The 2012 Conference on Transforming Research in STEM Education – Poster Session #1
Monday June 4, 8:00 PM
Odd numbers at your poster 8:00-8:45 PM
Even numbers at your poster 8:45-9:30 PM

1. Automated Course and Program Assessment

James Allert
University of Minnesota Duluth

Course and program assessment place heavy demands on both instructors (who must gather direct evidence) and administrators (who must compile data from multiple courses and generate reports). The reports must support critical analysis to determine whether outcomes are being met and performance indicators are being achieved. At the University of Minnesota Duluth, Department of Computer Science, software (Program Assessor) has been produced that automatically consolidates course and program data and generates reports suitable for the ABET accreditation process. This session explains the process used by the Program Assessor software and gives examples of the reports it produces.

2. A Survey Assessing Students' Awareness of and Attitudes Toward Scientific Research

Mary Beth Anzovino
John W. Moore
Andrew E. Greenberg
University of Wisconsin-Madison

Producing an educated, informed public is an important goal for colleges and universities. To this end, we have embarked upon developing a program to incorporate research-inspired experiments into the general chemistry laboratory, in hopes of increasing students' awareness of research and shifting their attitudes toward research in a positive direction. Numerous survey instruments exist to assess individuals' perceptions of science in general and of individual fields such as chemistry. However, this vast library of instruments does not include a valid, reliable survey to measure individuals' perceptions of and attitudes toward scientific research; thus, an instrument is needed to fill this void. Pilot testing of the early draft of our instrument revealed it to be invalid; this poster will describe the statistical analysis and efforts to revise and refine the survey.

3. Textual and Diagrammatic Analyses Reveal Novice Ideas about Hurricane Formation

Leilani Arthurs
Matthew Van Den Broeke
University of Nebraska-Lincoln

A two-question open-ended survey was administered to 337 students enrolled in introductory college level geoscience courses in Georgia (n=169) and Nebraska (n=168) to assess novice understandings of hurricane formation prior to explicit instruction on the subject. Survey participants were asked to explain in their own words how they think hurricanes form and to draw a picture to illustrate their ideas. The authors independently applied a coding rubric, developed using only the Georgia data set, to the entire data set. Inter-coder reliability was very high (93%) when initial codes for each response were compared and incongruities in coding were resolved with discussion. Textual and diagrammatic analyses of responses indicate a broad range of student ideas about hurricane formation, from more novice-like to more expert-like. The findings can be used to aid in the design of instructional materials, such as lecture tutorials, to address student misconceptions and facilitate conceptual learning.

4. Investigating Students' Understanding of Definite Integrals Using Graphical Representations

Rabindra Bajracharya
John R. Thompson
Thomas M. Wemyss
University of Maine

Physics students are expected to apply the mathematics learned in their mathematics courses to physics concepts and problems. Few PER studies have distinguished between difficulties students have with physics concepts and those with either mathematics concepts and their application or the representations used to connect the math and the physics. We are conducting empirical studies of student responses to mathematics questions dealing with graphical representations of (single-variable) integration. Reasoning in written responses could roughly be put into three major categories related to particular features of the graphs: area under the curve, position of the function, and shape of the curve. In subsequent individual interviews, we varied representational features to explore the depth and breadth of the contextual nature of student reasoning, with an emphasis on negative integrals. Results suggest an incomplete understanding of the criteria that determine the sign of a definite integral.

5. Social and Sociochemical Norms in an Inquiry-oriented Physical Chemistry Class

Nicole Becker
Marcy Towns
Purdue University

Engaging students in classroom discourse offers opportunities for students to participate in the construction of joint understandings, to negotiate relationships between different types of evidence, and to practice making evidence-based claims about science content. However, close attention to social aspects of learning is critical to creating inquiry-oriented classroom environments in which students learn with understanding. Using Toulmin's model of argumentation as an analytical lens, this study examined social norms and epistemic criteria for what counts as acceptable reasoning (sociochemical norms) in an inquiry-oriented undergraduate physical chemistry class. By describing how social factors support and constrain learning during whole class discussions, ways that teacher facilitation can support learning of chemistry content will be discussed

6. Chemistry Concept Inventories: Best Practices in Assessment Design

Stacey Lowery Bretz
Miami University

Learning chemistry requires students to understand information encoded in representations and to connect multiple representations. Failure to accurately interpret and connect these representations is one source of students' alternative conceptions. This project describes the creation of assessment tools (concept inventories) to advance our understanding of how students learn to think with chemistry. Emerging insights regarding the underlying assumptions and appropriateness of psychometrics will be discussed as alternatives to routine procedures to establish reliability and validity.

