Contributed Poster Session and Poster Number (1.X or 2.Y)	Name	Institution, STEM discipline	Title	Abstract	Co-Authors
1.01	Timothy Abell	Miami University, Chemistry	Students' Ideas of Enthalpy and Entropy when Ionic Salts Dissolve	Research has shown that students struggle with explaining how the dissolving process and precipitation occur and what the resulting products look like at the particulate level. It has also been shown that students hold many misconceptions surrounding the abstract concepts of enthalpy and entropy. In our study we are investigating how students apply their knowledge of enthalpy and entropy to explain the dissolving process. Semi-structured interviews using hands on dissolution and precipitation reactions were conducted to elicit students' ideas about enthalpy and entropy changes during these processes. These tasks included the observation of exothermic and endothermic dissolution (including temperature changes), the insolubility of silver chloride, and the precipitation of silver chloride from mixing two aqueous solutions. Students' explanations ranged from discussing enthalpy and entropy changes of the system through symbolic and particulate representations to explanations including only mathematical equations. Findings will be presented through the lenses of enthalpy and entropy.	Stacey Lowery Bretz Miami University
1.02	Gregory Allen	Miami University, Chemistry	Connecting students' misconceptions about bonding concepts, acid/base reactions, and redox reactions	Students generate misconceptions and incorrectly connect concepts when they are trying to make sense of new information. The Bonding Representations Inventory (BRI), Acid Base Concept Inventory (ABCI) and Redox Concept Inventory (ROXCI) have previously been used to measure the prevalence of specific misconceptions in their specific subject. The three concept inventories use one two-tiered questions to identify students' understanding, reasoning, and common misconceptions. Our present study administered all three concept inventories to approximately 900 general chemistry students at a large midwestern university to investigate the relationships among students' understandings and misconceptions about bonding concepts, acid/base reactions, and oxidation-reduction reactions. A confidence scale was added to further characterize the robustness of each misconception. Connections between misconceptions were analyzed using cluster analysis and results will be presented.	Alexandra Glinos, Miami University Stacey Lowery Bretz, Miami University

1.03	Zahilyn Roche A	Miami University , Chemistry	Students' Ideas about Probability, Energy Quantization and Electronic Structure	Previous research highlights students' difficulties with gaining a conceptual understanding of the electronic structure of the atom. The concepts of probability and quantization have been proposed as key factors students must learn in order to have an understanding of the atomic structure. Additionally, research in mathematics education and psychology has investigated how students' ideas about probability influence their reasoning, resulting in inconsistent reasoning across a variety of problems. As part of a larger study, we are investigating general and physical chemistry students' understandings of electronic structure with regards to probability and energy quantization. We also seek to compare our findings about students' ideas of probability to the misconceptions reported in mathematics education and psychology. The end goal of our research is to develop a concept inventory (CI), which could be used by practitioners to identify their students' misconceptions about the electronic structure of the atom. We conducted semi-structured interviews with general and physical chemistry students asking them to compare multiple representations of the atomic orbitals in helium and carbon atoms, along with questions targeting students' interpretations of probability to elicit their understanding. Preliminary findings will be presented.	Stacey Lowery Bretz (Miami University)
1.04	Sarah Andrews	University of New Hampshire, Biology	Life Science Majors' Attitudes Toward Using Math in Biology	One challenge of efforts to improve quantitative instruction in undergraduate biology courses is negative student attitudes toward math, which may impact a student's performance on quantitative tasks. However, little empirical evidence exists regarding undergraduates' attitudes toward using math in a biology context (math-biology). To characterize math-biology attitudes among life science majors, we administered the previously validated Math-Biology Values Instrument (MBVI) online to 777 life science majors at 11 institutions across the US. This instrument measures students' interest in using math to understand biology, perceptions of the usefulness of math for a life science career (utility value), and perceptions of the personal cost (e.g., anxiety) of math in biology courses. Data were analyzed using linear mixed-effect models. Students who were the first generation in their family to attend college reported significantly lower interest and utility value and significantly higher cost than students who were not first generation. Additionally, female students reported significantly lower interest and significantly higher cost than male students. Our results suggest that instructional strategies geared toward increasing interest in, and/or reducing stress related to using math in biology could be beneficial for addressing the needs of diverse learners, particularly first generation students and women.	Melissa L. Aikens, University of New Hampshire, Dept. of Biological Sciences

1.05	Naneh Apkarian	San Diego State University, Mathematics	Talking about teaching: Social networks of instructors of undergraduate mathematics	The Research in Undergraduate Mathematics (RUME) community has focused on students' understandings of and experiences with mathematics. This project sheds light on another part of the higher education system: the social structure within the department surrounding undergraduate mathematics instruction. This poster reports on the interactions of members of a single mathematics department, centered on their conversations about undergraduate mathematics instruction. Social network analysis of this groups sheds important light on the informal structure of the department, in that instructors of coordinated courses form a tight subgroup within the department.	
1.06	Jessie Arneson	Washington State University, Biochemistry	Examining the cognitive load of visual representation	Working memory can accommodate few elements simultaneously, but experts develop mental schema to link multiple elements together, increasing the amount of information processed at once. Instructional materials should support schema development without overwhelming working memory. Cognitive theory of multimedia learning suggests including visual representations may increase information uptake while reducing strain on working memory as processing occurs through visual and verbal channels. Conversely, cognitive load theory indicates interpreting the representation involves additional processing that may overload the working memory, leading to decreased task performance. Reported are pilot data collected from two semesters of undergraduate biochemistry, in which students in one semester were provided more practice with visual-based tasks at all Bloom's levels. Students in both semesters scored similarly on lower-order final exam questions, but students receiving more practice with visual representations performed significantly worse on higher-order exam items. Due to a lack of nonvisual higher-order questions in the pilot study, we cannot ascertain whether decreased performance may be more pronounced when students are assessed with strictly verbal prompts. Thus, we seek to examine how adding visual representations impacts student performance by implementing isomorphic assessment items, differing in presence or absence of visual representation, in three undergraduate courses.	Erika Offerdahl, Washington State University
1.07	Leslie Atkins Ellio	Boise State University, Physics	The Implicit Contract	The goal underlying the research presented here is to articulate a set of design principles that support transfer. Ultimately, I will argue that transfer is fostered in classrooms that are intercontextual: where out-of-class contexts (e.g. social, physical, temporal, functional contexts) are invoked by students in scientifically consequential ways as they develop and vet ideas. In this poster, I focus attention on distinctions between classrooms that support intercontextuality and those that don't. In particular, I will argue that intercontextuality in class is supported by disruptions (Ma, 2016) to traditional instructional practices that confer power on students (that is, devolution - Brousseau/Warfield, 2006).	

