STeLLA Program on Teacher and Student Learning

The Science Teachers Learning from Lesson Analysis Project (STeLLA) studied 48 upper elementary teachers and their students. The experimental group experienced a year-long professional development program focused on improving science content knowledge and pedagogical content knowledge through content instruction that was linked to analysis of videocases of science teaching. The control group received the same content instruction but no videocase analysis work. Changes in teacher knowledge and practices were measured with a pre-post written assessment, a lesson analysis task that serves as a proxy for pedagogical content knowledge, and detailed analyses of videotapes of science lessons. Students took a written content test which was compared to the teachers' students from the previous year; pre-to-post changes in students' performance before and after the teacher's participation in the PD program were compared. Ten teachers were interviewed before, during, and after the professional development program. Results show that compared to control group teachers, experimental group teachers who studied electricity and food webs increased their content knowledge through analysis of videocases of science teaching, and their students' learning also increased. In addition, experimental group teachers developed a common language for analyzing science teaching, and teachers reported increased confidence in teaching science.

# Eric Wiebe, M. Gail Jones, James Minogue, Jennifer Cowley, Denise Krebs

Unraveling the Influence of Haptic Feedback on Students' Learning about Levers

With increasing interest in the creation and use of computer-based instructional programs, the aim of the present study is to systematically explore students' learning about the three classes of levers via a haptically augmented virtual lab. The core research questions concerned the efficacy of haptic augmentation to promote conceptual understanding of levers. Learning measures, eye tracking data, and coding of system interaction behaviors were all used understand the impact of this augmentation. Forty (40) middle school students participated in this study with half using the virtual lever lab with haptic augmentation (visual+haptic) and half without (visual only). The results indicated that while the written pre and post test did not show any difference between the two groups, the visual only group performed better on the embedded assessment. In addition, the visual+haptic group spent more time interacting with the levers than the visual only group. Eye tracking measures did not reveal any differences between how much time was spent looking at key elements on the screen. Results are interpreted using prior research on haptics and cognitive load theory. Implications for haptics augmentation of virtual science labs is discussed.



#### E. Grant Williams, John Clement

Co-Constructing Explanatory Mental Models in High School Physics: Comparing Ratios of Teacher/Student Participation

We compared the teacher-to-student participation ratios of two experienced high school physics educators during whole-class co-construction of explanatory mental models for concepts in circuit electricity. While students in both teachers' classes experienced comparable levels of impressive pre to post-instructional test gains, analysis of selected class discussions showed that considerable differences existed between the two groups in the ratios of student-to-teacher contributions to the development of model elements. Identified teaching tactics appeared to fall into two categories, those that support the dialogical elements of classroom interaction, and those that support cognitive model-construction processes. Teacher and student contributions of the latter type were coded into model construction cycle categories: referring to experimental observations (O), indicating the generation of a conceptual scientific idea (G), evaluating an idea currently under discussion (E), and making a modification to a previous idea (M). This analysis based on the OGEM cycle made it possible to describe the specifics of how the model co-construction process was shared in each classroom. We conclude that teachers may vary their levels of participation in the model co-construction process but what remains most important is their ability to foster students' engagement in the activity.

#### Christopher Wilson, Brett Merritt, Andy Anderson, John Merrill, Joyce Parker

Principled Reasoning and Procedural Display in Undergraduate Biology Education: A Model for Assessment

One goal of undergraduate biology education is for students to engage in principled reasoning, meaning incorporating biological principles across scales (molecules to ecosystems) into their accumulated experience and applying that extended experience appropriately. Students come (and unfortunately leave) many undergraduate biology courses with strong but incorrect explanations of processes in living systems. These are rarely robust misconceptions, bur rather pieces of knowledge they cannot bring together. When students encounter material that does not link to their accumulated experience, many make erroneous connections to what they think they know, or attempt to memorize facts or terms for working particular types of problems separate from their accumulated experiences. Therefore, they cannot connect ideas, cannot apply their knowledge, and are a long way from reasoning based on a set of principles. Instead they engage in procedural display of their fragmented knowledge. To examine how, when and why students engage in either procedural display or principled reasoning, we have developed Diagnostic Question Clusters that are designed to measure how students engage in reasoning with specific scientific models. We present here the development, application and interpretation of one cluster that measures students' inclination and ability to engage in principled reasoning with models of cellular respiration.

#### Charles Winrich, Andrew Duffy, Arthur Eisenkraft, Russ Faux, Luciana Garbayo, Peter Garik

The Impact of Teaching the Conceptual History of Physics as a Sequence of Models on the Understanding of the Nature of Science by Physics Teachers

For the past two years, we have been working with a cohort of teachers of physics who are teaching outside of their content fields. These teachers have been attending classes in physics intended to remedy their content knowledge of physics. To help the participants better understand the nature of physics, the conceptual history of physics has been included in these courses. The rationale for this was to anchor their reasoning with modern scientific models through compare and contrast exercises with earlier models. In the research presented here we examine the impact on the participants' understanding of the nature of science from multiple assessments. We find that the participants have a relatively sophisticated understanding of the nature of science in most areas. The notable exception to this is that they have a hierarchical view of the relationship between scientific theories and laws.



#### Nathan Wood

Multimedia Learning in a Real Classroom

It is common for fairly sophisticated instruments to be used in undergraduate, general chemistry, laboratory courses. Typically, these instruments are treated as incidental to the experiment: students are given extensive operating instructions, but told little or nothing about how they work, because understanding the instruments themselves is not an objective of the course. However, cognitive load theory (Sweller, 1988, 2005) predicts it would be more difficult for students with limited prior knowledge to make sense of their data if they do not know how measurements made with the instruments are actually derived from their physical sample. This experimental study was intended to determine whether a multimedia tutorial, designed to help students understand how a UV/vis spectrophotometer works, brings about any changes in performance on a laboratory experiment about food dye solutions. While results provided evidence the tutorial helped students learn more efficiently, evidence could not be found that they learned more deeply. Potential explanations for these results and their implications are discussed.

#### Ann Wright, Sue Tunnicliffe, Michael Reiss

Students Learn About Their Own Bodies as Part of Their Biological and Citizenship Deduction. How Do They Learn? What Do They Learn First? From Whom Do They Learn?

The paper presents a longitudinal study on student's ideas about human anatomy and physiology. These ideas (mental models) are being assessed using five different approaches. The only way for a researcher to understand a subject's mental model of a particular phenomenon is by eliciting one or more of their expressed models. Three science educational researchers, 2 from the United Kingdom, and 1 from the United States, will present research findings on students' understanding about the digestive system. UK students, year 5 (age 9/10) have a better understanding of the digestive system than year 3 students (age 7/8). US students, grade 5 (age 9/10) and grade 7/8 (age 12/13) and grades 9, 10, 11 (ages 14-18) were found to have alternative conceptions about basic digestive system structure and function after instruction. Students construct their ideas from various environments and from an individual prospective or a social prospective. Scott, Asoko, and Leach (2006) state, "There are strong commonalities in how individuals appear to think about the natural world" (p. 38). The results from several studies in the UK and US suggest students have commonalities about the order of organs of the digestive system and how the digestive system functions.

# Ying-Tien Wu, Chin-Chung Tsai, Chun-Yen Chang

High School Students' Scientific Epistemological Beliefs, Cognitive Structures Regarding Nuclear Power Usage, and Their Informal Reasoning on the Debates of Nuclear Power Usage

With both qualitative and quantitative analyses, this study aimed to examine the ability of students' scientific epistemological beliefs (SEBs) as well as their cognitive structures regarding nuclear power usage for predicting their informal reasoning on the debates of nuclear power usage. The participants were 68 tenth graders in Taiwan. In this study, the participants' SEBs were assessed by an quantitative questionnaire; the data regarding their cognitive structures regarding nuclear power usage were collected through tape-recorded interviews and analyzed with the flow map method; their informal reasoning on nuclear power usage was evaluated with an open-ended questionnaire. It was found that, among the scales of SEBs, only the students' scores on the ¡Sjustification;" scale could significantly and positively predict the amount of rebuttal they constructed, while, among the variables regarding cognitive structures, only their usage of the information processing mode, ¡Scomparing;", could significantly predict their rebuttal construction. More importantly, it was revealed that, among all the variables regarding SEBs and cognitive structures, the students' usage of the information processing mode, ¡Scomparing;", was the best predictor for their informal reasoning quality, while their beliefs on the justification of scientific knowledge was the second best predictor for their informal reasoning quality.



#### Vanessa Wyss, Christine Liu, Robert Tai

The Influence of Service Learning in High School Science on Undergraduate Majors

Recent labor projections predict large deficits in the STEM workforce. The current number of bachelor degrees being earned in STEM fields can not address this pending discrepancy. Service learning has a list of potential benefits that are cited in the literature. Among those cited is the opportunity to explore potential careers. In fact some studies have shown career aspirations are significantly influenced by service learning experiences. Most of these studies are not specific to science. This study uses data from project FICSS to assess the use of service learning as a method for increasing high school science student interest in science measured by intentions to major in a science field. These findings do not offer evidence supporting the use of service learning as a method for increasing student interest in majoring in science. This study does offer the basis for more research and closer analysis on the efficacy of service learning as a method for attracting students to STEM fields.

#### Bugrahan Yalvac, Nurcan Turker, Ozgul Yilmaz-Tuzun

Constructivist and Traditional Approaches to Teaching and Learning: Validation of Teacher Beliefs Survey

The purpose of this study was to validate a Teacher Beliefs Survey (TBS). The TBS has been developed to measure teachers' beliefs of constructivist and traditional approaches to teaching and learning (Woolley, Benjamin, & Woolley, 2004). The TBS contains 34 items in four dimensions, namely, Traditional Teaching, Constructivist Teaching, Traditional Management, and Constructivist Parent. Data were collected from 411 preservice elementary science and mathematics teachers in Turkey. Our analysis revealed a reasonable model with four-factor structures. The final model included 19 items. Our indexes are parallel with Woolley et al.'s (2004) findings. The goodness of fit statistics were 2 = 516.28, df = 146, NFI = .78, NNFI = .80, CFI = .83, GFI = .90, AGFI = .84, RMSEA = .08. We also investigated the relationships among teachers' self-efficacy and their beliefs of the constructivist and the traditional approaches to teaching and learning.

# Wen-Gin Yang, De-Wei Feng, Jia-Cheng Ye

Effects the Representational Structures on Students' Nervous System Image Reading Comprehension

This study, based on the perspective of visual grammar, aimed at exploring the effects of representational structures of image on pupils' understanding of nervous system. The representational structure depicts the way an image represents the compositions of nervous system (conceptual domain) and/or the dynamics of neural transmission (narrative domain). A two stages design was developed. At the first stage, a set of three images from a current textbook were selected as the Target images, the reading difficulties of these images by 30 students (who had studied the nervous system before participating in the study) were examined quantitatively and qualitatively. Then the Modified images were formed by the results accordingly. A pair of probes of diagnosing image reading understanding were developed that having exactly the same verbal description with Target or Modified images embedded. 140 students were administered to these two probes randomly. Major findings include: Only a portion of students (20%-67%) read correctly both the conceptual and narrative domains from the Target images. Meanwhile, the Modified images readers outperformed significantly on both domains. The implications for science textbook construction and science teaching and learning were discussed.

# Fang-Ying Yang, Ying-Shao Hsu, Meng-Jung Tsai

A Cross-Analysis for High-School Students' Personal Epistemology and Understanding About Inquiry

In the study, an attempt was made to explore the association, if any, between high-school students' personal epistemological beliefs and understandings about scientific inquiry. One hundred and eighteen students with 60 males and 58 females participated in the study. The Revised Epistemology Questionnaire (REQ) adapted and reduced from Schommer's Epistemology Questionnaire (SEQ) is the instrument for assessing students' personal epistemological beliefs while theViews of Scientific Inquiry (VOSI) questionnaire was employed to probe students'


understandings about scientific inquiry. Content analysis, descriptive analysis and other analytical methods such as correlation analysis and One-way ANOVA are used to reveal students' epistemological perspectives and associations between different epistemological positions. In so for the result indicates that most students' personal epistemological beliefs fall in-between the simple and complex forms of personal epistemology. In addition, our subjects seem hold a rather multiplist view toward scientific inquiry.

#### Anat Yarden, Nir Esterman

#### The Effect of Disciplinary Identity on Interdisciplinary Learning During Scientific Group Meetings

Learning to become an interdisciplinary scientist will be needed in order to fully participate in the scientific research of the future. It is therefore of great importance to learn about the challenges graduate students, with various disciplinary backgrounds, face when carrying out interdisciplinary scientific research. In this study we used the weekly group meetings of an interdisciplinary research group, in the field of systems biology, as a platform to probe the challenges to learning interdisciplinary science. Group meetings were observed and in-depth interviews were carried out with members of the group. A visible, if sometimes subtle, difference between the challenges facing biologists and those facing physicists was identified. Physicists encountered difficulties in grasping the biological knowledge organization; while biologists found the models suggested by physicists over simplistic. The views of the group members on the nature of the disciplines of physics and biology complement our understanding of the possible causes of some of the identified challenges. The initial disciplinary identity that one acquires during his academic education was found here to strongly influence the way one acquires knowledge in and about other disciplines. The results of this study may facilitate interdisciplinary transitions of scientists, teachers and students at all levels.