7. Using Lab-Based Analogies to Facilitate Meaningful Understanding

Mitchell Bruce
Shirly Avargil
François Amar
Virginia Flood
Alice Bruce
University of Maine

Using and enacting analogies in an active and engaged way can help learners understand phenomena on the molecular scale and relate abstract concepts to their prior knowledge. In this paper, we will describe how analogies are being integrated into an introductory lab course using our Analogy/Learning Cycle (A/LC) curriculum. The approach is aimed at helping students construct their conceptual understanding through a "just in time" structured analogy activity during the lab experiment. We encourage students to construct the correspondence and consider the limitations of an analogy. Anchoring analogical reasoning in a context of experimental observations prompts students to think about the chemistry they cannot see while giving them a way to understand the inherent limits of a model. The project includes the interrelated pieces of curriculum, assessment, and research on student ideas. We present an overview of the A/LC curriculum, pre- and post-assessment results, a web-based tool for eliciting students' answers for analogy reasoning, and students' answers content analysis from fall 2011 and spring 2012 (n = 502).

8. Solving Logic Puzzles Using Logic Programming

Sandeep Chintabathina
University of Arkansas, Pine Bluff

Puzzles have always been intriguing to humans since the dawn of math and science. Every now and then we encounter some sort of puzzle in our daily lives that requires human intelligence and reasoning. With enough practice we are able to train our brain to solve some of these puzzles in a very short amount of time. However, with the introduction of computers we have access to tremendous computation power, which allows us to solve several different puzzles in a relatively short time. Researchers have come up with computer languages to represent such puzzles and tools to compute solutions to these puzzles. Since solving these puzzles requires logical reasoning, programming in logic or logic programming has been a popular choice for solving them. Specifically, logic programming under answer set semantics, also called Answer Set Programming (ASP), has been shown to represent and reason about a variety of logic puzzles including Sudoku, Kakuro, and so on. The language is declarative which makes the programs very easy to understand and write. It is a good way to introduce programming to students because it has very simple syntax and is quite intuitive. Students are often amazed when their simple programs are able to compute solutions to complex puzzles very easily.

9. Investigating Student Understanding of Eigen Theory in Quantum Mechanics

Warren Christensen
North Dakota State University

An initial investigation into students' understanding of Eigen theory using semi-structured interviews was conducted with students at the end of a first-semester course in quantum mechanics. Using a previously published interview protocol, I was interested to see if the reasoning patterns among Quantum Mechanics students were similar to those identified by Henderson et al. That is, 1) students who used superficial algebraic cancellation, 2) students who correctly solved the system but were unable to interpret their result, and 3) students who correctly solved the system and correctly interpreted their result. Of the three students interviewed, all fell into either category 2 or 3. Additional questions were added at the end of the protocol about how these concepts were used in their quantum mechanics course. Students were

somewhat successful relating them to Hamiltonians and energy eigenvalues, but couldn't articulate the type of physical situations where they might be useful.
1 Henderson, Rasmussen, Zandieh, Wawro and Sweeney (2010, February). Symbol sense in linear algebra. Paper presented at the Thirteenth Conference on Research in Undergraduate Mathematics Education, Raleigh, NC."

10. Toward Sustained and Effective Reform: A Study of the Change Process in 15 Faculty

Melissa Dancy, *University of Colorado*
Charles Henderson, *Western Michigan University*

We are currently following 15 new physics faculty who attended the Physics and Astronomy New Faculty Workshop for the three years following their workshop experience. Data collected includes pre- and post-semester interviews, periodic surveys and teaching artifacts (i.e. exams, syllabi, conceptual testing, student evaluations, etc.). All participants indicated a strong interest in reforming their teaching toward research-based practices. In this poster we present a preliminary analysis of the decisions made by these faculty regarding teaching, motivations behind their decisions, and common barriers and affordances encountered. Recommendations will be highlighted for better supporting faculty through the change process.