1.08	Kinsey Bain	Purdue University, Chemistry	Blended processing: Mathematics in chemical kinetics	How do non-major students understand and use mathematics to solve chemical kinetics problems involving integrated rate laws? Informed by different bodies of DBER literature, this central question motivated this project and guides our work. The theoretical framework, personal constructs (a blend of personal and social constructivism) lays the foundation for this study. Semi-structured interviews with 36 general chemistry students, 5 upper-level physical chemistry students, and 3 chemical engineering students were conducted using a think-aloud protocol. The use of a Livescribe pen afforded the collection of audio and written data. The audio data were transcribed, and screenshots of students' written data were inserted into the transcripts. To aid analysis, these transcripts were then refashioned into problem-solving maps. Open coding of the problem-solving maps reveals initial themes regarding students' understanding and use of mathematics when solving chemical kinetics problems. Blended processing was used as a methodological framework to guide the coding process. Through this analysis, distinctive types of blended processing have emerged. Other findings are also being explored, such as the relation of students' problem-solving steps with their blended processing ability.	Jon-Marc G. Rodriguez, Purdue University Alena Moon, University of Michigan Marcy H. Towns, Purdue University
1.09	Anna Marie Berg	Portland State University, Mathematics	The Multiple Representations of the Group Concept	This poster explores the various representations of groups found within introductory abstract algebra textbooks. Representations play an essential role in students understanding of mathematics (Goldin, 2002). Textbooks provide one source for analyzing the intended curriculum and what representations students may have access to within their introductory course.	Kathleen Melhuish, Texas State Univeristy San Marcos Dana Kirin, Portland State University
1.10	Kristen Bieda	Michigan State University, Mathematics	The ICALC^2 Project: Integrating Chemistry and Algebra in College Courses	Undergraduate students with inadequate mathematics preparation face significant challenges to completing a STEM degree, including placement into non-credit-bearing remedial (NCBR) algebra courses and insufficient mathematics skills to succeed in gateway science courses such as general chemistry. The ICALC2 project aims to provide integrated support in both an NCBR algebra course and an Introduction to Chemistry course to enhance students' mathematical preparation for STEM coursework. In particular, we designed instructional interventions focused on mathematical topics that typically present barriers to learning chemistry content: (1) proportional reasoning, including unit conversions; (2) linear rates of change, including understanding that slope is a rate of change that can expressed as a ratio and interpreting the rate of change from a graph; (3) modeling covarying relationships with functions; and (4) translating between multiple representations. We piloted these interventions in an Introduction to Chemistry course (CEM 121) and in an enrichment workshop (MTH 100E) accompanying a NCBR algebra course. Interventions in CEM 121 provided just-in-time instruction in the mathematics required to support chemistry learning, while those in the NCBR course used chemistry applications to provide context and relevance for the mathematics topics. Examples of interventions from the two courses and the associated instructional goals will be presented.	Lynmarie Posey (Michigan State University)

1.11	Mitchell Bruce	University of Maine, Chemistry	CORE: Using analogical reasoning in lab to foster macroscopic-submicroscopic connections	Prior studies show that many students have difficulty in coordinating ideas across macroscopic, submicroscopic and representational levels. This is problematic in the intro chemistry lab where interpretation requires thinking about nonobservable entities like atoms and molecules. Analogical reasoning is considered an essential skill to connect macroscopic and submicroscopic domains. The CORE laboratory learning cycle (Chemical Observations, Representations, Experimentation) involves: making chemical observations (phase 1); using analogical reasoning to explore a representation (phase 2); and designing experiments (phase 3). This poster presents preliminary findings from the first year of an NSF-sponsored research study, which is designed to answer: 1) How do students use analogical reasoning in constructing scientific arguments related to chemistry lab work? and 2) How does repeated exposure to CORE experiments influence students' abilities to coordinate ideas across macroscopic, submicroscopic and representational levels? A cohort of 27 undergraduate students in a first semester general chemistry lab course were selected to participate. The study employed 3 surveys to characterize 1) prior experience with inquiry-based labs; 2) operational level of thinking (GALT) and 3) meaningful learning in the laboratory (MMLI). Student pre-lab assignments, lab notebooks, and lab reports are being examined and preliminary findings will be described.	Joseph C. Walter (a) Mitchell R. M. Bruce (a,b) and Alice E. Bruce (b) (a) Center for Research in STEM Education (RiSE), University of Maine, Orono, ME 04473. (b) Department of Chemistry, University of Maine, Orono, ME 04473
1.12	Kelli Carter	University of South Florida, Biology	Text analysis models for assessing understanding of structure and function	Formative written assessment is a low stakes method to reveal student understanding, but can be time consuming to grade. We used computerized scoring to facilitate the analysis of student writing. We designed 10 written questions using the core principle structure and function and developed scoring models to predict human scoring of the core concept based on text analysis categories. Over 4000 written student responses from general physiology and human anatomy and physiology courses were analyzed using text analysis and logistic regression. Models for five questions produced acceptable human-computer agreement (Kappa >0.7). The core concept structure and function is interdisciplinary with roots in biology, chemistry and biochemistry. These models will provide feedback to science instructors on their students' understanding of structure and function.	Luanna Prevost, University of South Florida
1.13	Warren Christens	North Dakota State University, Physics	Student Resource Use in Non-Cartesian Coordinate Systems	To be filled in by Warren Later	Brian Farlow, NDSU; Micheal Loverude, Cal St Fullerton; Marlene Vega, Cal St Fullerton

1.14	Renee Cole	University of Iowa, Chemistry	Designing for sustained adoption: Shifting from Dissemination to Propagation	Systemic and sustained adoption of research-based instructional practices is a goal of those who develop these practices, funding agencies, and many educators. Scholarly studies and national reports document failure to achieve systemic adoption despite compelling evidence of efficacy of these instructional practices. We have used the research literature to develop a six-item rubric to predict the likelihood that an education development project will successfully spread. We applied this rubric to 71 education development proposals funded by the National Science Foundation in 2009. The rubric predicted that 80% of these would be unsuccessful in spreading their innovations. Data collected for a subset of these projects, via web searches and interviews with the PIs, suggests that the rubric can be used to make reasonably accurate predictions. Two paradigms, dissemination and propagation, characterize patterns within efforts to achieve the desired goal of transforming undergraduate STEM education. Based on our synthesis of the literature, our analysis of successfully propagated innovations, and our analysis of a subset of funded NSF CCLI proposals, we argue that a primary reason for the lack of adoption is that developers focus their efforts on dissemination (spreading the word) instead of propagation (promoting successful adoption). Analysis indicates that planning for scale and propagation typically occur after the product is developed and often leads to failure to propagate. We argue that such planning needs to occur from the very beginning of a project.	Charles Henderson - Western Michigan University; Jeff Froyd - Texas A&M University; Raina Khatri - Western Michigan University; Courtney Stanford - Virginia Commonwealth University; Debra Friedrichsen - MJ Innovations
1.15	Frank Conic	University of Florida, Mathematics	Analysis of Impacts of Senate Bill 1720	Many educators regard educating the unprepared and under-prepared students as the most pressing problem in higher education today (Bailey & Cho, 2011). Developmental Education programs have been considered as the panacea to bridge the gap for underprepared students. Calls for changes in the developmental education programs have intensified over the past two decades with the emergence of studies showing that developmental programs are costly, and do not necessarily improve students' chances for obtaining a college certificate or degree, (Venezia & Hughes, 2013). One of the outcomes of the mounting opposition to developmental programs in the State of Florida is the passage of Senate Bill 1720 (SB 1720) which was signed into law in July 2013. The law mandates Students who graduated from a Florida public high school in 2007 or later will not be required to take placement tests or to enroll in developmental classes, however, enrolling in developmental courses will be strictly up to the student based on their academic advisor. The chief methodological goal of this study is to measure the impact of SB 1720 on student achievement by examining outcomes of students at a large community college enrolled in a required gateway mathematics course from 2014-2017. These students exercised their choice to opt in to enroll in recommended developmental courses or opt out the developmental courses and enrolled in the gateway mathematics course	

1.16	Joel Corbo	CU Boulder, Physics	Departmental Action Teams as a Mechanism for Promoting Departmental Change	Since 2014, we have facilitated and studied Departmental Action Teams (DATs) in several STEM departments at a large research-intensive university as part of a change effort to improve undergraduate STEM education. A DAT is a departmentally-based team of faculty, students, and staff working together to address a broad-scale educational issue. Rather than trying to "solve" the problem themselves, the DAT focuses on creating structures to address the issue in a sustained, ongoing fashion and to positively impact department culture. Through this process, DAT participants come to see the value of collective action in trying to make change. DATs are supported by external facilitators who provide DAT participants with expertise in education and institutional change research, logistical support, connections with related work across campus, and a functional process for achieving their goals. Work with several pilot DATs has been successful, and this project is now expanding to run more DATs at two universities, with the goals of (1) institutionalizing the DAT model on these campuses, (2) learning how different departmental and institutional contexts impact the success of DATs, and (3) developing robust measures of departmental culture around education.	Daniel Reinholz, San Diego State University Noah Finkelstein, CU Boulder Mary Pilgrim, Colorado State University
1.17	Leanne Doughty	University of Colorado Denver, Physics	Understanding Active Learning and Learning Assistant Support in Undergraduate Science Classrooms	There is strong evidence that the implementation of active learning methods in undergraduate science courses can lead to increased student conceptual understanding and course achievement. There is also evidence that Learning Assistants, a practice embedded resource, can support the use of active learning methods in the large lecture science classroom. Though researchers have many ideas for why active learning helps students learn, achieve, and persist in a course, we do not know what specific characteristics of active learning contribute the most to these outcomes, or the mechanisms by which these activities work. Further, it is unclear how the Learning Assistant model contributes to student success in these courses. In our work, we use Activity Theory to characterize large enrollment undergraduate science courses as systems and to examine how Learning Assistants influence the classroom system, and ultimately student outcomes. We are observing, characterizing, and interpreting the activities and interactions occurring in LA supported and non-LA supported science courses at three large research universities. This poster explains our conceptualization of the activity system and describes our efforts to characterize the components and the interactions between components of that system, with a particular focus on active learning tasks and LA-student interactions.	Leanne Doughty (University of Colorado Denver), Brian Farlow (North Dakota State University), Jeff Boyer (North Dakota State University), Laurel Hartley (University of Colorado Denver), Hagit Kornreich-Leshem (Florida International University), Laird Kramer (Florida International University), Paul Le (University of Colorado Denver), Amreen Nasim Thompson (University of Colorado Denver), Mary Nyaema (Florida International University), Robert Talbot (University of Colorado Denver)