#### Senay Yasar- Purzer, Sibel Uysal, Dale Baker, Elizabeth Lewis, Michael Lang

Teachers' Progress Towards a Modernist View of Nature of Science Communication

Teachers' Progress towards a Modernist View of Nature of Science Communication Abstract In this study we examined in-service teachers' views of nature of science communication. Forty-six science and English teachers teaching at high school or middle school levels were asked to define the nature of science and how science is done at the beginning of a Communication in Science Inquiry Project (CISIP) summer institute. The analysis of teachers' initial definitions of the nature of science revealed a traditionalist view regardless of the grade level or subject being taught. In their initial definitions, teachers commonly talked about knowledge development and rarely about the subjectivity of scientific knowledge. Teachers had the opportunity to modify or expand their definition after collaboratively discussing a list of cards that included statements about the nature of science. The nature of science cards activity increased teachers' awareness of the role of discourse and collaboration in science. We also examined how teachers' views of science were reflected in their scientific investigation reports. The teachers generally used a modernist approach when verifying their data and developing their knowledge based on their findings. Discussions of the nature of science, inquiry investigations, and scientific writing helped teachers progress from a traditionalist to modernist view of science.

#### Yue Yin, Miki Tomita, Richard Shavelson

Using Formative Assessment to Promote Conceptual Change

This study explored the effectiveness of using formative assessment to promote conceptual change in science classroom. Fifty-one sixth graders were randomly assigned to either an experimental group or a control group. Both groups were taught by the same teacher with identical learning materials and activities. In addition, the experimental group received three formative assessments over the course of the study. Preliminary results show that the two groups did not perform differently on the tests assessing content related achievement, after their pretest scores were controlled for. However, the experimental group out-performed the control group on measures diagnosing misconceptions. Theoretically, this study connects two previously isolated educational frameworks. Practically, it



suggests a useful way of promoting conceptual change in the science classroom.

#### Betty Young, Barbara Sullivan Watts, Robert Pockalny, Barbara Nowicki

Patterns in the Science Knowledge of Elementary Preservice Teachers Engaged in Inquiry Teaching

This study examined the teaching practice of 36 elementary preservice teachers during a science methods course at a northeastern university. Evidence of science knowledge and its appropriate presentation was coded, looking for patterns in the preservice teachers' hands-on inquiry lessons in elementary classrooms. The study further considered teachers' science content background and confidence. Preliminary results showed teachers needed a deeper understanding of the concepts they were teaching in order to guide student investigations more effectively. Primary lessons were more successful than those in intermediate elementary grades. Preservice teachers used questioning to present concepts, followed by manipulatives, visuals, and verbal discussions. Students had the most difficulty building science content using the evidence of student investigations during the closing of the lesson.

#### Betty Young, Barbara Nowicki, Barbara Fitzsimmons, Kathleen Guglielmi, Judy Paolucci, Sharon Lee

Use and Quality of Inquiry Pedagogy in the Science Video Lessons of Elementary Preservice Teachers

This study examined the classroom teaching practice of 36 elementary preservice teachers during a science methods course at a northeastern university. Evidence of inquiry pedagogy was coded, looking for patterns in the preservice teachers' first attempts at incorporating the methods course content into their instructional practice by designing a hands-on inquiry lesson and teaching it in an elementary classroom. The video analysis was viewed in relation to the preservice teachers' plans, written reflection papers, and the guidance and feedback from course instructors. Preliminary results showed the teachers engaged students in hands-on explorations and guided students rather than giving directed lessons. Students had the most difficulty with managing science content in the openended environment and summarizing the lesson in the closing.

#### Shu-Mey Yu

Quality and Evolution of Students' Argumentation in Organic Agriculture Issue

The purpose of this study was to investigate the quality and evolution of students' argumentation in organic agriculture issue. Subjects were forty-four freshmen majored in science. They were classified into three groups based on their epistemological views. Argumentation in organic agriculture issue was developed and validated by two science educators. The task was set in e-learning system. Subjects engaged two rounds argumentation in e-learning system and classroom. Data collected were coded and analyzed in quality and evolution of argumentation by three trained graduate students independently, and an inter-rater consistency was .92. Results indicated that there was improvement in the quality and evolution of freshmen's argumentation in organic agriculture issue. More constructivist-oriented group and mixed group changed their position than empiricist-aligned group. More mixed group evolved their argument than constructivist-oriented group and empiricist-aligned group. Further discussion and educational implications of these findings will be discussed in the conference.

#### Molly Yunker

A Learning Progression for Understanding the Context, Cyclic Nature, and Timescales Associated With the Rock Cycle

Learning progressions have recently been considered as a way to help teachers assess students' levels of understanding, and to measure changes in conceptual development. These progressions can help guide the development of rich and more sophisticated ideas over time. Learning progressions can be useful tools for a variety of people interested in all levels of education, including curriculum developers, teachers, and policy makers. The study described here worked towards the development of a learning progression through data collection. This study was designed to gather information about geologic processes through interviews with novices (6th graders), intermediates (preservice teachers), and experts (Geology professors). Specifically, the interviews focused on processes associated with



#### **2008 NARST Annual International Conference**

the rock cycle—a topic central to the Earth Sciences. The learning progression that emerged from these interviews describes how people develop an understanding of where rock formation processes occur on and within the Earth. This contextual information about geologic settings provides evidence that can eventually lead students to better understand the causal mechanism underlying these processes—plate tectonics. A possible outdoor learning experience, based upon work by Orion and colleagues, to target the development of contextual knowledge of rock cycle concepts will be discussed.

#### Ozgul Yýlmaz-Tuzun, Nurcan Turker

Validation of Mentoring for Effective Primary Science Teaching Instrument for a Turkish Sample

The purpose of this study was to validate an instrument, Mentoring for Effective Primary Science Teaching (MEPST), for a Turkish sample. Preservice elementary teachers (n=411) participated in the validation of the MEPST from two universities in Turkey. MEPST measures preservice teachers' perceptions about their mentors based on their mentoring practices. The instrument was developed by considering constructivist theory. MEPST included five dimensions, which are personal attributes, system requirements, pedagogical knowledge, modeling, and feedback. Originally MEPTS included 34 items. In this study, we obtained not good but acceptable model with 25 items. Five factors that describe effective mentoring practices in elementary science and mathematics teaching were supported by confirmatory factor analysis. Cronbach alpha coefficients of internal consistency reliability of each dimension were found as .61 for personal attributes, .77 for system requirements, .93 for pedagogical knowledge, .80 for modeling, and .84 for feedback. Final model fit indexes were found as 2 = 1736.30, df = 265, CMIDF = 6.55, IFI = .86, CFI = .86, RMR = .046, RMSEA = .12. Relationship between preservice elementary teachers' perceptions of their mentoring practices and self-efficacy beliefs was also investigated.

#### Zacharias Zacharia

Experimentation with Combined Physical and Virtual Materials: An Attempt to Enhance Undergraduate Students' Conceptual Understanding in Physics

The purpose of this study was to investigate the value of combining Physical Materials (PM) with Virtual Materials (VM) with respect to changes in students' conceptual understanding of electric-circuits. A second aim was to compare the effect of PM and VM on students' understanding of concepts of electric circuits that were introduced in those parts of the curriculum where PM was substituted with VM. A pre-post comparison study design was used which involved 119 undergraduate students that attended an introductory course in physics. The participants were randomly assigned to two experimental and one control conditions. All conditions used the same inquiry-oriented curriculum. Participants in the control condition used PM to conduct the experiments, whereas, participants in the experimental conditions used both PM and VM. Conceptual tests were administered to assess students' understanding before, during, and after teaching. Results indicated that the combinations of PM and VM enhanced students' conceptual understanding more than the use of PM alone. Additionally, the use of VM alone enhanced students' conceptual understanding, in those parts of the curriculum where PM was substituted with VM, more than the use of PM alone.

#### Dana Zeidler, Troy Sadler, Martina Nieswandt, Chin-Chung Tsai, Vaille Dawson, Grady Venville

Impact of Socioscientific Issues Research on Research, Policy and Practice

The Socioscientific Issues (SSI) framework seeks to involve students in decision making regarding current social issues with moral or ethical implications embedded in scientific contexts. The goal of this symposium is to raise and discuss key issues associated with the position of socioscientific issues in science education. Organization of the symposium will provide opportunities for the audience to hear from leading researchers and practitioners in the field as well as opportunities to discuss specific components of the socioscientific issues agenda with the intent of moving the field's dialogue in new directions. Four focus areas relative to SSI have been identified as important topics for shaping future directions in science education: 1) Socioscientific Issues and Policy; 2) Socioscientific



Issues and Character Education; 3) Learning Outcomes Associated with Socioscientific Issues; and 4) Classroom Strategies for Socioscientific Issues. The symposium will be structured around a series of small group discussions related to these sub-themes with opportunities to synthesize key points at the symposium's conclusion.

#### Josie Zesaguli, Blakely Tsurusaki, Brook Wilke, Charles Anderson, Christopher Wilson

The Development of a K-12 Learning Progression for Biodiversity in Environmental Systems

This poster describes students' understanding of the structure of systems in which biodiversity is present; processes that generate, maintain and reduce that diversity; and long-term change over time in populations and ecosystems, including evolution by natural or human selection. Two versions of a written assessment, one focusing on aspects of diversity in populations and the other on diversity in ecosystems, were administered to middle and high school students, in urban, suburban and rural schools. The populations test solicited students' accounts of sources of variation among individuals in populations, including tomatoes, strawberries, carrots, and people. Most students attributed variations within a population to be due to genetic, environmental, or life-cycle factors but not to the interactions among those factors. 1 Few students mentioned genetic variability or selective breeding in their accounts of population change over time. For example, students did not mention selective breeding practices in their accounts of variability among dog breeds; similarly, few students mentioned variation or selection in accounting for insects' developing resistance to pesticides. Few students were able to give model-based accounts that were constrained by principles and hidden processes such as selection. Implications of these findings for science curriculum development, instruction and assessment will be highlighted.

#### Albert Zeyer

Students' Post-Ecological Discourse in a Secondary One SETS (Science-Technology-Society-Environment) Education

In the central part of Switzerland, a STSE curriculum for secondary one level has been used for more than 10 years. Environment and environment protection play a prominent role in it. Previous research has shown, that the curriculum induced a teachers' and school culture of ecological scientism. The research presented here investigates the students' attitude towards environmental questions. Three classes were inteviewed, followed by in depth interviews of the science teachers and of twelve students. Discourse analysis shows a post-ecological attitude of the investigated students. Their discursive register is sober, pragmatic, and materialist. Their subject position is constructed as powerless in front of depersonalized powerful mights and tendencies. They use the discourse of othering to point out their lack of personal influence and to legitimize personal abstinence from environmental engagement. They show a pragmatic view of nature as a resource for lifestyle. In depth discourse analysis reveales patterns of a hidden environmental depression. These results have been interpreted in terms of a cultural clash between ecological scientism and the culture of the students (yet to be closer investigated). Conclusions for science teacher education are discussed.

#### Albert Zeyer, Marco Adamina, Francois Gingin, Peter Labudde

Swiss National Standards – a Political Mandate to Researchers in Science Education

The Swiss national project HarmoS (Harmonization of the Compulsory School) can be seen as a rare example of an explicit political mandate to researchers in science education. HarmoS intends to harmonize and monitor the educational system in Switzerland, which is currently segregated into 26 separate subsystems governed independently by the 26 cantons or "states". It was initiated by the Swiss Conference of Cantonal Ministers of Education, and enjoys high priority in the Swiss political agenda. Since the result of HarmoS is bound to change the Swiss educational landscape, its design not only reflects the national political culture, but also scientific and methodological considerations. The proposed contribution to the seminar will sketch out this joint venture of politics and education research, discuss first experiences, and provide an outlook to future political challenges of the project.



#### Meilan Zhang, Tom McConnell, Mary Lundeberg, Matthew Koehler, Jan Eberhardt

Teachers' Burning Questions: Understanding Challenges That Science Teachers Face and Problem-Based Learning as a Framework to Support Teacher Researcher

Understanding the challenges that science teachers face and providing corresponding support are critical for effective professional development. However, the field lacks a clear understanding about the real needs of teachers. Drawing on 3 years of data collected in a professional development program for science teachers, in this study we explored two questions: 1) what challenges do science teachers face when they struggle to meet the increasingly high expectations set up for them by current educational reform? and 2) how does Problem-based Learning (PBL) as a framework support teachers in researching their teaching challenges in a year-long effort? Participants were 68 K-12 science teachers from a 3-year PD program. Multiple sources of data were collected, including worksheets, presentation posters, meeting notes, and reflections that teachers generated during a year- long process. Data analysis shows that science teachers struggle with a number of issues, including 1) assessment, 2) using new instructional approaches to teaching a specific topic, 3) science process skills, 4) group work, 5) making connections between science content, and 6) making connections to real world experience. We also found that Problem-Based Learning as a framework holds great potential for supporting teacher research. Implications of this study for science teaching are discussed.

#### Meilan Zhang, Mary Lundeberg, Tom McConnell, Matthew Koehler, Jan Eberhardt

#### Conditions for Collaborative Knowledge Construction of Inservice Science Teachers in Problem-Based Professional Development

Problem-Based Learning (PBL) holds great promise as an innovative professional development (PD) model in preparing effective science teachers. However, little empirical research has been done to examine its use in the PD context. Particularly, little attention has been paid to the group collaboration process, one of the essential characteristics of PBL. In this study we examine how science teachers collaboratively construct their knowledge in a professional development seminar using a PBL approach, and explore conditions that support or hinder teachers' collaborative knowledge construction. Multiple sources of data, including video recordings, artifacts, pre-post tests and evaluations, were collected in a two-week summer professional development workshop, in which 35 science teachers participated. We employed discourse analysis and conversation analysis methods to analyze the talk in problem-based learning, and found six conditions that support collaborative knowledge construction, which included: 1) a clear focus for discussion; 2) a controversial discussion topic that allowed for disagreement; 3) a discussion topic relevant to teachers' practice; 4) appropriate questioning by facilitators; 5) appropriate questioning by group members; and 6) a small number of learning issues for research. Absence of these conditions may inhibit collaborative knowledge construction. Implications for science teaching are discussed.