11. Training Supplemental Instruction peer leaders: Preliminary findings from qualitative interviews

Mary Emenike
Michael Loverude
California State University

Supplemental Instruction (SI) provides weekly, voluntary, cooperative, peer-led, active learning sessions to students in high-risk courses. While the theoretical frameworks behind SI enables programs to be adaptable enough to fit different courses and learning environments, the potential for flexibility could also result in a lack of accountability and structure necessary for SI to achieve its touted effectiveness. Typical measures of SI effectiveness compare exam grades, course grades, and retention rates between students who do and do not attend SI sessions. We qualitatively investigated SI across multiple disciplines (biology, chemistry, mathematics, and physics) through interviews with faculty members, SI leaders, and students in courses with an SI component. Preliminary findings related to the training of SI leaders will be presented, which suggest that the leaders felt more prepared to handle aspects related to the administrative tasks of their position than to developing materials and activities.

12. Contribution to Science: Toward a New Conceptualization of the Role of Underrepresented Students in Undergraduate Courses

Sanaz Farhangi
New York University

Underrepresentation of women and racial minorities in STEM fields is a known issue in science education. Most interventions designed to improve enrollment focus on student participation within the norms of practice but ignore how contribution of students can be a strong motivator for engagement. Contribution is an essential aspect of identity formation and the transformation of practice, more so than participation. I propose to re-conceptualize and study undergraduate science students' engagement with science/education using cultural-historical activity theory and the concept of contribution to activity of science and science learning to understand how students can use their agency and take an active role in their science learning.

13. The Role of Gesture and the Body in Molecular Geometry

Virginia J. Flood, *University of Maine*
François G. Amar, *University of Maine*
Michael C. Wittmann, *University of Maine*
Ricardo Nemirovsky, *San Diego State University*
Mitchell R. M. Bruce, *University of Maine*

Gesture is inherently linked to how people think and talk about spatial relationships. An important skill in STEM disciplines is the ability to reason and solve problems about complex three-dimensional phenomena. We examine the role of general chemistry students' spontaneously produced body motion as they predict the three-dimensional molecular geometry of the molecule PF5. During descriptions, gesture conveys molecular shape in the absence of technical language, carrying complex spatial information unmentioned in speech. Furthermore, students use their bodies to solve problems in three dimensions. We present the case of a student who cannot recall the particular molecular shape of PF5 and uses his hands as resources to generate and revise a solution. Our findings illustrate that our students demonstrate valid body-based apropositional forms of knowing and problem solving that are irreducible to other modalities. Successful knowing and problem solving, in the context of molecular geometry, is enacted by the body.

14. Research on Students' Reasoning about Interdisciplinarity

Ben Geller
Benjamin W. Dreyfus
Vashti Sawtelle
Chandra Turpen
Edward F Redish
University of Maryland - College Park

We present qualitative data of undergraduates describing the relationship between scientific disciplines. Rather than viewing biology, chemistry, and physics as existing in disconnected silos, these students often describe the relationships in a hierarchical or horizontal fashion. The hierarchical arrangements order the disciplines by degree of system complexity, or by the scale used to examine a particular system. For example, a student might view the full description of folded proteins at the top (biology), chemical reactions involving proteins' functions as chemistry, and motion of the protein's individual atoms as foundational (physics). Other students describe a horizontal view of disciplinary boundaries, without a foundational bottom but maintaining overlapping realms of interest. Others want physics embedded in a context that positions its relationship to biology via analogy. We examine evidence that students' conceptions are unstable and context-dependent, and suspect that these conceptions are related to course messaging in a bidirectional manner.

15. Problem-based Learning and its Effects on Nature of Science Conceptions, Self-efficacy Beliefs and Attitudes Toward Chemistry

Megan Grunert
Kelley Becker
Lloyd Mataka
Western Michigan University

Most chemists recognize the value of the laboratory experience, yet due to constraints with teaching assistant (TA) experience and turnover, as well as variable student preparation, many large institutions rely on "cookbook"-style laboratory activities. Using a meaningful learning framework (Bretz, 2001; Fink, 2003) we have designed and implemented a set of Problem-Based Learning (PBL) laboratory units in Western Michigan University's (WMU) general chemistry laboratories. These PBL units were¬ developed from research topics currently under investigation within the WMU chemistry department. With the PBL laboratory units in place, we will be studying the PBL lab's effect on TAs' educator identity formation with

a focus on alterations in TAs' conceptions of the nature of science (NOS). In addition, we will also be studying the influence of PBL on students' attitude and self-efficacy beliefs toward chemistry. As this study is ongoing, we will be presenting the preliminary results collected from four sections of 24 students working with a pesticide sensors PBL lab unit and three sections of 24 students working in a bio-diesel production PBL lab unit.