1.18	Jason Dowd	Duke University, Physics	Identifying empirically-derived “learning dispositions” relevant to student learning and writing	We have investigated how students’ motivation, self-efficacy in science and writing, and epistemic beliefs about the nature of scientific knowledge mediate and moderate the scientific reasoning and writing skills that students exhibit in writing an undergraduate thesis. Synthesizing data that have been collected across multiple STEM departments and institutions over several years, we share findings regarding (1) the relationships among these dimensions, (2) changes to those relationships throughout one semester of a writing-intensive capstone thesis course, and (3) relationships between such characteristics and other learning outcomes. Specifically, we carry out cluster analyses to identify multiple “learning dispositions” that characterize student engagement and scientific identity development. Collectively, this work speaks to both cross-discipline and discipline-specific aspects of engagement in the authentic practice of writing in STEM. Writing is a high-impact practice associated with improved learning in STEM disciplines. Previous work indicates that scaffolding the writing process in a thesis-writing course can be an effective strategy for promoting learning, but the underlying processes are not well-understood. We endeavor to better understand these processes. Ultimately, we intend for this work to motivate institution- and department-specific changes.	Robert J. Thompson, Jr., Duke University; Julie Reynolds, Duke University
1.19	Mary Emenike	Rutgers University, Chemistry	Introductory chemistry and physics: investigating cognitive and affective domains	While Rutgers has enjoyed isolated success with course transformation in a variety of STEM disciplines, most of the courses taken by introductory engineering students remained largely passive in structure and traditional in content. Programmatic changes were introduced in the calculus-based physics course for engineers over the past four years, while the general chemistry course for engineers remained relatively unchanged over this time period. The least effective traditional structures were replaced with research-validated instructional practices; specifically, invention-tasks and collaborative problems were introduced into the recitation sections to compliment mini-labs. The institutionalized Learning Assistant (LA) Program enabled in-class transformations in physics, but was utilized only to offer some supplemental study groups in general chemistry. Many of the students in this 4-year study co-enroll in both chemistry and physics during their first year at Rutgers. The CLASS-Phys and FCI instruments were administered in the physics course, while the CLASS-Chem and CCI were administered to students in general chemistry. A series of proportional reasoning items (PRAT) were also administered to students in both courses. Changes in students’ content knowledge and affective characteristics (measured three times across the academic year) will be reported and compared between the chemistry and physics course experiences.	Suzanne Brahmia, Misha Faerovitch, Charles Ruggieri

1.20	Timothy French	DePaul University, Chemistry	Teaching Scientific Writing and Communication: A Cross-Disciplinary Course Collaboration	Scientific knowledge is constructed through the performing of experiments, the analyzing and interpreting of data, and the writing of coherent scientific arguments. Therefore, teaching students to be professional scientists requires teaching them to be professional writers within their discipline. We have created a new course for graduate students in chemistry that brings together instructors from the Department of Chemistry and the Department of Writing, Rhetoric, and Discourse at DePaul University. By leveraging our respective strengths and areas of expertise, we afford students the opportunity to rigorously improve their written and oral communication skills within scientific contexts. The philosophy and structure of this course will be discussed as will a proposed follow-up assessment study looking at the impact this innovative course structure has on student learning.	Sarah Read, DePaul University
1.21	Cody Gette	North Dakota State University, Physics	Examining the role of insight in student reasoning*	Many students fail to arrive at a correct solution to a given problem even though they possess the required knowledge and skills to do so. We aim to identify cognitive mechanisms that may account for the observed reasoning patterns. In some cases, an unproductive heuristic representation of a problem may lead to a mental impasse. To break the impasse, the problem representation may need to be changed. This mental change to a more productive representation is known as “insight”. This switch often results in a fast, immediate solution (an “Aha!” moment). It does not stem from gaining additional knowledge and is rather due to a change in the reasoner's initial heuristic model. The relevance of insight to physics learning will be illustrated in multiple contexts. Instructional implications will be discussed. *This material is based upon work supported by the National Science Foundation under Grant Nos. DUE-1431857, 1431541, 1431940, 1432052, 1432765.	Mila Kryjevskaia; North Dakota State University
1.22	Dan Grunspan	Arizona State University, Biology	Study partnerships: How they form, dissolve, and impact learning	Learning in college classrooms is a highly social process with potentially impactful relationships forming between students. This is especially true in active learning courses, where peer interactions play a critical role in the learning process. The details of these social dynamics often remain hidden from instructors. Thus, we know little about how many peers students study with, how those peers are similar, and whether these peers effect student learning. A more nuanced understanding of these relationship dynamics may be useful for classroom design. Longitudinal analyses of who students study with for each exam throughout three large active learning introductory biology classrooms were performed to explore 1) what makes study partnerships more likely to form, 2) what makes study partnerships more likely to persist, and 3) the impact study group composition has on exam performance. We find that ethnic homophily is a strong predictor of study partnership between students and some evidence of assortment by performance in the class. Lastly, we find a positive within-student association between the number of study partners and exam scores.	Benjamin Wiggins, University of Washington

1.23	brant hinrichs	drury university, Physics	Helping Students Make Sense of non-Cartesian Unit Vectors in Upper Level E&M	An upper level 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 classes and apply it to help represent and make sense of the physics. In 2010 we showed that students at different levels (pre-E&M course, post-E&M course, 1st year graduate students) and in different disciplines (physics, electrical engineering) had great difficulty using non-Cartesian unit vectors appropriately in a particular context. Since then we have developed a set of four linked problems that students work on in groups and discuss as a class, to help them confront and resolve some of their difficulties. This poster presents those problems, typical student responses, and three years of post-tests (given on quizzes or exams) that were used to assess their effectiveness.	
1.24	Steven Jones	Brigham Young University, Mathematics	STEM connections: Examples of conceptual blending between biology and mathematics	STEM integration is an important area of work for mathematics, science, and engineering education researchers. While much work has described connections between physics and mathematics, or engineering and mathematics, there is less work that has examined connections between biology and mathematics. This poster provides examples of connections between (a) the Hardy-Weinberg equations and Punnett squares from biology and (b) two quite distinct mathematical topics: polynomial multiplication and probabilities involving independent events. Through the lens of "conceptual blending," I briefly relate some examples of students creating blended spaces between the biology input spaces and the mathematics input spaces. These blended spaces enhanced students' understanding of both the biology concepts and the mathematics concepts. For instance, considering polynomial multiplication and Hardy-Weinberg equations together helped some students make connections that strengthened their understanding of both. Similarly, seeing probabilities involving independent events and Punnett squares together helped support students' understanding of each. These results suggest possible examples where STEM integration could incorporate concepts from biology and mathematics that mutually reinforce each other.	Liz Bailey, Brigham Young University - Hawaii
1.25	Alexis Knaub	Western Michigan University, Physics	Iowa State Calculus Team-based Learning Course Transformation	Department of Mathematics at Iowa State has recently implemented a team-based learning (TBL) approach to some of their Calculus 1 courses. We report on results from the Calculus Concept Inventory and other assessments that have suggested that the TBL has been more effective than traditional pedagogy. These data have guided the next steps for TBL at Iowa State. Next steps include spread to other sections and other pedagogical innovations to further enhance student learning.	Travis Peters (Iowa State), Heather Bolles (Iowa State), Elgin Johnston (Iowa State), Craig Ogilvie (Iowa State)