#### Irene Zilker, Gary Holliday, Alexander Kauertz, Hans Fischer, Judith Lederman, Norman Lederman

Developing a Large Scale Assessment Instrument Measuring Students' Competencies in Nature of Science and Scientific Inquiry

The topics Nature of Science (NOS) and Scientific Inquiry (SI) have been a subject of research in science education for many years. Moreover, these topics are considered in educational standards and curricula worldwide. Studying research reports and science education standards documents, one would find different lists of aspects related to NOS and SI. In order to develop a large scale assessment instrument measuring students' competencies in NOS and SI, the authors combine a three dimensional model of competency with sets of characteristics related to NOS and SI. Thereby, NOS and SI are meant as concepts, by which any content can be structured. Both concepts are described by two category systems that might structure any list of NOS/SI characteristics. For the NOS concept the categories "research questions", "answers" and "researchers", and for the SI concept the categories "conditions", "methods" and "results" are chosen. Based upon this 180 multiple choice items are developed. This way we can describe and observe students' learning about NOS and SI, and, in addition, we will possess an instrument making diagnosis about students' level of competency related to NOS and SI.



#### Esther Zirbel, Claudine Kavanagh, Cary Schneider

Learning to Think about Gravity II: Aristotle, Newton, and Einstein

Instructors widely teach Newton's 1687 gravitational theory, despite the fact that gravity was radically reinterpreted by Einstein in 1915. This modern theory of gravity is widely considered "too difficult" for pre-college classrooms. However, we propose the benefit of discussing gravitational theories in a comparative fashion. We document and contrast expert and student views on the essence of each historical interpretation: Aristotle, Newton, and Einstein. We provide a classification rubric to assist students in understanding how each thinker would account for free fall, projectile motion, and orbital motion. Preliminary results indicate that there are strong similarities between the Aristotelian interpretation and Einstein's ideas, which provide sharp contrast to the Newtonian conception. We argue that the foundations of Einstein's theory should be taught in pre-college classrooms, alongside earlier descriptions. Another goal is to develop a Gravity Concept Diagnostic Tool (using Fischer's Skill Theory) to evaluate student's emergent understanding of current theories, limited to Newton and Einstein. We also present a "double conceptual change" in which students learn about: 1) the process and nature of science, 2) the methodologies to construct theories and 3) how to critique theories, including their own.

#### Uri Zoller

Science Education Reforms Worldwide: Are They Compatible with the Teaching to Learning Paradigm Shift?

Given the current world state of affairs, the striving for sustainability and the consequent paradigms shift, such as from correction-to-prevention and from options selection-to-options generation, the corresponding paradigms shift in science education, such as from the currently dominant traditional algorithmic oriented teaching - to - higher-order cognitive skills-promoting LEARNING, is unavoidable. Such a shift requires new types of flexible, contextually-bound relevant, adaptive knowledge and more so -- persistent, purposed development of students' evaluative, critical and system THINKING, decision making and problem solving capabilities, for effectively dealing/coping with the complexity and fragility of multi-dimensional socio-economical-technological-environmental systems. Are the science education reforms, worldwide, compatible with this, appearing to be agreed upon, TEACHING-to-LEARNING paradigm shift? Responding to this question will constitute the focus of this presentation, concluding, that the success of this shift is contingent on a paradigm shift in the corresponding ASSESS-MENT methodologies and practices: From algorithmic, 'correct/incorrect' knowledge-based, to those promoting EVALUATIVE THINKING in learning.

#### Uri Zoller, David Ben-Chaim, Orit Herscovitz, Azaiza Ibtisam

Decision Making in Higher Education; A Probe into STES-Oriented Courses

This paper focuses on decision making (DM), a process that aims at resulting in a desirable result to the decision maker leading, eventually, to a commitment to action. The development of students' DM capability within on-going science education, worldwide, typifies contemporary trends in science teaching and learning within the paradigm shift from algorithmic teaching to higher-order cognitive skills (HOCS)-promoting learning. Our study purposed at assessing the 'base-line' DM capability of science students in traditional vs. interdisciplinary sciencetechnology-environment society (STES)-oriented science teaching in higher education. The responses to a specially-developed and pre-study validated DM questionnaire, administered to a probe of B.Ed/B.Sc (N=105) and MA (N=26) students in traditional and STES-oriented college science courses, respectively, suggest that: (a) DM capability; (b) complexity and rationalization of decisions made; and (c) interdisciplinary, system evaluative thinking of students in STES-oriented science courses, are significantly higher than those in traditional science courses in higher education. This research-based, in- depth insight into the "DM issue" supports the current trends in HOCS-oriented science education reforms, worldwide and their potential impact on public policy.





Abdel-Kareem, Hasan | Michigan State University | 54,57,58 Abd-El-Khalick, Fouad | University of Illinois at Urbana-Champaign | 33,40,60,70,71,84,125 Abell, Sandi | University of Missouri-Columbia | 69,73,46,103,121,125,148,212,33,35,37 Abell, Sandra | University of Missouri-Columbia | 33,35,37,46,55,69,73,103,101,125,148,212 Abrams, Eleanor | University of New Hampshire | 49,53,55,61,85,148 Acar, Omer | The Ohio State University | 78,85 Adadan, Emine | Bogazici University | 53,85 Adamina, Marco | 35,266 Adams, April | Northeastern State University | 39,188 Adams, Betty | Western Michigan University | 39 Adams, Jennifer | American Museum of Natural History | 65,246 Adams, Krista | Arizona State University | 47,66,187 Adams, Raymond | University of Melbourne (Australia) | 37,192 Akerson, Valarie | Indiana University | 34,44,48,49,59,70,77,85,86,128,150,209,220 Albe, Virginie | Unité de recherche Toulouse EducAgro | 49,86 Albro, Elizabeth | 49,86 Alexakos, Konstantinos | Brooklyn College, CUNY | 47,87 Al-humiari, Mohammed | Florida State University | 51,142 Allen, David | Kansas State University College of Education | 78,236 Allen, Deborah | University of Delaware | 36,80,136,165 Alonzo, Alicia | The University of Iowa | 65,87 Alozie, Nonye | University of Michigan, School of Education | 81,131 Alsop, Steve | York University, Toronto | 49,52,99,259 Alters, Brian | McGill University | 47,90 Alvarado, Cheryl | Arizona State University | 60,104 Ancelet, Jeanine | Institute for Learning Innovation | 57,147 Anderson, Andy | Michigan State University | 35,260 Anderson, Charles | Michigan State University | 54,57,58,66,84,88,110,111,121,146,161, 167,251,266 Anderson, David | University of British Columbia | 55,65,204 Anderson, Janice | Boston College | 40,48,88 Anderson, Richard | University of Illinois at Urbana-Champaign | 69.159 Anderson, Sybol | St Marys College of Maryland | 79,162 Annetta, Leonard | North Carolina State University | 37,52,72,79,101,237 Anthony, Robert | University of Victoria | 50,89 Applegate, Brooks | Western Michigan University | 39,233 Aronson, Isaak | University of Maryland | 59,89 Arsenault, Amy | University Of Illinois At Chicago (UIC) | 72,89 Arsenault, Nicole | Mount Saint Vincent University | 45,102 Arslan, Harika | Yuzuncu Yýl University | 50,90 Aryal, Bijaya | Lake Superior State University | 37,42,90,223 Asghar, Anila | Johns Hopkins University | 47,90 Ashmann, Scott | University of Wisconsin-Green Bay | 52,91 Atar, Hakan | 81,91 Atkins, Leslie | LessonLab Research Institute | 32,228 Atwater, Mary | University of Georgia | 40,74,91,92 Atwood, Dana | University of Kansas | 47,92 Augustin, Line | Queens College | 32 Austin, Barbara | Northern Arizona University | 33,92 Aydeniz, Mehmet | The University of Tennessee | 77,93 Bae, MinJung | Michigan State University | 51,121 Baek, Hamin | 80,170 Baek, John | George Mason University | 69,190 Baker, Dale | Arizona State University | 36,37,93,181,252,263 Baker, Perry | Midwestern University | 36,93 Baldwin, Brian | Kean University | 60,93 Balgopal, Meena | Minnesota State University Moorhead | 38,74,94,255 Balliet, Russell | Purdue University | 62,225 Balls, Daniel | Oregon State University | 50,167 Bamberger, Yael | Technology and Science | 78,94 Bannan-Ritland, Brenda | George Mason University | 69,190

Bantwini, Bongani | Human Sciences Research Council, South Africa | 61,94 Baptista, Mónica | Universidade de Lisboa Faculdade de Ciências | 42,95 Barak, Miri | Technion, Israel Institute of Technology | 52,95 Barbieri, Federica | Applied Linguistics, Northern Arizona University | 50,160 Barnes, Lehman | University of North Florida | 56,95 Barnes, Marianne | University of North Florida | 56,95 Barnett, Michael | Boston College | 40,65,71,73,88,96,140,155 Barrow, Lloyd | University of Missouri-Columbia | 53,70,178,256 Barta, James | Utah State University | 46,200 Barthel, Celeste | Oregon State University | 33,96 Bartley, Anthony | Lakehead University | 70,134 Bartosh, Oksana | University of British Columbia | 67,96 Barufaldi, James | The University of Texas at Austin | 38,137 Bar-Yossef, Nurit | Kibbutzim College of Education Ministry of Education | 34,175 Basis, Tamar | 32,96 Bausch, Andrew | Rutgers University | 76,144 Bautista, Nazan | Miami University | 44,97 Bayles, Taryn | University of Maryland Baltimore County | 48,214 Bayne, Gillian | Lehman College of the City University of New York | 32,39,50,58,97,103,219 Beatty, Ian | University of Massachusetts Amherst | 69,97 Beauchamp, Arthur | University of California, Davis | 60,215 Beccles, Christopher | Hiroshima University | 77,97 Becker, Kurt | Utah State University | 46,200 Becker, William | PSU - Center for Science Education | 48,71,170,235 Beer, David | University of Chicago | 39,228 Beeth, Michael | University of Wisconsin Oshkosh | 55,130 Beimers, Michelle | OISE, University of Toronto | Bell, Philip | University of Washington | 52,98 Bell, Randy | University of Virginia | 34,232 Bellomo, Katherine | OISE/UT | 52,98 Benaissa, Fatima | Purdue University | 80,103 Ben-Chaim, David | University of Haifa | 38,268 Benckert, Sylvia | Umeå University, Sweden | 68,153 Bencze, Larry | OISE/UT | 40,45,49,56,99,102,124 Ben-Hur, Yehuda | Weizmann Institute of Science | 34,175 Bennett, William | 50,149 Berg, Cheryl | Gateway Community College | 45,72,99 Bevins, Stuart | Sheffield Hallam University | 78,99 Bever, Carrie | University of Michigan | 35,51,58,100,132 Bhattacharya, Jasodhara | OISE, University of Toronto | Bianchini, Julie | University of California - Santa Barbara | 56,100 Binns, Ian | University of Virginia | 34,232 Black, Alice (Jill) | Missouri State University | 38,101 Blanchard, Margaret | North Carolina State University | 72,101 Blatt, Erica | University of New Hampshire | 61,85 Blockus, Linda | University of Missouri - Columbia | 55,227 Boakes, Norma | The Richard Stockton College | 39,178 Bodner, George | Purdue University | 34,74,80,158,244 Bogner, Franz | 35 Bolte, Claus | Free University, Germany | 59,145 Bonner, Janice | College of Notre Dame of Maryland | 59,101 Bottoms, SueAnn | Oregon State University | 33,65,224 BouJaoude, Saouma | American University of Beirut | 44,59,67,71,77,84,102,114,230 Bowen, G. Michael | Mount Saint Vincent University | 45,102 Bowen, Gervase | Mount Saint Vincent University Halifax | 40,99 Bowler, Celeste | West Warwick Public School | 81,104 Bowyer, Jane | Mills College School of Education | 34,141 Bozeman, Dane | Texas A&M University | 70,243 Bradbury, Leslie | Appalachian State University | 34,179 Bradley, Kelly | University of Kentucky | 66,195 Bratton III, Donald | Florida State University Tallahassee | 51,142