16. Comparing Instructional Effects of Graphics- and Text-Based Programming Languages

Kathleen A. Harper, Richard J. Freuler, Stuart H. Brand, John T. Demel
Engineering Education Innovation Center, The Ohio State University

Traditionally, programming has been taught via text-based languages where the students use an editor to type in language statements which are compiled into a program. In Ohio State's Fundamentals of Engineering for Honors program, the language of choice has been C++ for many years. Recently, one section of the course was offered that was based upon LabVIEW, a graphically-based platform. We compared the students in the alternate section to a matched sample of students in the text-based class in three ways: 1) performance on identical questions on the final exam, 2) success in learning a subsequent (text-based) language, MATLAB, 3) shift in attitudes during the term, as measured by a modified subset of questions from the MPEX.[1] Results were mixed, but intriguing, setting the stage for a current continuation study.

17. A Student Difficulty With Spherical Unit Vectors In Intermediate E&M

Brant Hinrichs
Drury University

An intermediate E&M course (i.e. based on Griffiths) involves the extensive integration of vector calculus concepts and notation with abstract physics concepts like field and potential. We hope that students take what they have learned in their math courses and apply it to help represent and make sense of the physics. To assess how well students are able to do this integration and application I have developed several simple concept tests on position and unit vectors in non-Cartesian coordinate systems as they are used in intermediate E&M. In this poster, I describe one of these concept tests and present results that show both undergraduate physics majors and physics graduate students have difficulty using spherical unit vectors to write position vectors in 3-D space.

18. Categorizing Students' Use of Differential Resources in Physics Integration Problems

Dehui Hu
N. Sanjay Rebello
Kansas State University

Developing the skills to set up integrals is critical for students' success in calculus-based physics. It requires a high level of understanding of both math and physics concepts. Previous studies have shown that students encounter a lot of difficulties when setting up integrals in the context of electricity and magnetism. Understanding differentials (i.e., infinitesimals) is one of the main difficulties. We conducted group interview sessions with 13 engineering students enrolled in a second semeter introductory calculus-based physics course. We present data about students' reasoning of differentials when applying integral concept in a physics context. From the resources perspective, we categorized the mathematics and physics resources activated by students associated with the understanding of differentials. Our research provides further insights into why students have difficulties when solving physics integration problems. Finally, we provide suggestions for teaching in order to help students better transfer calculus concept in physics.

19. Inhibitors of Problem Solving Strategies for Representational Task Formats

Bashirah Ibrahim
N. Sanjay Rebello
Kansas State University

We investigated the factors influencing students' problem solving strategies with respect to representational modes. Each of the 19 engineering students in the sample participated in four individual interview sessions, lasting for one hour each. The students completed 10 tasks from the topics of kinematic and work. The tasks were posed in linguistic, symbolic and graphical forms requesting either a qualitative or a quantitative solution. We compared the approaches employed by individual students when attempting the same representational format task across the two topics. Their strategies for tasks requiring qualitative or quantitative solutions were also compared. We found that representational mode impacts problem solving approach. The level of understanding and familiarity with a topic influence students' interpretation of a representation but does not affect their approach to generate a quantitative solution. Finally, the nature of the task's solution does not seem to influence students' strategies. Supported in part by NSF grant 0816207.

20. Relationship between metacognition and identity development in physics

Paul Irving
Eleanor C. Sayre
Kansas State University

As part of a larger study of upper level physics students' identity formation in physics, we investigate sophistication of epistemology, approach to learning, metacognitive development and level of cognitive development. In this poster, we present initial findings from individual interviews with journeymen physics students enrolled in theory courses (Classical Mechanics and Electromagnetic Theory). Students develop an explicit awareness of themselves as learners as well as their processes of learning physics in order to develop a sense of identity and awareness of the position they occupy in the physics community. We connect their identity as physicists and their level of metacognitive development.