1.26	Regis Komperda	Portland State University, Chemistry	Influence of wording on motivation instrument functioning: A quantitative investigation	High quality instruments are necessary to support research investigating classroom environments, the effects of different pedagogical approaches, and other discipline-based educational research. Assessing instrument quality requires examination of evidence for the reliability and validity of scores in every environment in which the instrument is used. This research describes the evaluation of data obtained from administration of an existing student motivation instrument in lower-division undergraduate biology, chemistry, and physics courses. Nearly 2000 responses were collected online from the randomized administration of multiple versions of the instrument in which either the ‘science’ or the discipline-specific wording, such as ‘chemistry’, was used. Evidence for the generalizability of student responses across variations in item wording as well as course type is being examined using factor analytic methods. Demonstrating the generalizability of the instrument will facilitate cross-disciplinary research by providing a meaningful measure with which to compare student motivation in different undergraduate science courses.	Kathryn R. Hosbein, Portland State University Jack Barbera, Portland State University
1.27	Mila Kryjevskaia	North Dakota State University, Physics	Probing the relationship between cognitive reflection and student reasoning*	As part of a multi-year, multi-institutional effort, we have been investigating the development of student reasoning skills in physics courses. In particular, we have been focusing on the identification of factors and instructional circumstances that appear to enhance or suppress the application of correct reasoning approaches. Previously, we employed the Cognitive Reflection Test (CRT) to measure students’ abilities to engage analytical thinking to evaluate (and possibly override) initial intuitive ideas. We have identified a strong correlation between CRT scores and learning gains, as measured by the FMCE. In this presentation, further evidence for the impact of cognitive reflection skills on students’ learning will be discussed. A correlation between CRT scores and student performance in the specific context of frictional forces will be examined. Implications for instruction will be discussed. Abstract Footnotes: *This material is based upon work supported by the National Science Foundation under Grant Nos. 1431857, 1431541, 1431940, 1432052, 1432765.	Nathaniel Grosz, Cody Gette, MacKenzie R. Stetzer, Andrew Boudreaux

1.28	Sandra Laursen	University of Colorado Boulder, Chemistry	When is seeing believing? Challenges in characterizing STEM teaching	For many studies of classroom practices and outcomes in higher education, it is important to characterize teaching. Researchers may wish to describe teaching practice across an institution or a discipline, relate student outcomes to teaching practices, or measure change in teaching practice over time. Thus we must understand what can be learned from different approaches to characterizing teaching, and what are the strengths and limitations of each of these methods. Motivated by a need for good methods to measure change in teaching after professional development, we have recently conducted two studies of measuring teaching practice in college mathematics. In one study, we compare classroom observations of instructors to survey items used to characterize teaching before and after professional development workshops. In a second study, we closely examine the practices of seven early-career instructors, comparing insights gained from student and instructor surveys, observations, and coding of syllabi and major assessments. Here we share highlights of findings from these studies that suggest how and when each measurement method can be useful. While observation is often considered the most valid approach for characterizing teaching, we challenge common practices around time-based sampling of class observations to characterize STEM instruction at the course level.	Tim Archie, U. Colorado Boulder Charles N. Hayward, U. Colorado Boulder Brian Katz, Augustana College Timothy J. Weston, U. Colorado Boulder
1.29	Katherine Lazent	University of Iowa, Chemistry	General chemistry students' understanding of the nature and purpose of models in chemistry contexts	Understanding the nature and purpose of models, including mathematical models, is critical to enabling undergraduate chemistry students to use models to predict and explain phenomena. To gain a sense of how students understand different models in the general chemistry curricula, we developed a survey to examine general chemistry students' reasoning about specific mathematical models in the general chemistry curriculum. Here, we will discuss emerging themes pertaining to how students think about the nature and purpose of models including the ideal gas law and rate laws. Preliminary findings highlight that even after a year of chemistry coursework, many students hold naïve and inconsistent conceptions of the nature and purpose of mathematical models and their use in science.	Dr. Nicole Becker

1.30	Dennis Lee	Clemson University, Biology	Students' Scientific Ways of Knowing in an Introductory Biology Course	Science educators design instructional strategies to help students gain knowledge, but the ontology of how students approach knowledge acquisition typically remains unclear. We conducted a pilot study in a project-based introductory biology class to explore students' ways of knowing while constructing a scientific argument. Student interviews and artifacts (reflections and project reports) were analyzed through the lens of epistemic beliefs. Initial analysis of the data revealed that some students believe knowledge comes from authority, a way of knowing that requires no justification or construction of knowledge. Other students presented the argument from an ethical way of knowing, using moral principles to justify their argument, or from a medical way of knowing, using patient well-being to justify their stance. Still other students used core concepts in biology such as evolution or structure and function – a biology way of knowing – to support the reasonableness of their claims. This suggests that while some students are capable of understanding and using a scientific way of knowing, they may not adopt this way of knowing when appropriate. Exploring student ways of knowing will help in building educational strategies that encourage students to use scientific ways of knowing to foster a deeper understanding of science.	Dylan Dittrich-Reed, Clemson University; Lisa Benson, Clemson University
1.31	Elise Lockwood	Oregon State University, Mathematics	Computational Thinking and Activity in Mathematics: An Initial Discussion	Computational activity is becoming increasingly relevant in our society, and computing is an important mathematical disciplinary practice among mathematicians and mathematics students. Computational thinking (Wing, 2006; 2008) is a construct from computer science, which, while difficult to define, may be a type of thinking we want to foster among students. In this preliminary work, I discuss two projects in which I seek to better understand computational thinking and activity in mathematics. First, I present results from a study in which I interviewed mathematicians about computational thinking and activity in their own work (in particular, I discuss a term called algorithmic thinking). Second, I describe a new project investigates how computational activity can help develop and improve students' combinatorial thinking. I share preliminary results and facilitate a theoretical discussion about both studies.	
1.32	Brandon Lunk	Texas State University, Physics	Attitudes of Life Science Majors Towards Computational Modeling in Introductory Physics	Biological and health care majors comprise one of the largest populations of students enrolled in physics courses each year. Because of this, there is a growing interest within the physics and biology communities to restructure the introductory physics courses for life science majors to better support the needs of these students. In this context, computational modeling could prove to be an accessible and compelling tool for exploring biologically and medically relevant phenomena within in the physics course. As a first step leading to implementation, we conducted an exploratory study to help us learn about life-science majors' attitudes towards programming. Our observations suggest that these students had an apprehension towards programming but at the same time held a positive attitude towards data tables, which can be used to scaffold more rigorous programming in the classroom.	Anna Lewis, Elon University; Robert Beichner, North Carolina State University