Bricker, Leah | University of Washington | 52,98 Brickhouse, Nancy | University of Delaware | 58,247 Britner, Shari | Bradley University | 54 Brodie, Eleanor | Sheffield Hallam University | 78,99 Brodie, Marilyn | Sheffield Hallam University | 78,99 Brown, Bryan | Stanford University | 32,70,76,103,106,200 Brown, Katherine NYC Center for Space Science Education 45,69,159,243 Brown, Patrick | University Missouri-Columbia | 73,103 Bryan, Lynn | Purdue University | 64,74,77,78,80,103,122,158,234,244 Buck, Gayle | Indiana University | 79,104 Buckingham, Brandy | 80,170 Bueno de Mesquita, Paul | University of Rhode Island | 80,81,104 Bueno Watts, Nievita | Arizona State University | 60,104 Bulte, Astrid | Utrecht University | 22,35 Burke, Barbara | California State Polytechnic University | 48,105 Busch, Allison | San Francisco State University | 51,69,105,170 Butler, Susan | Gulf Coast Community College | 44,107 Butler-Songer, Nancy | University of Michigan | 79,188 Buxner, Sanlyn | University of Arizona | 52,105 Buyukkasap, Erdogan | Erzincan University | 69,132,165 Buzzelli, Cary | Indiana University | 44,85 Bybee, Rodger | Biological Sciences Curriculum Study (BSCS) | 37,192 Cakiroglu, Jale | 53,245 Calabrese Barton, Angela | Michigan State University | 37,72,76,106,239,254 Cam, Aylin | Middle East Technical University | 50,90 Capobianco, Brenda | Purdue University | 79,106 Carassco, Alicia | The City College of New York | 73,204 Carlisle, Karen | Queens University Belfast | 56,203 Carlone, Heidi | University of North Carolina at Greensboro | 59,67,106,125,164 Carlsen Powell, Janet | BSCS | 73,142 Carlson, Stephan | U of MN Extension | 36,106 Carolan, James | 50,255 Carrier, Sarah | North Carolina State University | 38,107 Carter, Glenda | North Carolina State University | 42,43,44,107,119,120 Carter, Lyn | Australian Catholic University | 48,107 Cartier, Jennifer | University of Pittsburgh | 51,65,107,238 Carver, Jeffrey | Illinois Valley Community College | 67,108 Catalan, Rosa | Universidad de Concepcion | 58,208 Catley, Kefyn | Western Carolina University | 33,39,70,108,201,207 Catlin, Janell | Teachers College, Columbia University | 47,108 Cavagnetto, Andy | Binghamton University | 55,109 Ceglie, Robert | University of Connecticut | 69,109 Center, Laurie | Upper School Moses Brown Independent School Providence Rhode Island | 81,107 Century, Jeanne | University of Chicago | 39,56,109,228 Cha, Heeyoung | Korea National University of Education | 44,147 Chabalengula, Vivien | Southern Illinois University | 70,202 Chan, Jamie | San Francisco State University | 43,110 Chandrasegaran, A | Curtin University of Technology | 73,117 Chang, Chun-Yen | National Taiwan Normal University | 38,40,54,61,72,156,184,251,261 Chang, Huey-Por | National Changhua University of Education | 56,60,140 Chang, Hyunsook | Bangwon Middle School | 57,179 Chang, Jung-Chi | National Changhua University of Education | 33 Chang, Ricy | National Taiwan Normal University, Taiwan | 46,156 Chang, Wen-Hua | National Taiwan Normal University, Taiwan | 46,47,48,156 Chang, Wen-Yu | National Changhua University of Education | 56 Chapman, Seri | Dacula Middle School | 65,246 Charmatz, Kim | University of Maryland | 71,110 Charusombat, Umarporn | Purdue University | 49,116 Che-Di, Lee | National Taiwan Normal University | 38,47,112,251 Chen, Catherine | LessonLab Research Institute | 32,51,228

Chen, Hsiu-Ling | National Taiwan University of Science and Technology | 55,112 Chen, Jing | Michigan State University | 54,57,110,111 Chen, Jun-Yi | National Chiavi University | 56,111 Chen, Kathy | Cal Poly State | 59,128,259 Chen, Kuei-Hsiang | Ming-Jeng Junior High School | 33,111 Chen, Sufen | National Taiwan University of Science and Technology | 48,55,111,112,182 Chen, Wen-Ling | National Hualien University of Education | 48,111,182 Cheng, Meng-Tzu | North Carolina State University | 37,89 Cheng, Yeong-Jing | Department of Life Science, National Taiwan Normal University | 47,112 Chern, Jang-jeng | Kaohsiung Municipal Tsoying Senior High School | 44,112 Chiang, Shing-ho | National Kaohsiung Normal University | 44,112 Chidsey Pizzo, Jennifer | University of Pennsylvania | 66,113 Chin, Chi-Chin | National Taichung University | 43,44,113,250 Chin, Christine | Nanyang Technological University | 66,67,113,114,249 Chinn, Pauline | University of Hawaii | 53,61,76,85,106,114 Chiu, Mei-Hung | National Taiwan Normal University | 35,50,67,71,114,115,184 Cho, Moon-Heum | Indiana University | 45,115 Choi, Aeran | Science Education, University of Iowa | 38,50,116,149 Choi, Jinnie | 54,57,129 Choi, Sanghee | University of Houston | 32,81,103,116 Choi, Soyoung | Purdue University | 49,116 Choi, Sung-Youn | Ewha Womans University | 66,116 Chomchid, Panwilai | Kasetsart University, Thailand | 72,117 Chou, Chien | National Chiao-Tung University | 53,250 Chu, Hye-Eun | Curtin University of Technology | 73,117 Chuang, Hsueh-Hua | 48,185 Chun, Miran | Seoul National University, Korea | 48,161 Chun-Yen, Chang | National Taiwan Normal University | 38,40,54,61,75,156,251,261 Cigdemoglu, Ceyhan | Atýlým University | 50,90 Clapham, Andy | 45,206 Clark, Douglas | Arizona State University | 34,43,55,117,230,231 Clark, Julia | National Science Foundation | 53,118 Clarkson, Philip | Australian Catholic University | 48,107 Clary, Renee | Mississippi State University | 65,118,255 Clement, John | University of Massachusetts - Amherst | 50,51,118,242,260 Clevenstine, Richard | Ridley School District | 81,182 Clough, Michael | Iowa State University | 65,210 Cobern, William | Western Michigan University | 39,233 Coffey, Janet | University of Maryland, College Park | 32,228 Cohen, Ariel | Hebrew University of Jerusalem, Israel | 65,234 Cohen, Carmit | Weizmann Institute of science | 32,119,210 Colak, Huseyin | Indiana University | 49,59,77,119,209,220 Collins, Angelo | Knowles Science Teaching Foundation | 64,194 Conley, Mark | Michigan State University | 66,167,251 Constantinou, Constantinos | University of Cyprus | 33,74,186,212 Cook, Michelle | Clemson University | 42,43,119,120 Cooper, James | UNC Chapel Hill | 40,120 Cooper, James | University of North Carolina at Chapel Hill | 40,120 Copeland, Liesel | Kathleen Haynie Consulting | 50,120 Corbit, Margaret | Cornell University | 53,207 Corpuz, Edgar | University of Texas Pan American | 37,43,53,117,120,225 Coughlin, Linda | St Marys College of Maryland | 79,162 Covitt, Beth | Michigan State University | 51,54,57,58 Cowley, Jennifer | North Carolina State University | 67,259 Crawford, Barbara | Cornell University | 37,52,56,64,68,100,121,122,158,195,215 Cunningham, Deborah | University of Missouri-Columbia | 45,115 Cunningham, Jessica | University of Kentucky | 66,195 Cutshaw, Daniel | Old Dominion University | 49,126 Czerniak, Charlene | University of Toledo | 33,67,125 Dai, Amy | University of Maryland | 60,194 Daly, Shanna | Purdue University | 74,80,103,122,244

DAngelo, Cynthia | Arizona State University | 34,43,117,231 Danielowich, Robert | Northeastern Illinois University | 56,70,122 Dantley, Scott | Florida A&M University | 60,195 Darby, Linda | Deakin University, Australia | 59,123 Darrellee, Clem | Texas Tech University | 217 Davis, Betsty | University of Michigan | 56,100 Davis, Elizabeth | University of Michigan | 35,51,65,80,100,113,132,136,158,224 Davis, James | Temple University | 69,180 Davis, Julius | Morgan State University | 57,203 Davis, Kathleen | University of Massachusetts Amherst | 43,49,123,191 Dawson, Vaille | Edith Cowen University | 70,79,123,265 DeBoer, George | AAAS / Project 2061 | 34,47,73,124,129,153,180 DeCoito, Isha | Wayne State University | 56,124 Demetriou, Dorita | University of Cyprus | 47,125 Demir, Abdulkadir | University of Toledo | 33,46,125 den Brok, Perry | Eindhoven University of Technology | 68,125 Deneroff, Victoria | Agnes Scott College | 66,126 Dewitt, Jennifer | King's College London | 78,126 Dias, Michael | Kennesaw State University | 34,176 Dickerson, Daniel | Old Dominion University | 37,49,126,127 Diefendorf, Emily | The Pennsylvania State University | 45,127 Dierking, Lynn | Oregon State University | 38,59,127 DiGiuseppe, Maurice | OISE, University of Toronto | 40,49,56,99,124 Dillon, Justin | Kings College London, UK | 35,71,84,115 Dodick, Jeff | Hebrew University of Jerusalem | 73,127 Dolan, Erin | Virginia Tech | 59,163 Donham, Richard | University of Delaware | 36,136 Donna, Joel | University of Minnesota | 70,128 Donnelly, Lisa | Kent State University | 34,44,77,85,86,128 Dori, Judy | Technion, Israel Institute of Technology | 52,95 Dotger, Benjamin | Syracuse University | 40,128 Dotger, Sharon | Syracuse University | 40,77,128,143 Downing, Brigid | Manchester Metropolitan University | 44,238 Drame, Elizabeth | University of Wisconsin-Milwaukee | 45,189 Drane, Denise | Northwestern University | 59,71,128,213 Draney, Karen | University of California, Berkeley | 54,57,88,129 Driscoll, Mary | The City College of New York | 73,204 Dubois, Natalie | AAAS/Project 2061 | 34,47,124,129 Dudek, Rebecca | 54,58,121,146 Duffy, Andrew | Boston University | 46,260 Duit, Reinders | Institute for Science Education, Kiel, Germany | 50,55,60,71,84,130,169,197,211 Dunn, Glenna | Liberty University | 68,257 Duschl, Richard | Rutgers University | 52,54,57,88,98 Ebenezer, Jazlin | Wayne State Univesity | 61,130 Eberhardt, Jan | Michigan State University | 46,60,79,192,267 Edelson, Daniel Northwestern University 65,70,163,191 Eisenkraft, Arthur | University of Massachusetts at Boston | 46,260 Eklund, Jennifer | University of Michigan, School of Education | 81,131 Elfring, Lisa | University of Arizona | 69,209 Elmesky, Rowhea | Washington University in St Louis | 61,131 Elster, Doris | Leibniz Institute of Science Education University, Germany | 81,131 Emdin, Christopher | Teachers College, Columbia University | 34,43,61,131 Emig, Brandon | Penn State University | 55 Erdosne Toth, Eva | Duquesne University | 132 Erkol, Mehmet | Ataturk University | 53,132 Ertepinar, Hamide | 53,246 Esswein, Jennifer | Ohio State University | 78,216 Evagorou, Aristos | University of Cyprus | 43,186 Evans, Micahael | Virginia Tech | 49,143 Evans, Rosemary | Curtin University of Technology | 45,224 Everett, Susan | University of Michigan-Dearborn | 39,79,81,133,202,237

Everhart, Jerry | Eastern New Mexico University | 56,95 Ezrailson, Cathy | University of South Dakota | 45,133 Falconer, Kathleen | Buffalo State College | 39,133 Falk, Hedda | Weizmann Institute of Science | 60,64,218 Falk, John | Oregon State University | 38,60,133 Fargo, Jamison | Utah State University | 46,162 Farlland, Donna | The Ohio State University | 34,134 Faux, Russ | Davis Square Research Associates | 46,260 Fazio, Xavier | Brock University | 67,70,134,168 Fechner, Sabine | University of Duisburg-Essen, Germany | 54,134 Feldman, Allan | University of Massachusetts Amherst | 69,97 Feldman, Phillip | University of South Alabama | 45,154 Felix, Lisa | University of Arizona | 67,135 Fen, Yen | Providence University | 44,61,85,185 Feng, De-Wei | National Taiwan Normal University | 70,262 Fensham, Peter | Monash University (Australia) | 37,67,135,192 Ferrini-Mundy, Joan | 53 Fetters, Marcia | Western Michigan University | 46,135 Fifield, Steve | University of Delaware | 36,136 Firestone, Jonah | Arizona State University | 66,47,187 Fischer, Hans | University of Duisburg-Essen | 54,60,79,197,205,267 Fisher, Darrell | Curtin University of Technology | 68,125 Fisher, Kathleen | San Diego State University | 80,165 Fitzsimmons, Barbara | Educational Consultant, CRH Consulting, LLC | 81,264 Flash-Gvili, Inbal | Hebrew University of Jerusalem | 73,127 Fleischhauer, Jan | University of Giessen, Institute of Physics Education | 55,92 Ford, Danielle | University of Delaware | 36,64,136,218 Forrester, Jennifer | North Carolina State University | 69,136 Fortney, Brian | University of Texas at Austin | 38,40,137 Fortus, David | Weizmann Institute of Science | 35,39 Foster, Angie | Washington State University Vancouver | 60,205 Frazier, Wendy | George Mason University | 78,137 Freeman, Cassie | University of Chicago Center | 37,109,228 Freeman, Tonjua | The University of Georgia | 74,91 Freidenreich, Hava | Rutgers University | 76,144 Freire, Ana | Universidade de Lisboa Faculdade de Ciências | 42,95 Friden, Kelley | Brigham Young University | 72,138 Friedrichsen, Patricia | University Missouri-Columbia | 73,103 Fulmer, Gavin | University at Buffalo, SUNY | 56,186 Fulop, Rebecca | San Francisco State University (SFSU) | 43,138 Furtak, Erin | University of Colorado, Boulder | 68,77,138 Gable, Robert | Georgia State University | 45,190 Galganski, Martha | Washington University in St. Louis | 56,139 Gallagher, Jack | Northwestern University | 73,167 Gallard Martínez, Alejandro | Florida State University | 32,48,81,91,139,200 Gallo-Fox, Jennifer | Boston College | 56,203 Ganchorre, Athena | University of Arizona | 78,139 Garbayo, Luciana | Boston University | 46,260 Garcia, Paula | e-Learning Assessment, Northern Arizona University | 50,160 Gardner, April | BSCS | 73,142 Garik, Peter | Boston University | 44,46,206 Gatling, Anne | Boston College | 65,140 Gay, Andrea | Chicago State University | 65,140 Ge, Yun-Ping | National Changhua University of Education, Taiwan | 61,140 Geban, Omer | Middle East Technical University | 50,90 Gehrke, Coral | Oregon Institue Of Marine Biology | 33,141 Gelbart, Hadas | Weizmann Institute of Science | 76,141 Genel, Abdulkadir | Indiana University | 59,220 George, Magnia | Emory University | 70,200 Gerard, Libby | Mills College School of Education | 34,141 Gess-Newsome, Julie | Northern Arizona University | 73,142