21. A Comparison of Research Studies on Education within STEM Disciplines

Heidi Iverson
Colorado State University

Over the last several decades, the efficacy of the traditional lecture-based model of undergraduate science courses has been challenged. As a result, a large number of reform-oriented instructional innovations have been developed, enacted, and studied in undergraduate science courses around the globe – all with the intended purpose of improving student learning. As part of a previous research study, 310 published research studies on undergraduate science course innovations have been assembled: composed of 98 studies in biology, 26 in chemistry, 38 in engineering, and 148 in physics. These articles have subsequently been coded with respect to the characteristics of the innovation used and the methodology of the study design. The purpose of the present study was to compare and contrast the characteristics of the published articles across the four disciplines. Preliminary results indicate that some notable differences exist, particularly with respect to the innovations and assessments used across the disciplines.

22. Understanding Ionizing as the Mechanism for Radiation Tissue Damage

Andy Johnson
Anna Hafele
Black Hills State University

We are investigating how non-science undergraduates come to understand the interaction of alpha, beta, or gamma radiation with matter through guided inquiry activities. We find that students have difficulties forming or expressing a coherent mental model of ionization by radiation. Substantial scaffolding is required to get more than a small fraction of the class to develop usable models of ionization. The Radiation By Inquiry project has developed extensive support including research-based strategies and a new simulator for ionization to enable the development of viable mental models. Students must put multiple ideas together to create a complete mental model of the ionization process. Although we have made significant progress in the number of students who understand ionization, approximately 30% of our students still fail to understand this fundamental radiation process. Notable causes of difficulty include alternative models for the characteristics of radiation and for the interaction of radiation with cells, and problems with thinking on different size scales. This poster identifies some of the learning difficulties and explores our efforts to resolve them. This research is part of the Radiation By Inquiry project supported by NSF DUE grant 0942699. http://www.camse.org/radiation

23. Training Physics Concentrators to Think like Scientists

Rachael Lancor
Robert Hart
Joon Pahk
Amir Yacoby
Harvard University

This poster will report on the progress of a curriculum development project called "Principles of Scientific Inquiry" (PSI). PSI is the laboratory component of the introductory physics courses for majors. The goal is to develop a three-semester sequence that will expose students to the cycle of scientific inquiry and prepare them to be practicing scientists. The curriculum emphasizes model building, testing, and revising by focusing on a small number of related experiments throughout the semester. Students in the first-semester mechanics course study a parametric pendulum system; in second-semester electricity & magnetism they study the Thompson's jumping ring; and in the third-semester waves course they study holography. These systems are presented as a series of puzzles for the students to solve each week that get them closer to understanding the final system, while introducing inquiry skills such as estimating error, data analysis, statistics, and basic programming.

24. Assessing the Impact of a Values Affirmation Task in Science

Shanda Lauer
Jennifer L. Momsen
Erika Offerdahl
Warren Christensen,
Mila Kryjevskaia
Lisa Montplaisir
North Dakota State University

STEM education research has documented a persistent and pervasive achievement gap between men and women, especially in math and physics. Previous research (Miyake et al, 2010) demonstrated a 15-minute values affirmation writing exercise could significantly reduce gender gaps in introductory physics: women's average exam grades increased modally from a C to B. While these results are impressive, they demand replication with a diverse student population, across courses, and disciplines. This study replicates Miyake across introductory science courses at NDSU. We collected final exam grades, final grades, and concept inventory scores as measures of gender achievement gaps in physics, biochemistry, and biology. We found no effect of the values affirmation writing task on female achievement in any of the

studied courses. While this replication failed to confirm the utility of the values affirmation task, we believe such tasks can reduce achievement gaps but may depend on the context of instruction, curriculum, student population, and institution.

25. The Role of Sets of Outcomes in Students' Combinatorial Problem Solving

Elise Lockwood
University of Wisconsin, Madison

Counting problems are central to computing probabilities, and they are a key part of effectively writing and implementing computer programs. Because of such applications, the teaching and learning of combinatorics has appeared with increasing prevalence in undergraduate curricula. Authors of combinatorial texts describe enumeration as a nuanced and difficult process, and research on the teaching and learning of combinatorics indicates that, across ages, students struggle with solving various types of counting problems. In spite of difficulties for students, the state of research in combinatorics education is relatively sparse. To investigate ways in which students think about counting problems, graduate and undergraduate students were interviewed as they solved a variety of counting problems; these interviews were analyzed using grounded theory. What emerged was an initial model of students' combinatorial thinking, which elaborated certain aspects of students' combinatorial thinking. The importance of sets of outcomes emerged as a particularly important aspect of student counting, and four particular ways in which students utilized sets of outcomes were identified. By exploring the ways of thinking that might be effective for students, this research can contribute to the field by helping teachers and researchers better understand (and ultimately improve) students' work on counting problems.