1.33	Louise Lynch	University of Nebraska-Lincoln, Biology	Situating Biology Faculty Technology Perceptions in TPACK	Technological pedagogical content knowledge, referred to as TPACK (Mishra & Koehler, 2006), is the leading conceptual framework for explaining and improving teacher knowledge needed to successfully integrate technology in K-12 education. Instructional technologies are just as pervasive in higher education, where instructor knowledge bases and instructional landscapes likely differ. A multiple case study was carried out to better characterize biology instructor's technology uses in undergraduate biology classes, and explore how faculty's teaching perceptions explain their technology integration. The findings will connect faculty perceptions to TPACK and influence efforts to measure and improve successful technology integration in higher education settings.	Marilyne Stains, UNL; Doug Golick, UNL; Trisha Vickrey, UNL
2.01	Vinayak Mathur	Georgetown University, Biology	Faculty Training and Student Performance Gains in Bioinformatics	Bioinformatics is an interdisciplinary field that brings together mathematics, statistics, and computer science to analyze biological sequence information. Anyone with access to a computer, the internet, and minimal training in this field can contribute to authentic genomics research. Yet many biology faculty may not feel comfortable teaching bioinformatics to their students because they lack training. To overcome this challenge, the Genome Solver project aims to empower undergraduate faculty by offering training and resources for creating hands-on bioinformatics course materials. In this study, we measured student performance using a 20-question multiple choice quiz delivered before and after bioinformatics instruction. Data collected from 641 students at five different schools demonstrated that bioinformatics instruction led to learning gains on a variety of bioinformatics topics. Student performance increased for all five schools suggesting that bioinformatics training workshops are an effective means of encouraging faculty to engage in bioinformatics instruction and positively influence student learning.	Gaurav Arora (Gallaudet University), Mindy McWilliams (Georgetown University), and Anne Rosenwald (Georgetown University)

2.02	Becky Matz	Michigan State University, Chemistry	Incorporating the Three Dimensions in Gateway Science Courses	The 2012 NRC report, A Framework for K-12 Science Education, introduced the idea of three-dimensional learning as a guide to help students develop a robust understanding of science. Three-dimensional learning helps instructors to define what they want students to learn (core ideas), what they want students to do with their knowledge (scientific practices), and how students should connect their knowledge across science disciplines (crosscutting concepts). Multiple projects and activities at our university have encouraged faculty to improve gateway courses by incorporating the three dimensions into their assessments and instruction. We developed the Three-Dimensional Learning Assessment Protocol (3D LAP) as a tool for characterizing the potential for assessment tasks to elicit evidence of three-dimensional learning. In coding approximately 5,000 exam items from 200 course sections of introductory biology, chemistry, and physics course exams, we find evidence that faculty are now incorporating more three-dimensional items into their exams. The development of a corollary protocol for for characterizing the three dimensions in teaching is underway. Student grades, drop-fail-withdraw rates, and persistence in STEM degree programs will be compared across course sections based on the extent to which they reflect the three dimensions in assessments.	James T. Laverty, Kansas State University; Marcos D. Caballero, Michigan State University; Justin H. Carmel, Michigan State University; Diane Ebert-May, Michigan State University; Cori L. Fata-Hartley, Michigan State University; Deborah G. Herrington, Grand Valley State University; Lynmarie A. Posey, Michigan State University; Jon R. Stoltzfus, Michigan State University; Ryan Stowe, Michigan State University; Ryan D. Sweeder, Michigan State University; Sonia M. Underwood, Florida International University; Melanie M. Cooper, Michigan State University
2.03	Melody McConne	North Dakota State University, Biology	The Effect of Departmental Social Context on Instructor Assessment Thinking	In the interest of improving undergraduate science education, we are investigating how an instructor’s social context (measured by informal social interactions of instructors within a department) affects his/her attitude toward teaching ideas, potentially mediating the adoption of evidence-based instructional practices. Within a supportive departmental environment in which many potential barriers to faculty instructional change have been removed, we chose to focus on instructor ideas about assessment, since effective assessment is often indicated as a critical aspect of effective active learning. Using the Faculty Self-Reported Assessment Survey (Hanauer and Bauerle 2015), we surveyed undergraduate biology instructors within a single department at a research university on their assessment knowledge, practices, attitudes, and confidence. We also asked them to indicate the other instructors in the department with whom they interact about teaching, about research, and socially, and which instructors they saw as a resource for teaching ideas within the department. The survey was repeated once per semester over a period of two years. Results will be presented showing the relationship between instructor assessment thinking and node-level network attributes over time, and the structure of the network produced by instructor-reported teaching related interactions will be described.	Lisa Montplaisir, North Dakota State University; Erika Offerdahl, Washington State University

2.04	Chris Minter	Michigan State University, Chemistry	Characterizing Student Explanations of Atomic Emission Spectra	The goal of this study was to characterize general chemistry students' explanations of atomic emission spectra to gain insight into how students understand the mechanistic process for how atomic spectra are created. We analyzed student explanations of atomic spectra using a modified Knowledge Integration Framework that was used to characterize the extent to which students connect together relevant concepts within their responses. We present our approach used to analyze student explanations of phenomena and discuss how it can be used to gain insight into how students understand the relationship between concepts.	Melanie Cooper (Michigan State University) Justin Carmel (Michigan State University)
2.05	Bahar Modir	Kansas State University, Physics	"Looking ahead" as an extended readout strategy in EM	As part of a larger project to investigate how upper-division students solve mathematically-intense problems, we use coordination class theory to describe how students connect physical scenarios with mathematical insight. Within coordination class theory, students read information out of problem statements, connecting the specifics of the problem with generalized conceptual schemata (the "coordination class") in a causal net. While previous research using coordination classes has focused on identifying particular coordination classes or details of the causal net, our research focuses on an extended readout strategy, which we call "looking ahead". To characterize the mechanism of looking ahead, we study students' problem solving with separation of variables and Taylor series expansions. When students look ahead in a problem, their mathematical and physical insight can help them avoid time consuming calculations. We will illustrate the structure of looking ahead with video-based classroom data.	Eleanor C Sayre - Kansas State University
2.06	Jenni Momsen	North Dakota State University, Biology	Unpacking how and why conceptual models promote learning in biology	Scientists routinely use models to represent and evaluate knowledge, foster collaboration and communication, and test hypotheses about system properties. Although models and modeling are common in science practice, college STEM learners, particularly in introductory courses, rarely engage in modeling activities beyond interpretation of provided models in textbooks. In biology, creating and interpreting models of all types is increasingly emphasized as a core competency. At the undergraduate level, little research has investigated how the practices of creating and interpreting models impact student learning of biology or support the development of discipline competency. As part of a multi-institutional collaboration, we are investigating the role of conceptual modeling in promoting learning about biological systems in undergraduate biology Specifically, we are working to (1) develop a systems thinking framework for introductory biology, (2) characterize the skills and knowledge elicited during modeling activities, (3) compare knowledge and reasoning elicited on models versus other conceptual assessments, and (4) identify instructional interventions that promote improvement in students' modeling and systems thinking skills. Through this research, we will better understand how and in what contexts modeling serves to promote student learning about biological systems.	Tammy Long, Michigan State University Elena Bray Speth, St Louis University Caleb Trujillo, Michigan State University Sara Wyse, Bethel University

2.07	Alena Moon	University of Michigan, Chemistry	Faculty conceptions of writing and its role in the classroom	Writing is widely recognized as fundamental to the construction and communication of scientific knowledge. Building on this relationship between writing and knowledge construction, writing-to-learn (WTL) activities have shown to be effective in many STEM classrooms. Science education studies have elicited scientists' conceptions of their own writing practices, while writing studies have explored instructor conceptions of writing instruction. This study bridges those two lines of inquiry by exploring how research-intensive STEM faculty conceive of writing and its role in the STEM classroom. To this end, 33 STEM faculty across multiple disciplines and positions were interviewed about writing and their ideas about its role in their classes. A phenomenographic analysis resulted in four faculty "types" consisting of unique combinations of concept and practice, organized according to compatibility with WTL. Profiles were built that describe unique conceptions, desired outcomes, and challenges for each type. These profiles, along with a discussion of disciplinary differences, will be presented.	Anne Gere, University of Michigan Ginger Shultz, University of Michigan
2.08	Kevin Moore	University of Georgia, Mathematics	Broadening students' representational experiences	Students' representational activities are key to their success in STEM fields. Specifically, students' representational activities must be sophisticated enough to support their constructing productive meanings for STEM ideas and concepts. In this poster, I draw on Piagetian ideas and educational research to frame the sophistication of students' ways of thinking for graphing. Namely, I illustrate distinctions between those ways of thinking dominated by sensorimotor experience and those ways of thinking dominated by the coordination of mental actions. Against the backdrop of these distinctions, I argue that we, as educators and researchers, need to broaden students' representational experiences. Instructionally, doing so can afford students increased opportunities to construct productive and generative meanings for ideas and concepts that connect STEM fields. In terms of research, broadening students' representational experiences enables researchers to form more viable and detailed working hypotheses of students' ways of thinking for graphing and related topics.	