Ghent, Cynthia | University Towson | 33,142 Gilbert, John | University of Reading, UK | Gili, Marbach-Ad | University of Maryland | 51,60,194,205 Gilmer, Penny | Florida State University Tallahassee | 42,51,68,142 Gingin, Francois | 35,266 Giordano, Nicholas | Purdue University | 74,80,244 Giscombe, Claudette | University of Massachusetts, Amherst | 48,143 Givvin, Karen | LessonLab Research Institute, Santa Monica, California | 32,228 Glasser, Howard | Michigan State University | 37,239 Glasson, George | Virginia Tech | 79,143 Glen, Nicole | Syracuse University | 77,143 Gnanakkan, Dionysius | Wayne State University | 61,130 Godoy, Juan | Universidad de Concepcion, Chile | 58,208 Golan Duncan, Ravit | Rutgers University | 76,114 Goldman, Daphne | Beit Berl Academic College | 39,216 Gomez-Zwiep, Susan | California State University, Long Beach | 39,144 Gomillion, Crystal | North Carolina State University | 32,103 Goodnough, Karen | Memorial University of Newfoundland | 52,144 Goubeaud, Karleen | Clemson University | 35,144 Grady, Julie | Arkansas State University | 40,137 Graeber, Wolfgang | IPN Leibniz-Institute for Science Education, Germany | 59,145 Graham, Karen | University of New Hampshire | 55,148 Granger, Ellen | Florida State University | 65,80 Gray, Kara | University of Colorado at Boulder | 43,211 Green, Andre | University of South Alabama | 45,145 Green, Wendy | University of Pennsylvania | 66,113 Greenbowe, Thomas | Chemistry, Iowa State University | 38,50,116,149 Grier, Jeanne | California State University Channel Islands | 78,164 Grooms, Jonathon | Florida State University | 43,230 Grotzer, Tina | Harvard Graduate School of Education | 47,152 Grube, Christiane | Justus-Liebig-University Giessen, Germany | 64,198 Grueber, David | Michigan State University | 72,145 Guarino, Anthony | Auburn University | 38,107 Guderian, Pascal | Ruhr-University Bochum, Germany | 36,146 Guglielmi, Kathleen | University of Rhode Island | 81,264 Gunay, Abdulkadir | Darica Ulkun Yalcin High School | 52,209 Gunckel, Kristin | Michigan State University | 51,54,57,58,80,121,146 Gunel, Murat | Ataturk University, Turkey | 69,132,165 Guo, Chorng-Jee | National Taitung University | 56,61,82,111 Gupta, Ayush | 32 Guskey, Selcen | University of Minnesota | 47,187 Guy, Mark | University of North Dakota | 43,58,147 Guzey, Selcen | University of Minnesota | 66,187 Gwekwerere, Yovita | University of Delaware | 36,136 Ha, Minsu | Korea National University of Education | 44,147 Hacieminoglu, Esme | Selcuk University | 3,838,211 Hackling, Mark | Edith Cowan University | 78,147 Hadjichambi, Demetra | University of Cyprus | 49,147 Hadjichambis, Andreas | Cyprus Centre for Environmental Research and Education | 49,147 Haefner, Leigh | Penn State Altoona | 46,148 Hagevik, Rita Anne | University Of Tennessee | 49,67 Hale, Stephen | University of New Hampshire | 55,148 Hall, Kendra | Brigham Young University | 68,239 Halverson, Kristy | University of Missouri-Columbia | 33,59,148 Hammer, David | University of Maryland, College Park | 32 Hamza, Karim | Stockholm Institute of Education | 50,54,149,219 Hand, Brian | University of Iowa | 38,50,53,55,69,109,116,132,149,165 Handa, Vicente | University of Georgia and West Visayas State University, Philippines | 33,149 Hanegan, Nikki | Brigham Young University | 56,71,72,138,150,217 Hans, Meytal | Technion - Israel institute of technology | 40,150 Hanuscin, Deborah | University of Missouri-Columbia | 59,150

Harlow, Danielle | University of California | 46,66,71,151,211 Harris, Christopher | University of Arizona | 46,52,105,249 Harris, Daniel | University Salisbury | 45,151 Harris, Diane | The University of Manchester | 151 Harris, Robby | University of Massachusetts | 69,97 Haslam, Maria | Deakin University | 42,157 Haugan, Mark | Purdue University | 78,234 Haugwitz, Marion | University of Duisburg-Essen, Germany | 54,134 Haun-Frank, Julie | The University of North Carolina | 59,152 Haury, David | The Ohio State University | Haynicz, Jacquelyn | Kansas State University | 37,223 Haynie, Kathleen | Kathleen Haynie Consulting | 50,120 Hazari, Zahra | Harvard Smithsonian Center for Astrophysics | 34,221 Hedges, Larry | Northwestern University | 55,254 Heffner-Wong, Amanda | Harvard Graduate School of Education | 47,152 Heimlich, Joe | OSU Extension | 36,106 Henderson, Cristen | University of Rhode Island | 81,104 Henriques, Laura | California State University | 40,137 Hermann, Ronald | Harford County Public Schools | 40,152 Hernandez, Cecilia | Kansas State University College of Education | 78,236 Herrmann Abell, Cari AAAS Project 2061 | 34,73,124,153 Herscovitz, Orit | Ort Braude College, Israel | 38,268 Hewson, Peter | University of Wisconsin-Madison | 35,38,132,153 Hick, Sarah | University of Minnesota | 47,187 Hickman, Paul | PhysTEC Consultant | 46,135 Hodges, Georgia | The University of Georgia | 74,91 Hodson, Derek | OISE/UT | 56,124 Hofstein, Avi | Weizmann Institute of Science, Israel | 34,59,67,79,145,180,189,249 Högström, Per | Umeå University, Sweden | 68,153 Holbrook, Jack | ICASE, Great Britain | 59,145 Holliday, Gary | Illinois Institute of Technology | 36,79,154,167 Holliday, William | University of Maryland | 33,37,44,45,51,59,101,121,142,151,160 Hollingsworth Koomen, Michele | Gustavus Adolphus College | 50,154 Holmes, Shawn | North Carolina State University | 32,37,39,89,103,144 Hom, Carole | University of California, Davis | 45,215 Honig, Sheryl | Valparaiso University | 77,154 Horvath, Larry | San Francisco State University | 81,154 Hößle, Corinna | Carl-von-Ossietzky-Universität Oldenburg, Germany | 66,198 Hotchkiss, Rose | 49 Houle, Meredith | Boston College | 71,73,96,155 Hovardas, Tasos | UNIVERSITY OF CYPRUS | 79,176 Howanski, Raymond | Ridley School District | 81,182 Howes, Elaine | University of South Florida | 79,155 Howitt, Christine | Curtin University of Technology | 73,155 Hsiung, Chao-Ti | National Taipei University of Education, Taiwan | 46,156 Hsiung, Tung-Hsing | National Taitung University | 46,48,156,182 Hsu, Pei-Ling | University of Victoria | 80,253 Hsu, Ying-Shao | National Taiwan Normal University | 35,47,53,64,112,156,184,250,262 Hua, Wang-Wei | National Hsinchu University of Education, Taiwan | 44,185 Huang, Chun-Chieh | National Taiwan Normal University, Taiwan | 61,156 Huang, Fu-Kwun | National Taiwan Normal University | 35,184 Huang, Hui-Ju | California State University Sacramento | 46,156 Huang, Mao-Tsai | National Academy of Educational Research | 48,182 Huang, Po-Hung | Ti-Bo Elementary School, Chiavi, Taiwan | 44,183 Huang, Shwu-yong | National Taiwan University | 77,157 Huang, Wanchu | Taipei Municipal University of Education | 66,157 Hubber, Peter | Deakin University | 42,50,157,221 Huffman, Douglas | University of Kansas | 39,47,82 Hug, Barbara | University of Illinois | 58,80,100,158,170 Hung, Jeng-fung | National Kaohsiung Normal University, Taiwan | 46,183 Hunter, William | Illinois State University | 67,70,108,202

Husic, Freda | University of California, Berkeley | 51,254 Hutchinson, Kelly | Purdue University | 80,103,158 Hvidsten, Connie | University of California, Davis | 60,215 Ibrahim, Sheliza | York University, Canada | 52,259 Ibtisam, Azaiza | University of Haifa, Israel | 38,268 Ilieva, Vessela | Utah State University | 46,200 Ingber, Jenny | NYC Center for Space Science Education | 45,61,69,159,227,243 Irving, Karen | Ohio State University | 37,53,67,85,159,172 Isaacs, Andy | University of Chicago | 39,109 Ivey, Toni | Texas A&M University | 70,243 Jackson, David | University of Georgia | 65,246 Jadallah, May Jadallah | University of Illinois at Urbana-Champaign | 69,159 James, Mark | Northern Arizona University | 50,71,160 Janney, Dorian | Montgomery County Public Schools Maryland | 44,160 Jayme, Bruno | University of Victoria | 71,77,160 Jen, Tsung-Hau | National Taiwan Normal University | 38,47,112,251 Jho, Hunkoog | Seoul National University, Korea | 48,161 Ji, Youngrae | Seoul National University | 66,173 Jiménez Aleixandre, Maria Pilar | Universidade de Santiago de Compostela, Spain | 58,64,71,84,201,218 Jin, Hui | Michigan State University | 54,57,60,61 Johnson, Angela | St Marys College of Maryland | 37,48,79,162,164 Johnson, Bruce | University of Arizona | 49,52,67,105,135,162 Johnson, Carla | University of Toledo | 46,73,162,163 Johnson, Deborah | Virginia Tech | 59,163 Johnson, Heather | Northwestern University | 70,163 Johnson, Keith | Shahala Middle School | 42,204 Johnson, Lisa | Winthrop University | 40,128 Johnson, Philip | Durham University | 52,164 Johnston, Adam | Weber State University | 67,71,164 Johnston, Carol | Mount St. Marys College | 78,164 Jones, Gail | North Carolina State University | 53,59,67,69,77,136,165,245,250,259 Jong, Cindy | Boston College | 40, 88 Juan, Tang | National Changhua University of Education, Taiwan | 44, 185 Jung, Joo Hye | Seoul National University | 45 Jurdak, Murad | American University of Beirut | 67, 102 Kabatas, Esra | Ataturk University, Turkey | 69,165 Kaftan, Julianne | University of Nebraska-Lincoln | 79,104 Kahle, Jane | Miami University | 46,162 Kahveci, Ajda | Marmara University | 61 Kahveci, Murat | University Of Chicago | 39,109,228 Kali, Yael | Technion - Israel institute of technology | 40,150 Kalita, Spartak | Kansas State University | 80,166 Kamon, Teruki | Texas A&M University | 45,133 Kang, Hosun | Michigan State University | 66,167,251 Kang, Nam-Hwa | Oregon State University | 47,50,166,167 Kanisek, Marijana | OISE, University of Toronto | 40,99 Kanna, Priya | 51 Kanter, David | Northwestern University | 52,73,167 Kara, Yilmaz | ATATURK UNIVERSITY | 61,67,168 Karen, Irving | The Ohio State University | 37,172 Karrow, Douglas | Brock University | 67,168 Kasper, Lutz | University of Potsdam | 37,43,168,196 Kastens, Claudia | Leibniz Institute for Science Education | 60,169 Kauertz, Alexander | University of Duisburg-Essen, Germany | 79,267 Kavanagh, Claudine | Tufts University | 43,58 KAYA, Ebru | Middle East Technical University, TURKEY | 32,169 Kaya, Osman | Wayne State University | 61,130 Kaya, Sibel | Florida State University | 58,77,187,225 Kelley, Loretta | Kelley, Petterson, and Associates | 51,170 Kelley, Sybil | PSU - Center for Science Education | 48,71,170,235