26. ACID I: A Diagnostic Tool to Elicit Organic Chemistry Students' Conceptions of Acid Strength

LaKeisha McClary
Stacey Lowery Bretz
Miami University

To improve learning outcomes in any domain, it is important for educators to be familiar with students' ideas within a topic and across topics within a domain. Quickly assessing students is a useful instructional strategy to learn what conceptions are held, and likely being used to reason. Thus, we designed a nine-item, multiple-tier, multiple choice concept inventory to assess second-semester organic chemistry students' conceptions of acid strength. Students (N=290) at two universities relied on two alternative conceptions to make decisions about acid strength. Furthermore, students were more confident about their incorrect conceptions after two semesters than they were after one semester. Findings and implications from the study will be presented.

27. Creating a Beneficial Link Between Developmental Mathematics and Teacher Education

Raven McCrory
Kristen Bieda
Pavel Sikorskii
Michigan State University

In this work, we are designing an intervention both in mathematics teacher preparation and in undergraduate developmental mathematics courses. In sections of the developmental mathematics course, MTH1825, at MSU, we will implement a problem-based curriculum with mathematics majors in the teacher certification program serving as mentors/teaching assistants. The mentors will use MTH1825 as the site for their senior year teaching lab, under the supervision of mathematics education faculty. MTH1825 is now taught as a fully online course with about 10 sections designated for face-to-face enrichment. The project will be piloted in half of the enrichment sections. Our research questions are: 1. What is the impact of a new curriculum employing student centered teaching methods on student learning in enrichment sections of a developmental (pre-algebra) mathematics course? 2. What is the impact on future secondary mathematics teachers of experiences teaching in a college level developmental

mathematics course as part of their teacher education curriculum? We present our research design and preliminary curriculum design.

28. Factors Affecting the Retention of Women in Doctoral Mathematics Programs

Emily Miller
University of Delaware

Although the proportions are improving somewhat, women still represent a minority of students studying math at the graduate level. Specifically, in 2006, women made up only 30 percent of doctoral degree recipients. Furthermore, women are less successful than men in completing doctoral degrees and take longer in doing so. Research is needed to determine the factors that prevent attrition and promote the retention of women in doctoral mathematics programs. Since most work in this area is qualitative, this poster will present a proposed study using a quantitative, survey methodology. The study will attempt to synthesize and quantify the factors addressed in prior literature. The research questions, research design, and data collection will be presented for the proposed study. Data analysis will utilize the Rasch model to overcome some of the limitations in using survey data.

29. Student Self-efficacy and Nature of Science Understanding: Possible Improvements

Beth Moss
Cinzia Cervato
Lori Ihrig
Iowa State University

Over the past three semesters we have transformed the Geology 100 Lab curriculum in an effort to increase students' understanding of the nature of science (NOS) (what science is, how it works, etc.) as well as their confidence in their ability to be successful in science, also known as their self-efficacy (SE) towards science.An understanding of the NOS is a key component of science literacy. Students with an accurate view of the NOS are able to make informed decisions regarding public policy (e.g. global climate change), and have a deeper understanding of the science concepts they are studying. Students with higher SE towards the skills required of a specific field are more likely to pursue a job in that field. With this in mind, we have integrated a research project based on the local hydrology into the curriculum, giving students the opportunity to participate in authentic science (formulating research questions and hypotheses, collecting, analyzing and presenting data).Students were given two surveys at the beginning and end of the semester, one measuring NOS views (SUSSI) and another measuring SE. Significant increases ($p<0.5$) in SE occurred in the Fall 2011 semester, while NOS increases have been less robust.

30. Language Comprehension and Learning Chemistry

Samuel Pazicni
Daniel Pyburn
Victor K. Benassi
Elizabeth Reilly
University of New Hampshire

While mathematical ability has long been implicated as crucial for learning Science, the role of language ability remains largely uninvestigated. The present study explores correlations between language comprehension ability and performance in general chemistry. We demonstrate here that comprehension ability correlates strongly with chemistry course performance. An examination of comprehension ability and prior knowledge suggests that high comprehension ability may be insufficient to compensate for low prior knowledge in certain classroom contexts (e.g. a one-semester general chemistry course). Intriguingly, our results also suggest that instruments used to measure comprehension ability and math ability are not wholly independent of one another. We also report the design and analysis of a multiple-testing intervention strategy that appears to close the chemistry achievement gap between students of

low and high comprehension ability. The effect of different types of questions (multiple choice versus elaborative interrogation) on this multiple-quizzing strategy has also been investigated.