2.09	Megan Nagel	Penn State Greater Allegheny, Chemistry	Student comparisons between ion interactions and macroscopic examples from physics	Potential energy is a conceptually rich topic that is relevant for providing the explanatory power for numerous energy changes in chemical contexts. Energy changes related to phase changes, bonding, and solution formation are all related to changes in a system's potential energy. Yet, potential energy presents many documented difficulties for students. We have been examining the most effective approaches for using students' existing correct ideas about potential energy to help support their understanding in chemical contexts. Our evidence suggests that some common analogies, like magnetic attractions, used for electrostatic interactions are appealing to students, but may ultimately reinforce incorrect ideas regarding potential energy changes of the system. Other potential energy examples, like those involving gravitation may avoid reinforcing student misconceptions, but suffer because the connection to electrostatics is not as obvious to students. We hope that by better understanding how students make interdisciplinary connections regarding potential energy, materials can be designed to support a robust and functional understanding of this important topic throughout the chemistry curriculum.	Beth Lindsey, Penn State Greater Allegheny
2.10	Abhilash Nair	Michigan State University, Physics	Exploring life-science students' conceptions of the relevance of physics	I present in-progress work of investigating student conceptions of relevance in the introductory physics classroom. This work is situated in the first semester of a studio physics for the life-sciences course aimed at leveraging students' disciplinary expertise in biology and chemistry as they learn physics. Physics is often communicated via policy recommendations and program requirements as being relevant and important for the future of life-science students, but often these students disagree. In trying to address this disconnect, I share analysis of interviews with students in the early weeks of the course to demonstrate that our current understanding of relevance in physics needs to be expanded.	Paul Irving (Michigan State University), Vashti Sawtelle (Michigan State University)

2.11	Erika Offerdahl	Washington State University, Biochemistry	Measuring instructor-generated feedback as a critical component of evidence-based instructional practices	Significant learning gains have been associated with evidence-based instructional practices (EBIPs), yet there is notable variability in the magnitude of these outcomes. A common hallmark of EBIPs is the emphasis on student engagement, construction of knowledge, and frequent feedback on in-progress learning. We hypothesize that diversity in instructors' formative assessment (FA) and feedback practices contributes to differences in the learning outcomes of EBIPs. To test this hypothesis, we adopt a fidelity of implementation (FOI) framework to (a) describe FA and feedback during evidence-based instruction and (2) characterize the relationship between variations in FA and student learning. We video-recorded teaching episodes with similarly student-centered COPUS profiles and documented variations in what instructors do after initiating a FA cycle using a refined FA observation protocol (k = 0.82). We noted the (a) format, Bloom's level (k = 0.85) and Socratic nature of all FA prompts, as well as (b) frequency and types of instructor-generated feedback and associated student responses. Our data reveal marked differences in the FOI of FA between instructors with similar pedagogical training, and in patterns of student responses. We discuss implications for faculty pedagogical training and research on EBIPs efficacy.	Melody McConnell, Jeff Boyer, Jennifer Momsen, Rachel Salter, Kurt Williams, Lisa Wiltbank.
2.12	Sam Pazicni	University of New Hampshire, Chemistry	Expertise reversal when using texts in general chemistry	Textbooks are commonly used as reference materials in general chemistry classroom settings, and students are expected to "read the text" if they need to review topics. Past studies have shown that students enter college with a range of reading comprehension abilities and background knowledge in chemistry, and that textbooks vary greatly in readability measures. This study investigated how student characteristics of prior knowledge and reading ability affect their understanding of material presented in text format. Four different student populations were studied, and the chemistry topics tested were bonding representations and redox chemistry. The results suggest there is an expertise reversal effect where students with higher prior knowledge are adversely affected when they read a text passage about a chemistry topic.	René Buell, University of New Hampshire

2.13	Michelle Plavnik	Georgia State University, Chemistry	Modeling Perception and Experience of Pleasure, Engagement and Meaning; Success	Students, educators, and universities benefit from the increased awareness attained through this research. Students make larger strides towards their academic goals, educators improve course designs, and universities create targeted interventions to promote desired outcomes. The aims of the study are to capture the perceptions and experiences of undergraduate students in the chemistry classroom. Guiding research questions probe the relationships among variables including flow, purpose, ambition, and brightness. Follow up research questions probe the implications for student success in chemistry. Pre and post semi-structured in person interviews are conducted. An online questionnaire is also distributed during class several times throughout the semester. The interviews are evaluated with the aid of Nvivo software, and the questionnaires are evaluated with the aid of Excel and R software. Both sets of data are used to discover statistical relationships among variables and student success. Future directions include exploration of attrition rates in undergraduate chemistry courses, perceptions and experiences of graduate students, and comparisons between lab, lecture, and mixed teaching methods. Preliminary results of the pilot study will be presented.	
2.14	Maia Popova	Miami University, Chemistry	Organic chemistry students' understandings of connections between reactions and reaction coordinate diagrams	No previous research has explored students' thinking when making connections between organic chemistry reactions and reaction coordinate diagrams. Our research has investigated students' ability to choose reaction coordinate diagrams that correspond to specific substitution and elimination reactions. An analysis was conducted of students' understandings of the kinetic and thermodynamic factors that correspond to these reactions and how students related these ideas when describing reactions with reaction coordinate diagrams. Ausubel's theory of meaningful learning was chosen as the theoretical framework for the study to explore the differences between meaningful learning of the concepts and rote memorization of dogmatic facts and rules. Thirty six students enrolled in organic chemistry II were interviewed in a qualitative study using semi-structured interviews. The preliminary findings will be presented.	Stacey Lowery Bretz, Miami University

2.15	Lynmarie Posey	Michigan State University, Chemistry	Graphing as a Tool to Build Mathematical Understanding in Chemistry	Proportional reasoning, particularly in the forms of understanding ratios and relationships between covarying quantities, is critical to student success in general chemistry. Students use this reasoning when doing unit conversions, performing stoichiometry calculations, and thinking about phenomena such as electrostatic forces or the relationship between temperature and average kinetic energy. At the same time, this is an area where students enrolled in non-credit-bearing-remedial (NCBR) algebra courses often struggle. As part of a chemistry bridge course developed for Michigan State's Dow STEM Scholars Program, which targets students interested in STEM degree programs who place into NCBR algebra, we have developed and piloted mathematics interventions supported by the mathematics education literature through a collaboration between chemists and mathematics educators. Our just-in-time mathematics instruction contextualized in chemistry uses multiple representations (symbolic, tables of numerical values, and graphs) to support students in building mathematical understanding. Examples of using construction and interpretation of graphs to support mathematical sensemaking in the context of unit conversions, stoichiometry, and relationships between covarying quantities will be presented.	Kristen Bieda, Department of Teacher Education, Michigan State University Pamela Mosley, Department of Chemistry, Michigan State University Jennifer Nimtz, Program in Mathematics Education, Michigan State University William Humes, Program in Mathematics Education, Michigan State University
2.16	Edward Redish	University of Maryland, Physics	Interdisciplinary Teaching as Inter-cultural Research	Much scientific instruction occurs across disciplinary boundaries. Physicists teach engineers; chemists teach biologists; and mathematicians teach everybody. But disciplines create their own distinct cultures: conventions, goals, expectations, and epistemologies. If we treat disciplines as different cultures, cross disciplinary instruction looks different. When exploring another culture, we bring a powerful measuring instrument – our personal intuitions and culture – that may distort or misinterpret what we see. We have to not only try to understand our subjects' perceptions, but to be aware of the inevitably biased interpretive tools we bring to our analysis.[1] This approach leads to deeper insights, both into the culture we observe and into our own. For seven years we have been exploring the culture of biology while developing an introductory physics course for biologists.[2] What we have learned encourages us to make significant changes in how we think about and present physics for life science students. [1] Michael Agar, Language Shock (1994, Harper Collins), ISBN:0-688-14949-9 [2] E. F. Redish et al., NEXUS/Physics: An interdisciplinary repurposing of physics for biologists Am. J. Phys. 82:5 (2014) 368-377. doi: 10.1119/1.4870386	Chandra Turpen