Kelly, Angela | Lehman College, City University of New York | 34,72,170 Kelly, Gregory | The Pennsylvania State University | 45,72,127,171 Kennedy, Anne | Washington State University Vancouver | 60,205 Kenyon, Lisa | Wright State University | 58,80,100,158,170 Keogh, Brenda | Manchester Metropolitan University | 44,238 Kerlin, Steven | The Pennsylvania State University | 72,171 Ketelhut, Diane Jass | Temple University | 52,171 Khalid, Tahsin | Southeast Missouri State University | 36,171 Khishfe, Rola | Loyola university chicago | 71,172 Khnelt, Helmut | 55 Kijne, Jan | Leiden University | 69,253 Kim, Beaumie | Nanyang Technological University, Singapore | 56,186 Kim, Byoung-Sug | Roosevelt University | 43,71,173,175 Kim, Hanna | DePaul University | 52,172 Kim, Mijung | Seoul National University | 66,173 Kim, Sun Young | The Ohio State University | 37,172 Kim, Sung-Won | Ewha Womans University | 66,116 Kimmel, Sue | The University of North Carolina | 59,152 Kinghorn, Brian | Michigan State University | 44,173 Kirch, Susan | New York University | 43,68,174 Kirchhoff, Allison | University of Minnesota | 66,187 Kisiel, James | California State University | 33,59,174 Kisoglu, Mustafa | Ataturk University | 132 Kitsantas, Anastasia | George Mason University | 69,190 Kittleson, Julie | University of Georgia | 34,176 Kleickmann, Thilo | University Of Muenster, Germany | 60 Klentschy, Michael | San Diego State University | 55,254 Klieger, Aviva | Weizmann Institute of Science Beit Berl College | 34,175 Ko, Eunkyung | Illinois Institute of Technology | 43,175,64 Koballa, Thomas | University of Georgia | 34,55,130,176 Kobarg, Mareike | IPN - Leibniz-Institute for Science Education | 65,87 Kochhar, Jeanetta | University of Pittsburgh | 51,107 Koehler, Catherine | University of Cincinnati | 74,193 Koehler, Matthew | Michigan State University | 46,60,267 Konstantopolous, Spyros | 73,167 Korfiatis, Konstantinos | University of Cyprus | 47,49,79,125,147,176 Korpan, Connie | University of Alberta | 65,176 Kowalski, Susan | Biological Sciences Curriculum Study (BSCS) | 34,176 Krainer, Konrad | 55 Krajcik, Joseph | University of Michigan | 35,39,50,54,57,80,88,92,106,220,224,234,237,258 Krebs, Denise | North Carolina State University | 67,259 Kremer, Kerstin | University Giessen Institut of Biological Education, Germany | 43,177 Krockover, Gerald | Purdue University | 51,214 Kuhn, Leema | Northwestern University | 58,100 Kumar, Rashmi | University of Pennsylvania | 66,113 Kwon, Melissa | School of Education University of California | 57,181 Labudde, Peter | Paedagogische Hochschule | 35,266 Ladewski, Barbara | University of Michigan | 80,234 Laius, Anne | University of Tartu | 43,177 Lambert, Julie | Florida Atlantic University | 49,54,57,71,74,126 Lamp, David | Texas Tech University | 72,217 Lang, Michael | Maricopa Community College District | 36,37,93,181,252,263 Lang, Sarah | University of Texas at Austin | 47,177 Lankford, Deanna | University of Missouri-Columbia | 45,70,115,178 Lardy, Corinne | San Diego State University | 55,244 Lasane, Terrell | St Marys College of Maryland | 79,162 Lau, Anna | University of Duisburg-Essen | 54,205 Laurence, Wendi | Washington State University Vancouver | 60,205 Laurie, Robert | University of New Brunswick | 37,192 Lawrenz, Frances | University of Minnesota, Twin Cities | 33,125 Lebak, Kimberly | The Richard Stockton College | 39,178

Lebard, Linda | Heritage High School | 42,204 Lederman, Judith | Illinois Institute of Technology | 35,36,57,72,79,154,178,179,233,267 Lederman, Norman | Illinois Institute of Technology | 35,36,43,57,71,79,154,173,175,178,17 9,233,267 Lee, Eun Ah | Seoul National University, Korea | 43,180 Lee, Gyoungho | Seoul National University | 34,214 Lee, Huei | National Hualien University of Education, Taiwan | 61,85 Lee, Hyunju | University of Massachusetts Amherst | 44,57,69,97,179 Lee, Michele | University of Missouri-Columbia | 59,150 Lee, Myon U | Chuncheon National University of Education, Korea | 73,213 Lee, Sharon | Rhode Island Department of Education | 81,264 Lee, Yeng-Sang | 54,57,129 Lehrke, Manfred | 60,169 Lemmens, Meike | LessonLab Research Institute | 51,259 Lennon, Kristen | AAAS / Project 2061 | 34,47,124,180 Leonard, Jacqueline | Temple University | 69,180 Leonie, Rennie | Curtin University of Technology | 45,78,224 Leslie, Debbie | University of Chicago | 39,109,228 Levin, Daniel 32 Levy Nahum, Tami | The Weizmann Institute of Science | 79,180 Lewis, Anna | University of South Florida | 66,181 Lewis, Elizabeth | Arizona State University | 36,37,93,181,252,263 Li, Min | University of Washington, Seattle | 57,181 LI, Tsai-Yen | National Chengchi University, Taiwan | 61,156 Li, Weiling | The University of Georgia | 74,91 Liang, Jhy-Chong | Chin Min Institute of Technology | 40,182 Liang, Ling | La Salle University | 56,81,182,186 Lieder, Christopher | San Diego State University Geosyntec Consultants | 65,225 Lieu, Sang-Chong | National Hualien University of Education | 48,111,182 Light, Greg | Northwestern University | 71,213 Lim, Gilsun | University of Iowa | 77,182 Lima-Tavares, Marina | Universidade Federal de Minas Gerais | 58,201 Lin, Chuan-Shun | National Kaohsiung Normal University, Taiwan | 53,184 Lin, Huei-Huei | Guangren Elementary School | 66,157 Lin, Jing-Wen | National Institute for Compilation and Translation | 50,32,184 Lin, Li-Fen | National Taiwan Normal University | 35,184 LIN, MingChao | National Taiwan Normal University | 40,184 Lin, Ming-liang | National Kaohsiung Normal University, Taiwan | 44,46,112,183 Lin, Shu-Fen | National Taiwan Normal University | 47,48,111,182 Lin, Shu-Sheng | National Chiayi University, Taiwan | 44,183 Lindner, Martin | IPN Leibniz-Institute for Science Education, Germany | 59,145 Ling, Chao | National Changhua University of Education, Taiwan | 44,185 Linn, Marcia | University of California | 42,51,185,254 Liu, Christine | University of Virginia | 51,262 Liu, Han-Chin | National Chiayi University | 48,185 Liu, Shiang-Yao | National Kaohsiung Normal University, Taiwan | 53,184 Liu, Xiufeng | University at Buffalo, SUNY | 47,56,186,229,81 Locke, Sharon | National Science Foundation | 53 Logerwell, Mollianne | George Mason University | 78,137 Losser, Janet | Brigham Young University | 239,68 Louca, Loucas | Cyprus College | 33,43,186 Loving, Cathleen | Texas A&M University | 45,133 Luehmann, April | University of Rochester | 36,208 Luera, Gail | University of Michigan-Dearborn | 39,133 Luft, Julie | Arizona State University | 37,47,56,187,197,66,100,121 Luna, Melissa | 44 Lundeberg, Mary | Michigan State University | 46,60,192,267,79 Lundeen, Cynthia | Florida State University | 58,77,187,225 Lunetta, Vincent | Penn State University | 32,238 Lung, Wang | National Changhua University of Education, Taiwan | 44,185 Lynch, Sharon | George Washington University | 39,51,56,79,188,208,257,259

Ma, Jimmy | University Neighborhood High School | 71,197 Mackensen-Friedrichs, Iris | Leibniz-Institute for Science Education, Germany | 76,188 Macklin, Monica | Northeastern State University | 39,188 Magner, Jacque | Columbus Middle School | 65,246 Majerich, David | Queens College-CUNY | 81,182 Malone, Kathy | Shadyside Academy | 68,188,232 Maloney, Jane | Institute of Education, London | 44,238 Mamlok-Naaman, Rachel | The Weizmann Institute of Science | 59,189,249,79,180 Mamolo, Charles | Kansas State University | 36,189 Manoli, Constantinos | University of Arizona | 49,162,189 Marbach-Ad, Gili | University of Maryland | 51,60,194,205 Marquis, Mya | Hunter College of the City University of New York | 50,218 Martell, Sandra | University of Wisconsin-Milwaukee | 45,189 Martin, Dean | Gardner Elementary | 65,140 Martin, Sonya | CNNY- Queens College | 56 Martinez, Patricia | George Mason University | 69,190 Martin-Hansen, Lisa | Georgia State University | 45,190 Marx, Ronald | University of Arizona College of Education | 34,141 Marx, Sherry | Utah State University | 73,163 Mason, Cheryl | San Diego State University | 55,244 Mason, Thomas | Northwestern University | 59,128 Matkins, Juanita Jo | College of William and Mary | 69,194 Matthews, Michael | University of New South Wales | 37,190 Mawn, Mary | University of Massachusetts Amherst | 43,49,123,191 Mawyer, Kirsten | Northwestern University | 65,70,163,191 Mayer, Juergen | Justus-Liebig-University Giessen, Germany | 43,177,198,64 Mayer-Smigh, Jolie | University of British Columbia | 67,96 Mayne, Fiona | Curtin University of Technology | 45,224 McBride, Dyan | Kansas State University | 37,42,191,223 McCollough, Cherie | Texas A&M University | 33,191 McCollum, Terry | Miami University, Discovery Centre | 55,130 McComas, William | The University of Arkansas College of Education and Health Professions | 34,134 McCombs, Michelle | UC Davis | 47,192 McConnell, Tom | Michigan State University | 46,60,79,192,267 McCrae, Barry | Australian Council for Educational Research (ACER) | 37,192 McCreedy, Dale | Franklin Institute Science Museum | 38,127 McDonald, Christine | Griffith University | 57,193 McDonald, James | Central Michigan University | 74,193,194 McDonald, Scott | The Pennsylvania State University | 72,122,129,171,193 McDonnough, Jacqueline | Virginia Commonwealth University | 69,194 McGinnis, J. Randy | University of Maryland | 60,194,232,64,68 McIntyre, Peter | Texas A&M University | 45,133 McNall Krall, Rebecca | University of Kentucky | 66,195 McNeill, Katherine | Boston College | 58,63,64,100,140 Medintz, Todd | 71,172 Melville, Wayne | Lakehead University, Canada | 70,134 Menekse, Muhsin | Arizona State University | 45,99 Merrill, John | Michigan State University | 35,36,201,225,260 Merritt, Brett | Michigan State University | 35,51,195,225,260 Merritt, Joi | University of Michigan | 80,137 Merritt, Kelly | Michigan State University | 66,167,251 Metty, Jane | Texas A&M University | 243 Michelsen, Claus | University of Southern Denmark, Denmark | 145 Miedijensky, Shirley | Technion, Israel Institute of Technology | 196 Mikelskis, Helmut | University of Potsdam, Physics Education Research | 37,43,168,196 Mikelskis-Seifert, Silke | IPN - Leibniz Institute for Science Education | 60,197 Mikeska, Jamie | Michigan State University | 51,121 Miles, Rhea | East Carolina University | 77,214 Miller, Brian | University of Illinois at Urbana-Champaign | 69,159 Miller, Chris | University of Illinois at Chicago | 52,197

Miller, Kornelia | 60,174 Miller-Jones, Dalton | Portland State University | 48,170 Milne, Catherine | NYU | 53,197,64,71 Milner, Andrea | University of Toledo | 53,240 Minogue, James | North Carolina State University | 37,259,67,89 Mintzes, Joel | UNIV OF N CAROLINA - WILMINGTON | 61 Miranda, Rommel | Towson University Department of Physics | 47,198 Mittelsten Scheid, Nicola | Carl-von-Ossietzky-Universität Oldenburg, Germany | 66,198 Moeller, Andrea | Institute of Biological Education, Justus-Liebig-University, Germany | 64,198 Mogge, Sabine | University of Kassel, Germany | 81,199 Mohan, Lindsey | Michigan State University | 54,57,58,199,110,111 Moin, Laura | University of Colorado at Boulder | 33,125 Molinaro, Marco | UC Davis | 47,192 Moll, Rachel | University of British Columbia | 54,199,219 Monhardt, Rebecca | Utah State University | 47,192 Moore, Felicia | Teachers College, Columbia University | 32,48,51,70,200,201 Morabito, Nancy | Vanderbilt University | 33,201 Morales, Amanda | Kansas State University College of Education | 78,236 Morey, Marilyn | Illinois State University | 73,213 Morris, Lucy | Burlington Public Schools | 47,152 Morrison, Sara | Brigham Young University | 72,138 Morrow, Cherilynn | Georgia State University | 77,239 Morse, Mo | Kansas State University | 65,248 Mortimer, Eduardo | Universidade Federal de Minas Gerais | 58,80,201 Moscarella, Rosa | Michigan State University | 36,201 Moscovici, Hedy | California State University | 46,202 Moss, David | University of Connecticut | 67,164 Moyer, Richard | University of Michigan-Dearborn | 81,202 Mumba, Frackson | Southern Illinois University | 70,202 Murdock, John | University Of Maryland, Baltimore County | 56,203 Murphy, Colette | Queens University Belfast | 56,203 Mutegi, Jomo | Sankore Institute | 57,70,76,106,200,203 Narayan, Ratna | Texas Tech University | 69,72,217,246 Nashon, Samson | University of British Columbia | 55,204 Naylor, Stuart | Manchester Metropolitan University | 44,238 Nazir, J | OISE/ University of Toronto | 49,99 Neakrase, Jennifer | Arizona State University | 66,187 neé Pennachetti, Catherine | SeaLab Supplies | 33,224 Nehm, Ross | The Ohio State University | 73,204 Nelson, C | Brigham Young University | 56,150 Nelson, Jennifer | University of Nebraska-Lincoln | 79,104 Nelson, Karen | University of Maryland | 51,205 Nelson, Michela | University Of Michigan | 35,80,132,158 Nelson, Tamara | Washington State University Vancouver | 42,73,79,60,204,205 Neumann, Knut | University of Duisburg-Essen | 54,205 Newton, Len | School of Educaion University of Nottingham, UK | 45,206 Nguyen-Jahiel, Kim | University of Illinois at Urbana-Champaign | 69,159 Niaz, Mansoor | Universidad de Oriente, Venezuela | 57,206 Nielsen, Jan Alexis | University of Southern Denmark | 59 Nieswandt, Martina | University of Toronto (OISE/UT) | 70,78,206,265 Nilsson, Pernilla | Halmstad University, Sweden | 77,206 Niyogi, Dev | Purdue University | 49,116 Norlock, Katherine | St Marys College of Maryland | 79,162 Norman, Obed | University of Southern Denmark | 58 Norris, Stephen | University of Alberta | 64,149,218,221,255 Norton, Catherine | Cornell University | 53,207 Norton-Meier, Lori | Iowa State University | 55,109 Novick, Laura | Vanderbilt University | 33,70,108,201,207 Novodvorsky, Ingrid | Univ. of Arizona | 46,207 Nowicki, Barbara | University of Rhode Island | 44,81,264 Noyes, Andy | 45,206