31. Design Research: Paper Folding to Elicit Mathematical Necessity

David Plaxco
Virginia Tech

The purpose of this research is to develop a paper folding activity that is intended to elicit students' intellectual need for more powerful mathematical operations. The activity builds from a naive iteration of a unique paper fold - a process that results in a new rectangle. This process is then discussed so that students make conjectures about the relationships between the beginning rectangle, initial fold, and resulting rectangle and seek to resolve these conjectures, necessitating mathematical tools along the way. The activity should provide students with an opportunity to reflect on their own actions and create a model of those actions that can be manipulated for a deeper understanding of the activity. A demonstration of the folding process and initial results will be shared.

32. Lexical Analysis of Writing Reveals Heterogeneous Student Thinking in STEM

Luanna Prevost
Kevin Haudek
John Merrill
Mark Urban-Lurain
Michigan State University

Constructed response assessments, in which students represent their understanding in their language, reveals that students' ideas are much more complex than simply "correct", "misconception 1" or "misconception 2." Writing can provide instructors with insight into students' thinking that may not be captured by closed-form assessments. However, the time and resources required to evaluate constructed response assessments often prevent their use, particularly in large-enrollment introductory courses. In the Automated Analysis of Constructed Response (AACR) research group at Michigan State University, we are using lexical analysis software to help reveal student conceptual understanding. We take a two-stage approach to analyzing constructed responses. First, we use lexical analysis to extract key concepts from student writing. We then use extracted concepts as variables for statistical classification techniques to predict expert ratings of student responses. We present the results of lexical analyses of student writing on thermodynamics and acid-base chemistry in an introductory biology course.

33. Exploring the Efficacy of Supplemental Instruction in the Sciences

Cheston Saunders, *West Virginia University*
Thomas Kunz, *University of North Carolina at Wilmington*

General dissatisfaction with current science teaching methods, a changing student population, mediocre science achievement, and decreased interest in science are some of the many reasons why colleges and universities are examining the teaching practices of faculty in areas typically viewed as challenging academic fields. In response to the call for reformed science education, many colleges and university are instituting peer-learning programs such as Supplemental Instruction (SI). At a mid-sized university in the Southeastern United States, the researchers collected qualitative and quantitative data from students who participated in Supplemental Instruction sessions for science courses. The researchers found that across 2008, 2009, and 2010, there is statistically significant data to demonstrate that 1) participation in SI sessions fosters the development of study strategies, 2) SI sessions utilize learning activities distinct from those employed in lecture, 3) students feel as though they are encouraged to help one another in SI, and 4), students believe that as a result of participating in SI session, their GPA has improved.
In their presentation, the researchers will share the assessment methodologies utilized in their mixed-methods approach in addition to reporting the detailed results of data analysis.

34. Analyzing Interdisciplinary Tasks in a Physics Course for Life Science Majors

Julia Svoboda
Vashti Sawtelle
Chandra Turpen
Edward F. Redish
University of Maryland, College Park

Recent national reports reflect an emerging consensus among scientists and educators that undergraduate science education needs to better prepare students to reason and communicate across disciplines. This aim raises challenges for curriculum designers centering on what it means for a task to be interdisciplinary. At the University of Maryland, we have piloted one year of a new physics course aimed at life science majors that has explicitly taken up designing education contexts that support reasoning across disciplinary boundaries. We present a framework for examining the ways in which disciplinary bridges are built and provide illustrative examples of the "interdisciplinary" tasks used in this course. Our aim in presenting this analysis is to bring awareness to variety of ways in which tasks can be considered interdisciplinary (i.e. application tasks or reconciliation tasks) and to examine the implications of this variation for student learning outcomes (i.e. conceptual understanding or epistemological sophistication).