2.17	Gilbert Reynders	University of Iowa, Chemistry	Developing Materials to Provide Formative Feedback on Students' Process Skills	Skills such as critical thinking, information processing, and communication are frequently cited as key outcomes for STEM degree programs. My work focuses on the development of resources for instructors that provide feedback to students and that inform the instructor as to the effectiveness of their instructional strategies in supporting skill development. To date, resources include rubrics to evaluate students' written work and a workshop to train instructors in assessing process skills in the classroom. These resources have been created and refined using an interactive development approach to ensure validity, reliability, and utility in multiple STEM disciplines and course levels.	Renee S. Cole, University of Iowa; Juliette Lantz, Drew University; Suzanne M. Ruder, Virginia Commonwealth University; Courtney L. Stanford, Virginia Commonwealth University
2.18	Dawn Rickey	National Science Foundation, Chemistry	National Science Foundation Programs that Support Discipline-Based Education Research	Several programs within and across the National Science Foundation's Directorate for Education and Human Resources (EHR) support projects focused on discipline-based education research. This poster will describe key programs and provide advice regarding how to design projects and develop proposals.	
2.19	Kimberly Rogers	Bowling Green State University, Mathematics	Synergizing Experienced and Novice Graduate Student Instruction via Peer-mentorship	We developed and implemented a peer-mentoring program at two US universities whereby nine experienced GSIs each mentored three or four first- and second-year GSIs (novices). Mentors facilitated bi-weekly small group meetings (as part of this NSF-funded peer-mentoring program, IUSE 1544342 & 1554346) whereby mentors provided context-specific support to help novices use active-learning techniques. Meeting discussion topics were informed by novices' interests, mentors and novices concerns, and ideas other small groups discussed. To inform collegiate mathematics teacher education we asked: What topics from small-group peer-mentoring meetings did novices value? Applying a social constructivist lens, we identified how the small group topics were valued. We qualitatively coded data as either within a group or from other groups and analyzed each of the 30 novice's ratings of topics discussed. Results indicate topics novices value and topics peer-mentors may struggle to facilitate well, informing future professional development. These results offer insight and synergy between educating GSIs and improving undergraduate mathematics teacher pedagogy.	
2.20	Erin Ronayne So	UMD, Physics	Adapting Canonical Representations in Quantum Mechanics	Canonical representations in quantum mechanics represent toy models from which physicists build more complex systems. Previous research has focused on conceptual and mathematical difficulties students have when reasoning about these toy models. What is underexplored is how students adapt these toy models and representations when faced with new, potentially more complex, situations. We will present analysis of interviews with three electrical engineering majors, showing some of the ways students adapt and transfer these canonical representations and associated toy models. We argue that students are capable of adapting these toy models, even while in the process of understanding the toy models themselves and that the process of adaptation can contribute towards deeper understanding of the toy models and associated canonical representations themselves.	Ayush Gupta

2.21	Charles Ruggieri	Rutgers, The State University of New Jersey, Physics	Catalyzing Sustained Transformations in a Large Enrollment Introductory Electromagnetism Course	Large enrollment physics courses for engineers at Rutgers include many components, with a team of faculty responsible for content. In addition, course administrators change every few years and often modify materials based on their own experiences, degrading improvements from a given year after a few iterations[1]. To address these issues, we initiated the Measurable Learning Objectives Project, which has helped inform the transformation of a large enrollment calculus-based electricity and magnetism course. Faculty and PER researchers collaborated to construct measurable objectives based on published goals from several sources[2-4] and coupled objectives to a form of assessment. We categorized topics from the prior year's course materials and extracted weekly learning objectives, used existing assessments to evaluate if the component satisfies the objectives, and used the results to influence modifications of content emphasis and method. In this poster, we address the learning objective development process and the collaborative effort to improve course materials. [1] Henderson (2007) [2] Pollock (2009) [3] Deslauriers (2009) [4] Beichner (2016)	Suzanne White Brahmia, Department of Physics, University of Washington
2.22	Elizabeth Sandqu	Iowa State University, Biology	Impact of introductory course-based research on gains in self-efficacy, science identity, and sense of community leading to persistence in STEM.	The Freshmen Research Initiative (FRI) is a program at Iowa State University whose strategy is to create course-based undergraduate research experiences for first-year students across STEM disciplines. Currently, the program oversees eleven courses, reaching over 200 students in majors including chemistry, biology and engineering. Analysis of self-reported gains using the Undergraduate Researcher Student Self-Assessment following a single semester of course-based research indicated good to great gains in Thinking and Working Like a Scientist, Personal Gains, and Gains in Skills. Some of the highest reported gains related to student attitude. Most students reported a sense of responsibility toward their projects and the opportunity to think creatively about their projects. Students also reported feeling like scientists, having a chance to participate in real world research. Participation in the FRI also significantly increased students' quantitative reasoning skills as assessed in a modified Test of Scientific Literacy Skills assessment. Pre- and post-tests indicated gains in reading and interpreting graphs, solving problems using quantitative skills, and understanding basic statistics. These are promising results from a single semester of freshmen research, demonstrating that it is possible to provide authentic research experiences and opportunities for independence at the introductory level.	Craig Ogilvie, Iowa State University

2.23	Benjamin Schern	University of Maine, Physics	Student determination of differential area elements in upper-division physics	Given the significance of differential area vectors in multivariable coordinate systems to the learning of physics in electricity and magnetism (E&M), students in junior-level E&M were interviewed about a number of typical E&M problems involving integration over areas. In one task, students were given the magnitude of a magnetic field from a long current-carrying wire and asked to solve for the magnetic flux through a square loop. A second task asked students to set up an integral to solve for the electric field as a function of distance from a charged circular sheet. During the tasks, students were asked to elaborate on their choices of differential area vectors. Several responses were common across interviews, as were a number of general difficulties that hampered students' choice of differential area. Additionally, students providing correct area elements for non-Cartesian problems were able to articulate how differential areas are built from their corresponding lengths.	John Thompson
2.24	Jennifer Schmidt	University of Iowa, Chemistry	Assessment of process skills in student responses to open-ended exam questions	Process skills can be applied broadly across STEM courses and professions. To optimize student development of process skills, there should be alignment between what instructors value and what they assess in the classroom. Alongside traditional learning outcomes, the Analytical Process Oriented Guided Inquiry Learning Project (ANA-POGIL) project clearly articulated key process skills that that students were encouraged to develop in addition to traditional content knowledge outcomes. The faculty consortium from this project developed open-ended, multiple-part exam questions to be used to assess skills and content developed using the classroom activities. The exam questions were administered across multiple institutions over seven semesters. Qualitative coding was used to analyze student responses in order to characterize the degree to which there was evidence that students had demonstrated their ability to engage in Information Processing, Critical Thinking, and Problem Solving. We report on qualities of question structure and phrasing that were more effective at eliciting specific process skills in the student responses. The results of the poster will also report on how successful the exam questions were at eliciting the faculty identified process skills for each question.	Renee S. Cole - University of Iowa; Caryl Fish - Saint Vincent College; Anne Falke - Worcester State University; Juliette Lantz - Drew University
2.25	Ginger Shultz (S	University of Michigan, Chemistry	Identifying and Addressing Barriers to Writing-to-Learn	Writing-to-Learn is known to support deep conceptual learning and yet it is not widely adopted in STEM. This presentation will describe a cross-disciplinary mutlti-institutional writing-to-learn project gram at the University of Michigan, Duke University, and University of Minnesota. Program goals are to 1) understand the challenges associated with adoption of Writing-to-learn and 2) to develop practical solutions that enable its broad dissemination. Faculty views and use of classroom writing were investigated using a survey of STEM faculty (Ca. 5000) from 71 research institutions nationwide. A subset of these faculty were also interviewed to further elicit their conceptions. Broadly, the study revealed a disparity between how STEM faculty view the role of writing in their own discipline and how they use writing in the classroom. The study further revealed barriers to faculty use of writing in the classroom and that these barriers are discipline specific. This presentation will also describe how the team is using these findings to work with faculty partners to implement writing in their classroom.	Anne R. Gere, Solaire Finkenstaedt-Quinn, Alena Moon (University of Michigan), Jason Dowd, Robert Thompson, Julie Reynolds (Duke University), Leslie Schiff, Pamela Flash (University of Minnesota)