Nunez-Oviedo, Maria | Universidad de Concepcion, Chile | 58,208 Occhino, Michael | University of Rochester | 36,208 Ochsendorf, Robert | The George Washington University | 56,79,257 ODell, Sam | University of Georgia | 65,246 ODonnell, Carol | George Washington University | 39,79,208 Offerdahl, Erika | University of Arizona | 69,209 Ogan-Bekiroglu, Feral | Marmara University | 52,209 Ogletree, Glenda | University of Alabama | 48,105 Oliveira, Alan | Indiana University | 49,59,35,209,220 Oliver, J. Steve | university of Georgia | 65,213 Olson, Joanne | Iowa State University | 65,210 Olson, Mark | University of Connecticut | 44,56,100,210 Oppewal, Tom | NC State University | 59,165 Orion, Nir | Weizmann Institute of Science | 32,43,96,98,119,210,258 Ormaechea, Luis | Spencer High School, NY | 53,207 Osborn, Jeffrey | University of Kentucky | 66,195 Osisioma, Irene | California State University | 46,202 Ostermeier, Christian | Leibniz-Institute for Science Education (IPN) | 55 Otero, Valerie | University of Colorado at Boulder | 33,43,46,71,125,151,211 Ottander, Christina | Umeå University, Sweden | 68,153 Otto, Charlotte | University of Michigan-Dearborn | 39,133 Oxford, Raquel | University of Wisconsin-Milwaukee | 45,189 Ozdemir, Gokhan | Nigde University | 43,117 Ozgelen, Sinan | Middle East Technical University | 38,211 Palouci, Shannon 71,172 Paolucci, Judy | Narragansett School District | 81,264 Papaevripidou, Marios | University of Cyprus | 74,212 Pappas, Christine | University of Illinois at Chicago | 72,89,166,251,254 Pareja, Enrique | University of Missouri - Columbia | 69,212 Park, Byeong-Geon | Joongdong High School, Korea | 43,180 Park, Do-Yong | Illinois State University | 73,213 Park, Eun Jung | Northwestern University | 59,71,128,212,213 Park, John | North Carolina State University | 44,107 Park, Miwha | Seoul National University | 34,214 Park, Soonhye | University of Iowa | 65,213 Park, Young-Shin | Seoul National University | 34,214 Park Rogers, Meredith | Indiana University | 46,227 Parker, Carolyn | The George Washington University | 37,48,214 Parker, Joyce | Michigan State University | 35,36,201,225,260 Parker, Loran | Purdue University | 81,214 Parson, Eileen | University of North Carolina | 38,70,77,214,238 Passmore, Cynthia | University of California | 45,51,60,81,107,154,215 Patterson, Ronald | Michigan State University | 35,36,201,225 Patton, Bruce | The Ohio State University | 55,78,85,216 Pease, Rebecca | University of Maryland | 60,194 Peck, Debby | University of New Brunswick | 45,216 Pedretti, Erminia | OISE/UT | 56,124 Peer, Sara | Oranim Academic College of Education | 39,216 Peers, Shelley | Australian Academy of Science | 78,147 Pegg, Jerine | Oregon State University | 56,70 Peker, Deniz | Middle East Technical University | 70,217 Penick, John | North Carolina State University | 32,238 Peterat, Linda | University of British Columbia | 67,96 Petersen, Spike | University of North Carolina | 77,214 Peterson, Jeremy | Brigham Young University | 71,217 Peterson, Jodi | 64 Peterson, Ken | 47,192 Petty, Lori | Texas Tech University | 72,217 Petzoldt, Mary | Teachers College Columbia University | 61,227 Phillips, Karen | Hunter College of the City University of New York | 39,50,218,219 Phillips, Linda | University of Alberta Edmonton | 64,218

Phillipson-Mower, Teddie | University of Louisville | 74,218 Phipps, Molly | Oregon State University | 33,219 Piazza, Peter | Urban Ecology Institute | 73,155 Pike, Curtis | George Washington University | 56,72,79,188 Pilot, Albert | Utrecht University | 35,222 Pineda, Monica | Arizona State University | 60,104 Piqueras, Jesús | Stockholm Institute of Education | 50,219 Pires, J | University of Missouri-Columbia | 33,148 Pitts, Wesley | Lehman College, CUNY | 39,61,71,77,131,219 Placanica, Joseph | Georgia State University | 45,190 Plummer, Julia | Arcadia University | 44,50 Pockalny, Robert | University of Rhode Island | 44,50,220 Pongsanon, Khemmawadee | Indiana University | 49,77,119,220 Ponzio, Richard | UC Davis | 47,192 Popejoy, Katerina | University of North Carolina at Charlotte | 34,60,65 Potter, Wendell | University of California | 60,215 Potvin, Geoff | University of Virginia | 34,73,221,244 Prain, Vaughan | La Trobe University | 50,78,147,221,255 Prenzel, Manfred | University of Kiel (Germany) | 37,55,192,211 Preusch, Peggy | University of Maryland | 67,221 Price, Laura | Brigham Young University | 71,217 Priemer, Burkhard | Ruhr-University Bochum, Germany | 36,146 Prins, Gjalt | Utrecht University | 35,222 Pyke, Curtis | The George Washington University | 257 Qian, Xiaoyu | University of Delaware | 36,136 Quistgaard, Nana | University of Copenhagen | 78,222 Rackley, Rhonda | The University of Georgia | 74,91 Rahm, Jrene | Universite de Montreal | 48,222 Ramsey, John | University of Houston | 81,116 Rannikmäe, Miia | University of Tartu | 43,177 Rea-Ramirez, Mary Anne | Western Governor University | 50 Rebar, Bryan | Oregon State University | 59,223 Rebello, N. Sanjay | Kansas State University | 36,37,53,120,189,223 Redish, Edward | University of Maryland College Park | 37,223 Reeve, Suzanne | University of Washington | 52,98 Reid-Griffin, Angelia | University of North Carolina-Wilmington | 44,51,107 Reis, Giuliano | University of Ottawa | 33,77,160,224 Reiser, Brian | Northwestern university | 39,61,80,224,237 Reiss, Michael | University of London | 76,261 Riccio, Jessica | Teachers College Columbia University | 61,227 Rice, Bronwen | Oregon State/Sea Girant | 33,224 Rice, Diana | Florida State University | 58,77,187,225 Rice, Rebecca | Arcadia University | 44,220 Rich, Hedman | California State University | 60,215 Richardson, Rasheedah | Texas A&M University | 70,243 Richmond, Gail | Michigan State University | 35,36,38,60,161,201,225 Rick, Grosberg | University of California | 45,215 Riemeier, Tanja | University of Hannover | 55,92 Rigano, Donna | James Cook University | 54,226 Riggs, Eric | Purdue University | 65,225 Rinke, Carol | Gettysburg College | 78,226 Ritchie, Stephen | Queensland University of Technology | 54,64,226 River, Ann | 50 Rivera Maulucci, Mraia | Barnard College, Columbia University | 37,226,32 Rivet, Ann | Teachers College Columbia University | 61,50,227 Roberts, Megan | NYC Center for Space Science Education | 45,69,159,243 Roberts, Shaun | Durham University | 52,164 Roberts, Tina | University of Missouri | 55,227 Robinson, Maureen | Cape Peninsula University of Technology | 38,153 Rock, Barrett | University of New Hampshire | 55,148 Rodari, Paola | International School for Advanced Studies, Italy | 248

Rodriguez, Alberto | San Diego State University | 32,58,79,106,247 Roehrig, Gillian | University of Minnesota | 47,66,70,187 Rogers, Amy | College of Charleston | 45 Rogge, Christian | University of Giessen, Institute of Physics Education | 55,92 Rojas, Sergio | Universidad de Concepcion, Chile | 58,208 Rommel, Bunuan | Texas Tech University | 217 Rop, Charles | University of Toledo | 53,240 Roseman, Jo Ellen | American Association for the Advancement of Science | 234,80 Ross, Julia | University of Maryland Baltimore County | 48,214 Ross, Shelley | University of Victoria | 33,224 Roth, Kathleen | LessonLab Research Institute | 32,51,56,228,259 Roth, Wolff-Michael | University of Victoria | 33,49,58,80,160,224,247,253 Rowe, Shawn | Oregon State University | 33,38,42,45,224,232,141 Roychoudhury, Anita | Purdue University | 73,78,85,228 Rudnick, Mollie | University of Chicago | 39,52,109,228 Ruppert, John | Rutgers University | 76,144 Rybczynski, Stephen | Miami University | 42,228 Ryoo, Kihyun | Stanford University | 58,229 Sabah, Saed | University at Buffalo, SUNY | 47,229 Saderholm, Jon | Berea College | 57,59,229 Sadler, Kim | Middle Tennessee State University | 80,165 Sadler, Philip | Harvard Smithsonian Center for Astrophysics | 34,221 Sadler, Troy | University of Florida | 70,265 Saka, Yavuz | Florida State University | 78,265 Salloum, Sara | Long Island University- Brooklyn Campus | 77,230 Sampson, Elizabeth | Mount Saint Vincent University | 45,102 Sampson, Victor | Florida State University | 43,55,230 Sanalan, Vehbi | Ohio State University | 67,159 Sandi, Cooper | Texas Tech University | 72,217 Sandmann, Angela | University of Duisburg-Essen, Germany | 54,137 Scantlebury, Kathryn | University of Delaware | 56,203 Scharmann, Larry | Kansas State University | 34 Schen, Melissa | Wright State University | 38,231 Schleigh, Sharon | Arizona State University | 34,43,117,231 Schmoock, Heidi | Oregon State University | 38,232 Schneider, Cary | Boston Museum of Science | 268 Schnittka, Christine | University of Virginia | 34,48,232 Schroeder, Jacob | 50,149 Schunn, Christian | University of Pittsburgh | 64,237 Schussler, Elisabeth | Miami University | 42,47,228,233 Schuster, David | Western Michigan University | 39,233 Schwartz, Renee | Western Michigan University | 35,37,39,233 Schwarz, Christina | Michigan State University | 51,80,121,137,170,224,234 Schwille, Kathleen | LessonLab Research Institute | 32,51,229,259 Sederberg, David | Purdue University | 80,103 Segal, Lea | Hebrew University of Jerusalem, Israel | 65,234 Seidel, Tina | University of Kiel, Germany | 65,77,87,138 Seiler, Gale | McGill University | 61,131 Seker, Hayati | Marmara University | 38,234 Semken, Steven | Arizona State University | 60,104 Seneby, Nadia Albanova University Centre 50,219 Serebrin, Lisa | Peel District School Board | 56,124 Settlage, John | University of Connecticut | 67,69,109,164 Seung, Eulsun | Indiana State University | 78,234 Shady, Ashraf | CUNY Graduate Center | 35,39,219,235 Shafer, Sally | University of Kentucky | 66,195 Sharkawy, Azza | Queen's University | 42,235 Shavelson, Richard | Stanford University | 58,263 Shelton, Rachel | Portland State University | 71,235 Shepardson, Daniel | Purdue University | 49,116,235 Sheppard, Keith | Stony Brook University | 34,170

Sherwood, Robert | Indiana University | 60,236 Shieh, Ruey | Tatung Institute Of Commerce and Technology | 61,236 Shields, Patricia | 51,205 Shirley, Melissa | Ohio State University | 159 Shroyer, M. Gail | Kansas State University College of Education | 78,236 Shwartz, Yael | University of Michigan | 35,39,80,137,237,258 Shymansky, James | University of Missouri St. Louis | 79,237 Siegel, Marcelle | University of Missouri - Columbia | 55,227 Silk, Eli | University of Pittsburgh | 64,237 Simmons, Patricia | University of Missouri-St. Louis | 32,238 Simon, Shirley | Institute of Education, London | 44,238 Simpson, Jamila | North Carolina State University | 38,238 Singletary, Lisa | Baltimore County Public Schools, Maryland | 61,131 Sink, Wendy | University of Pittsburgh | 51,65,107,238 Siry, Christina | University of New York and Manhattanville College | 43,174,203 Skidmore, Susan | Texas A&M University | 243 Slater, Stephanie | University of Arizona | 77,239 Slater, Timothy | University of Arizona | 77,239 Slaton, Adriane | Tatung Institute Of Commerce and Technology | 37,239 Slavit, David | Washington State University Vancouver | 60,205 Slekar, Timothy | Penn State Altoona | 46,148 Smith, Kathryn | Virginia Tech | 59,163 Smith, Leigh | Brigham Young University | 69,239 Smith, Michelle | Boston College | 71,96 Smith, Mike | Mercer University School Of Medicine | 57 Sneider, Cary | Boston Museum of Science | 43,58,169 Socha, Katherine | St Marys College of Maryland | 79,162 Solano-Flores, Guillermo | University of Colorado, Boulder | 57,181 Solberg, Jan | University of Aarhus, Denmark | 34,35,240 Sondergeld, Toni | University of Toledo | 53,240 Song, Jinwoong | Seoul National University | 34,48,66,161,173,214 Southerland, Sherry | Florida State University | 48,72,78,101,139,230 Spencer, Benson | University of Maryland | 60,194 Sperling, E | 49,99 Spikes, Sara | Texas A & M University | 70 St. Cyr, Karen | University of Massachusetts Amherst | 69,97 Stadler, Helga | University of Vienna, Austria | 38,55,241 Stains, Marilyne | University of Arizona | 59,241 Staples, Kimberly | Kansas State University College of Education | 38,39,236,242,78 Steele, Erika | University of Alabama | 55,244 Stephens, A Lynn | University of Massachusetts | 51,242 Sterling, Donna | George Mason University | 78,137 Stewart, Craig | Old Dominion University | 49,126 Stoddart, Trish | The University of California | 56,242 Storksdieck, Martin | Institute for Learning Innovation | 36,60,69,133,243,106 Straley, Joe | University of Kentucky | 66,195 Strauss, Eric | Boston College | 73,155 Stroud, Nicholas | NYC Center for Space Science Education | 45,69,159,243 Stuessy, Carol | Texas A&M University | 70,243 Su, Ming-jun | Shu-Te University, Taiwan | 44,46,112,183 Subramaniam, Karthigeyan | Penn State | 34,243 Sullenger, Karen | University of New Brunswick | 45,216 Sullivan Watts, Barbara | University of Rhode Island | 44,264 Sumfleth, Elke | University of Duisburg-Essen | 54,134,205 Sunal, Cynthia | University of Alabama | 55,244 Sunal, Dennis | University of Alabama | 48,55,105,244 Sungur, Semra | 53,245 Suriel, Regina | The University of Georgia | 74,91 Suter, Larry | University of Massachusetts | 53 Svoboda, Julia | University of California, Davis | 45,215 Swarat, Su | Northwestern University | 59,71,128,213