35. Analyzing Conceptual Gains in Introductory Calculus With Interactively-Engaged Teaching Styles

Matthew Thomas
Guadalupe Lozano
University of Arizona

Science education research has suggested that students who are engaged with subject matter in an active way have greater conceptual gains than students who are passive in their learning. Studies specific to interactive-engaged (IE) teaching styles (e.g. Just-in-time teaching, peer instruction) have shown larger gains in conceptual understanding by students. By developing a protocol for quantifying the interactive-engagement level of a classroom in various categories, our research aims to refine the notion of interactive-engagement and to identify characteristics of IE classrooms that are most strongly correlated with student conceptual gains. Concept inventories have allowed researchers to measure gains in conceptual knowledge in many subject areas, including introductory calculus. Our study combined gain results from the Calculus Concept Inventory given to over 500 introductory calculus students and classroom video data from 5 instructors. The videos are coded for occurrences of different types of interactive-engagement episodes, including incidences of sense-making, checking correctness, and immediate feedback from instructors and from other students. This approach to measuring interactive-engagement is novel because it does not rely on self-reporting of interactive-engagement levels and allows for analysis of specific aspects of interactive-engagement instead of classifying a classroom as IE or traditional lecture. Preliminary results will be presented.

36. Improving Student Understanding of Ionic Compounds with POGIL Instruction

Abdi Warfa, *University of Minnesota*
Jamie Schneider*, University of Wisconsin River Falls*
Gill Roehrig, *University of Minnesota*

Students often use molecular framework to represent ionic compounds at the particulate level. To address this issue, we developed POGIL (Process-Oriented Guided-Inquiry Learning) activities that specifically target student misconceptions related to molecular vs. ionic bonding. We used a quasi-experimental approach with a concurrent triangulation strategy in which one-group pretest–posttest quantitative data is coupled to qualitative data analysis to explore the effects of the intervention,. Our preliminary data suggests the POGIL activities we developed improved student representation of ionic compounds in aqueous solutions and reduced student reliance of molecular framework to describe ionic compounds at the atomic/molecular level. Our study provides proof of concept that targeted instructions inspired by evidence-based pedagogies can improve student's conceptual knowledge growth and reduce preconceived and alternate conceptions about chemical ideas. The preliminary findings and analysis of the data will be discussed.

37. Student Ways of Reasoning about Key Concepts in Linear Algebra

Megan Wawro
Virginia Tech

A rich understanding of key ideas in linear algebra is fundamental to student success in undergraduate mathematics, as well as in other STEM fields, such as physics, statistics, and engineering. Many of these fundamental concepts are connected through the notion of equivalency in the Invertible Matrix Theorem (IMT). This poster will present results from a larger study that investigated how, at both the individual and the collective level, a community of learners in a linear algebra classroom reasoned about the IMT over time. Classroom and interview data were analyzed via the tools of Toulmin's model and adjacency matrices. Presented results will highlight the ways of reasoning of one student, Abraham, concerning the concepts of existence and uniqueness of solutions, linear (in)dependence, span, and eigenvalues, as well how he reasoned about connections between these concepts. Analysis will also compare Abraham's ways of reasoning with those that developed at the collective level.

38. Do You "See" What I see? Students' Use of Biology Representation

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In 1961 a regulatory mechanism of protein synthesis in bacteria comprised of structural, regulator and operator genes was described. The classic representation of this "operon" system uses lines, boxes and shapes to represent DNA, genes, etc. Although operon diagrams are hallmarks of teaching transcriptional control, it is unclear if instructors know what their students "see" when they look at a classic operon diagram. To determine this degree of disparity, molecular biology students (n=56) were tested for their understanding of a depiction of an operon system using written, open-ended inquiry. Students were asked to assign meaning to the symbols and to describe the process. Responses/explanations revealed that many students do not "see" what the instructor sees and revealed gaps in understanding of central dogma and transcription. In-depth interviews validated written responses and revealed difficulties students have with scientific representation. These results will be useful in designing materials to address student difficulties with representations and Central Dogma concepts.

39. Using Introductory Research to Increase Success for At-risk STEM Undergraduates

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Universities across the nation are working to increase the number of STEM graduates. MTSU's FirstSTEP project funded by the National Science Foundation explores best practices for improving retention and graduation of STEM majors without the mathematical background needed to be successful in their desired major. Among other strategies, this project includes a team-based, guided- research experience for students. Research by Schwartz, et. al, (2008) indicates that students who cover one science topic in depth in high school experience greater success in college science courses. Can at-risk STEM majors who complete a three-week, introductory, science research program at the end of their freshman year experience similar success in their future science courses? In this study, we follow six teams through the research program and ask students and faculty to use Bloom's Taxonomy to determine to what extent the students had an in-depth experience in one area of science.