2.26	Tara Slominski	North Dakota State University, Biology	Effects of context on expert reasoning	We are interested in exploring how intuitive reasoning and prior knowledge contribute to students' learning difficulties in Human Anatomy & Physiology (HA&P). HA&P education research often coins students' wrong answers as "misconceptions" without investigating or characterizing the reasoning behind those wrong answers. Instead of attributing wrong answers to concrete, strongly held knowledge constructs, our research explores the possibility of more intuitive and teleologic origins of inaccurate ideas, ultimately exploring why students struggle to learn physiology. To facilitate this investigation into student reasoning and student difficulties, we rely on theoretical frameworks from PER and integrate them with work from BER and HA&P. The data presented here come from interviews conducted with faculty in biology, physics, and engineering. Our protocol was designed to reveal the impact of item context on the way faculty frame and reason about the given problem. Our analysis focuses on the language used by faculty when reasoning through a problem outside of their discipline and the same problem situated within their discipline. The results of this study provide insight into the resources experts use when reasoning about phenomena from physics and HA&P. Our next steps will be to conduct similar interviews with students in biology, physics, and engineering.	Warren Christensen (North Dakota State University), John Buncher (North Dakota State University), and Jennifer Momsen (North Dakota State University)
2.27	MacKenzie Stetz	University of Maine, Physics	Probing student ability to construct reasoning chains: A new methodology*	Students are often asked to construct qualitative reasoning chains during scaffolded, research-based physics instruction. As part of a larger effort to investigate and assess the development of student reasoning skills in physics, we have been designing tasks that examine student ability to generate qualitative, inferential reasoning chains. In an online "chaining" task, students are provided with correct reasoning elements (i.e., true statements about the physical situation as well as correct concepts and mathematical relationships) and are asked to assemble them into an argument that they can use to answer a specified physics problem. We have also recently begun to modify these chaining tasks in order to better explore the extent to which some reasoning phenomena in physics may be accounted for by dual-process theories of reasoning. In this poster, several chaining tasks are described in detail and relevant results are discussed. *This material is based upon work supported by the National Science Foundation under Grant Nos. DUE-1431857, DUE-1431541, DUE-1431940, DUE-1432765, DUE-1432052, and DUE-0962805.	J. Caleb Speirs and William N. Ferm, University of Maine; Beth A. Lindsey, Penn State Greater Allegheny

2.28	Joanne Stewart	Hope College, Chemistry	There is no single course in inorganic chemistry	The subdiscipline of inorganic chemistry includes the chemistry of the entire periodic table. At many institutions, this chemistry is supposed to be taught in one semester. This breadth poses a challenge for the development of a coherent curriculum that is thorough and engaging. A national survey asking faculty how inorganic chemistry is taught at their institution showed that while there is no single course in inorganic chemistry, there are some core concepts that appear in most classes. In addition, cluster analysis allowed the description of several course “types” that share significant content. Building from the survey results, a “Grand Experiment” has been proposed for the development of inorganic chemistry courses that improve the teaching of the core concepts, while maintaining the rich diversity of approaches.	Barbara A. Reisner, James Madison University; Sheila R. Smith, University of Michigan, Dearborn; Jeffrey R. Raker, University of South Florida; Johanna L. Crane, University of Puget Sound; Sabrina G. Sobel, Hofstra University; Lester L. Pesterfield, Western Kentucky University
2.29	Beth Thacker	Texas Tech University, Physics	Promoting and Assessing Thinking Skills in a Laboratory-based Physics Course	We examined the results of free-response questions as part of a large-scale assessment of our introductory courses, including an analysis of thinking skills both qualitatively and with a rubric based on Bloom’s taxonomy. We compare the results of students taught traditionally and non-traditionally. The non-traditionally taught students were enrolled in a hands-on, laboratory-based physics course taught without a lecture and without a text. Students worked through the materials developed for the course (1,2), doing experiments to explore the world around them and developing qualitative and quantitative models based on their experimentation. We discuss their thinking skills as evidenced on exams and homework compared to traditional classes. 1) National Science Foundation - Course, Curriculum and Laboratory Improvement grant CCLI-EMD #0088780, "Humanized Physics -- Reforming Physics Using Multimedia and Mathematical Modeling". 2) National Science Foundation - Course, Curriculum and Laboratory Improvement grant CCLI #9981031 for "Workshop Physics with Health Science Applications"	
2.30	John Thompson	University of Maine, Physics	TBD	TBD	TBD

2.31	Jorge Torres	Miami University, Chemistry	Characterizing the Structural Design of the Inorganic Chemistry Curriculum	Whereas the curricula of general and organic chemistry tend to be consistent across different institutions, recent studies have shown that inorganic chemistry courses are largely varied, leading to large variations in students' inorganic chemistry background upon completion of the chemistry degree. These studies prompt the need to investigate why inorganic chemistry courses are so diverse and to fully characterize the curriculum. Our project aims to determine inorganic chemistry instructors' stated and assessed learning objectives, how they design their curricula and assessments, and the alignment between the stated and assessed learning objectives. Inorganic chemistry faculty members were purposefully sampled on a national level and the constant comparative method and multiple curricular frameworks were used to analyze transcripts generated from semi-structured interviews, as well as course syllabi and assessments. Preliminary results indicate that although faculty members are influenced by many of the same factors, these lead to very different curricular and assessment decisions. This poster will present the factors that influence the curricular decisions of inorganic chemistry faculty and how these factors impact instruction. Additionally, the poster addresses logistics and challenges associated with methods used for studying faculty nationally.	Ellen Yezierski, Miami University
2.32	Sonia Underwoo	Florida International University, Chemistry	Developing assessments to characterize student reasoning regarding everyday phenomena	Numerous calls and reports emphasize the importance for students to develop a coherent understanding of science. But many studies document that students emerge from science courses with misconceptions and fragmented ideas, regardless of the science discipline. In this project we are beginning to develop an understanding of how students connect and apply their knowledge from three different science courses (chemistry, biology, and physics) to explain everyday phenomena. We investigated how students integrate their knowledge from their science courses and the real world to discuss various phenomena through semi-structured interviews and free-response questions using the online program beSocratic. This poster will highlight some of our preliminary findings from this project.	Scott, E.E. (Michigan State University), Mashood, K. K. (Michigan State University), Anderson, C. W. (Michigan State University), Matz, R. L. (Michigan State University), Sawtelle, V. D. (Michigan State University)

2.33	Kevin Watson	Virginia Tech, Mathematics	Student Understanding of Mathematical Norms and Normalization	Normalization of particular vectors from various vector spaces (e.g., R^n, C^n, function spaces, etc.) is mathematically important for a variety of contexts. Some examples are directional derivatives in multivariable calculus, states of quantum mechanical systems in Physics, and the development of orthonormal bases through the Gram-Schmidt process in Linear Algebra and Numerical Analysis. Despite the applicability of normalization to a wide variety of concepts within mathematics and science, students' understanding of norms and normalization has not been studied. Studies that have examined students' understanding of absolute value have come close to the topic of norms and normalization (e.g., Almog & Ilany, 2012; Sierpinska, Bobos, & Pruncut, 2011), but have not directly addressed them. With the wide applicability of normalization, this lack of research must be remedied. In this poster, I will present a preliminary framework for students' understanding of mathematical norms and normalization of vectors, with two goals in mind. First, modeling students' understanding of norms and normalization can give us greater insight into the reasons why students struggle or excel in using these concepts. Second, the framework could identify particular aspects of norms and normalization students need to grasp in order to have a robust understanding of these concepts.	