Switzer, Anna | University of Michigan | 59,255 Szeto, Alan | Purdue University | 32,74,80,103,244 Taconis, Ruurd | Eindhoven University of Technology | 68,125 Tai, Robert | University of Virginia | 34,51,221,244,262 Tal, Tali | Technion, Israel Institute of Technology | 42,196 Talanquer, Vicente | University of Arizona | 42,46,50,59,69,207,241,245 Talsma, Valerie | Northern Illinois University | 44 Tan, Edna | Columbia University | 32,54,57,103,251 Tanner, Dawne | U of MN | 36,106 Tanner, Kimberly | San Francisco State University | 43,47,51,69,80,105,110,138,170 Taylor, Amy | NC State University | 53,59,165,245 Taylor, Dawne | College of Charleston | 45 Taylor, Joseph | BSCS | 73,142 Tekkaya, Ceren | 53,245 Teksoz Tuncer, Gaye | 53,245 Teou, Lay-Yen | Ponggol Primary School | 66,114 Terzi, Aysegul | Cevre Koleji | 38,234 Tester, Kimberly | Northwestern University | 73,167 Thomas, Gregory | The University of Alberta | 53,246 Thomas, Julie | Oklahoma State University | 69,72,246 Thompson, Katerina | University of Maryland | 51 Thompson, LaTasha | Morgan State University | 57,203,205 Thompson, Laurie | California Institute of Technology-CAPSI | 55,254 Thomson, Norman | University of Georgia | 33,65,72,117,149,246 Tiberghien, Andrée | Ecole Normale Superieure de Lyon, France | 35,71,84,247 Tillotson, John | Syracuse University | 36,56,100,247 Tippett, Christine | University Of Victoria | 50,89 Tippins, Deborah | University of Georgia | 33,58,149,247 Tobin, Kenneth | University of New York | 39,56,58,71,203,219,247 Tolbert, Sara | The University of California | 56,242 Tomanek, Debra | University of Arizona | 46,69,78,207,209,139 Tomas, Louisa | Queensland University of Technology | 54,226 Tomita, Miki | University of Hawaii | 58,263 Toolin, Regina | University of Vermont | 70,81,248 Toth, Eva | University Of Victoria | 35,37,42,49,132 Totten, Iris | Kansas State University | 65,248 Touchman, Stephanie | Arizona State University | 45,99 Tran, Lynn | Kings College London, United Kingdom | 248 Travers, Karen | University of Arizona | 46,249 Treagust, David | Curtin University of Technology | 50,67,73,117,130,249 Trendel, Georg | University of Essen, Germany | 60,197 Tretter, Thomas | University of Louisville | 59,77,165,250 Trundle, Kathy | The Ohio State University | 53,85 Tsai, Chih-Chung | National University of Tainan, Taiwan | 33,40,54,70,111,182,261,265 Tsai, Meng-Jung | National Taipei University | 47,53,64,156,250,262 Tsai, Shinping | College of Education University of Washington | 57,181 Tseng, Chung-Hsien | National Changhua University of Education | 43,250 Tsung-Hau, Jen | National Taiwan Normal University | 38,251 Tsurusaki, Blakely | Michigan State University | 54,57,88,251,266 Tuan, Hsiao-Lin | National Changhua University of Education | 32,33,43,44,111,113,250 Tucker, Bradley | Mount Saint Vincent University | 45,105 Tuckey, Steven | Michigan State University | 66,167,251 Tunnicliffe, Sue | Institute of Education, University of London | 76,261 Turker, Nurcan | Ataturk University | 46,262,265 Turner, Tommie | Washington University | 56,139 Tymms, Peter | Durham University | 52,164 Tytler, Russell | Deakin University | 42,50,55,157,221,252 Tzou, Carrie | University of Washington | 52,98 Undreiu, Adriana | Western Michigan University | 39,233 Upadhyay, Bhaskar | University of Minnesota | 32,47,57,252 Urban-Lurain, Mark | Michigan State University | 35,36,201,225

Urhahne, Detlef | Ludwig-Maximilians-University Munich, Germany | 43,177 Uysal, Sibel | Arizona State University | 36,37,93,181,252,263 Uzoglu, Mustafa | Ataturk University, Turkey | 69,165 Van der Rijst, Roeland | ICLON - Leiden University Graduate School of Teaching | 69,253 van Driel, Jan | Leiden University, The Netherlands | 35,69,77,132,206,253 van Eijck, Michiel | University of Victoria | 49,80,253 Vanderlinden, David | Des Moines Area Community College | 65,210 Vanosdall, Rick | Tennessee State University | 55,254 Varelas, Maria | University of Illinois at Chicago | 72,89,166,251,254 Varma, Keisha | University of California | 51,254 Vath, Richard | University of Michigan | 59,255 Vaughn, Margaret | The University of North Carolina at Greensboro | 59,152 Vellom, Paul | Western Michigan University | 39,233 Venville, Grady | University of Western Australia | 70,73,79,123,155,265 Verloop, Nico | ICLON - Leiden University Graduate School of Teaching | 69,253 Vitale, Mike | East Carolina University | 79,188 Vogt, Helmut | University of Kassel | 81,199 Volkmann, Mark | University of Missouri - Columbia | 702,858 Von-Aufschnaiter, Claudia | University of Giessen, Institute of Physics Education | 55,58,92 Wackermann, Rainer | University of Essen, Germany | 60,197 Waldrip, Bruce | University Of Victoria | 37,50,255 Wallace, Alison | Minnesota State University Moorhead | 74,255 Wandersee, James | Louisiana State University | 51,65,118,255 Wang, Chia-Yu | National Chiao Tung University | 53,256 Wang, Hao-Chuan | Carnegie Mellon University | 61,156 Wang, Kuo-Hua | National Changhua University of Education, Taiwan | 61,140 Wang, Tzu-Hua | National Hsinchu University of Education, Taiwan | 34,44,256 Waters, Charlotte | Heritage High School | 42,204 Watson, Scott | Liberty University | 68,257 Watson, William | The George Washington University | 45,56,257 Weinstein, Matthew | University of Washington-Tacoma | 37,258 Weisbaum, Kathryn | Tennessee State University | 55,254 Weizman, Ayelet | Weizmann Institute of Science | 35,39,43,80,137,258,237 Welzel, Manuela | University of Education Heidelberg | 35 Wescott, Daniel | University of Missouri-Columbia | 45,115 West, Andrew | University of Missouri - Columbia | 70,258 White, Anne Fiona | York University | 52,259 White, Kevin | Illinois Institute of Technology | 57,179 Wickler, Nicole | California State Polytechnic University, Pomona | 51,259 Wickman, Per-Olof | Stockholm Institute of Education | 54,72,149,178 Wiebe, Eric | North Carolina State University | 42,43,44,67,76,108,120,119,259 Wiles, Jason | McGill University | 47,90 Wilke, Brook | 54,57 Willard, Ted | American Association for the Advancement of Science | 58,80,100,234 Williams, Brian | Georgia State University | 70,200 Williams, E Grant | University of Massachusetts - Amherst | 51,260 Williams, Julian | The University of Manchester School of Education Humanities | 151 Wilson, Christopher | Michigan State University | 33,35,54,57 Wilson, John | Georgia State University | 45,190,260 Wilson, Mark | 54,129 Wilson, Robert | Texas A&M University | 70 Winrich, Charles | Boston University | 46,260 Wischow, Emily | Purdue University | 74,244 Witenoff, Shulamit | Technion, Israel Institute of Technology | 52,95 Wolf, Jennifer | University of Louisville | 77,250 Wollring, Bernd | University of Kassel, Germany | 81,199 Wood, Nathan | University of Idaho - Department of Curriculum & Instruction | 48,261 Wright, Ann | Canisius College | 76,261 Wu, Hsin-Kai | National Taiwan Normal University | 35,185 Wu, Ying-Tien | National Taiwan University of Science and Technology, Taiwan | 54,261 Wyss, Vanessa | University of Virginia | 51,262

Xiang, Lin | University of California, Davis | 60,215 Yacubian, Hagop | Eastwood College | 44 Yager, Robert | University of Korea | 77,182 Yair, Yoau | 40,150 Yalvac, Bugrahan | Texas A&M University | 46,262 Yang, Fang-Ying | National Taiwan Normal University | 47,53,64,156,250,262 Yang, Kai-Ti | National Taiwan Normal University, Taiwan | 34,256 Yang, Wei-Cheng | National Changhua University of Education | 44,113 Yang, Wen-Gin | National Taiwan Normal University | 70,262 Yarden, Anat | Weizmann Institute of Science, Israel | 37,50,64,73,141,218,263,76 Yasar-Purzer, Senay | Arizona State University | 36,37,93,181,252,263 Yavetz, Bela | Kibbutzim College of Education | 39,216 Ye, Jia-Cheng | National Taiwan Normal University | 70,262 Yeh, Andy | Queensland University of Technology | 54,226 Yen, Chuing-Fen | Providence University, Taichung, Taiwan | 61,55,85 Yerrick, Randy | State University of New York at Buffalo | 79,188 Yildirim, Ali | Middle East Technical University, TURKEY | 32,169 Yilmaz-Tuzun, Ozgul | Middle East Technical University (METU) | 38,46,211,262,265 Yin, Yue | University of Hawaii | 58,263 Yoon, Heesook | Seoul National University | 66,173 Yoon, Susan | University of Pennsylvania | 61,113 Yore, Larry University of Victoria 50,61,85,89,79,237 Young, Betty | University of Rhode Island | 44,81,104,264 Young, Monica | Syracuse University | 36,247 Young, Tim | University of North Dakota | 43,147 Yu, Shu-Mey | National Taichung University | 38,264 Yunker, Molly | University of Michigan | 58,264 Yýlmaz-Tuzun, Ozgul | Middle East Technical University | 46,38,211,262,265 Zacharias, Zacharias | University of Cyprus | 33,43,74,78,186,212,265 Zawicki, Joseph | Buffalo State College | 39,133 Zeidler, Dana | University of South Florida | 65,70,234,265 Zembal-Saul, Carla | Pennsylvania State University | 37,51,65,107,121,256 Zesaguli, Josie | Michigan State University | 54,57,266 Zeyer, Albert | University of Zurich | 35,49,266 Zhang, BaoHui | Nanyang Technological University, Singapore | 56,186 Zhang, Helen | University of California at Berkeley | 43,117 Zhang, Meilan | Michigan State University | 46,60,79,192,267 Zhang, Tianyi | Michigan State University | 79,192 Zilker, Irene | University of Duisburg-Essen, Germany | 79,267 Zimmerman, Heather | University of Washington | 52,98 Zirbel, Esther | Tufts University | 43,58,68,169,268 Zoller, Uri | University of Haifa, Israel | 38,67,249,268 Zollman, Dean | Kansas State University | 37,42,55,80,90,166,191,223,244 Zozakiewicz, Cathy | San Diego State University | 58,247 Zvi-Assaraf, Orin Ben | 32,98



# New to Routledge for 2008

## Studies in SCIENCE EDUCATION

Editors: Jim Ryder & Phil Scott, University of Leeds, UK

Volume 44, 2 issues per year Print ISSN: 0305-7267, Online ISSN: 1940-8412

The central aim of *Studies in Science Education* (*SiSE*) is to publish review articles of the highest quality which provide analytical syntheses of research into key topics and issues in science education. In addressing this aim, the Editors and Editorial Advisory Board, are guided by a commitment to:

- maintaining and developing the highest standards of scholarship associated with the journal.
- publishing articles from as wide a range of authors as possible, in relation both to professional background and country of origin.
- publishing articles which serve both to consolidate and reflect upon existing fields of study and to promote new areas for research activity.



### Routledge Taylor & Francis Group



VOLUME 44 NUMBER 1 MARCH 2008

Studies in

SCIENCE EDUCATION

ISSN 0305-7267

#### International Journal of Science Education

Editor-in-chief: John K. Gilbert, University of Reading, UK Volume 30, 2008, 15 issues per year Print ISSN: 0950-0693, Online ISSN: 1464-5289 www.informaworld.com/ijse

#### Environmental Education Research

Editor: Alan Reid, University of Bath, UK Volume 14, 2008, 5 issues per year Print ISSN:1350-4622, Online ISSN: 1469-5871 www.informaworld.com/eer

## Research in Science and Technological Education

Editor: Chris Botton, University of Hull, UK Volume 26, 2008, 3 issues per year Print ISSN: 0263-5143, Online ISSN: 1470-1138 www.informaworld.com/riste







Visit the Journal's homepage at: www.tandf.co.uk/journals/0305-7267

