PERC 2013:

From Fearing Physics to Having Fun with Physics: Exploring the Affective Domain of Physics Learning from Multiple Perspectives

July 17 – 18, 2013

Portland, OR

Responses to learning physics are strongly emotional, for better or worse. While many students fear physics, an implicit goal that drives many PER researchers is the desire to cultivate in our students a love of the discipline. Nonetheless, affective issues are rarely explicitly addressed in our research or curricula. This may reveal a tacit assumption within our community that such "hot cognition" has little bearing on the "cold cognition" conceptual goals of physics. Recent research calls such assumptions into question, and the goal of this PERC is to highlight research across many disciplines that demonstrate the role of affect in science education.

Researchers from various fields, including educational psychology, neuroscience and the social sciences, have underscored the central role of affect in cognition. In cognitive science, researchers have shown that affect plays a central role in a variety of cognitive endeavors that are relevant to the learning of physics, including decision-making, attention, problem-solving, persistence, evaluations and judgments. In the social sciences, researchers have pointed to the close entwinement of affect to issues of identity, epistemology, agency, and a belonging to a community. While affect was once seen as a hindrance to cognition, this wide array of research seems to be converging towards a common theme: affect is fundamental to cognition. As a community, attending to affective issues in the teaching and learning of physics is pivotal to our understanding of students' engagement, achievement, and retention in the discipline.

The central goal of PERC2013 is to consider affect in physics education from multiple disciplinary perspectives. The sessions are designed to explicitly attend to affect in the teaching and learning of physics, in part by incorporating active engagement and experiential learning techniques. Since the best cross-pollination of ideas often happens outside a seminar room, we will incorporate a blending of social, academic, and online spaces utilizing local coffee and chocolate shops and innovative crowd-sourcing technology.

Organizers:
Dedra Demaree
Leslie Atkins
Luke Conlin
Sissi Li
Yuhfen Lin

Additional information on the PERC website:

http://www.compadre.org/per/conferences/2013/

(or use QR code)

Meeting at a glance

Wednesday, July 17

Bridging session
4:30pm – 6:00pm
Grand Ballroom I

Banquet and Keynote
6:15pm – 8:15pm
Pavillion East/West

Contributed poster session
8:15pm – 10:15pm
Ballroom Level: various rooms

Thursday, July 18

Breakfast, plenary session and discussion
8:00am – 11:00am
Grand Ballroom I

Parallel sessions I
11:15am – 12:45pm
Plaza Level: various rooms

Lunch
12:45pm – 2:00pm
Grand Ballroom I

Parallel sessions II
2:00pm – 3:30pm
Plaza Level: various rooms

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Full Meeting Schedule

WEDNESDAY, JULY 17

4:30pm – 6:00pm Grand Ballroom I	BRIDGING SESSION Speaker: **Noah Finkelstein** Affect not as an afterthought: Coupling content and social-psychological aspects in physics learning Speaker: **Kevin Pugh** Having the Journey: Physics Education and Transformative Experiences
6:15pm – 8:15pm Pavillion East/West	BANQUET AND KEYNOTE Speaker: **Sian L. Beilock** From Cognitive Science to Physics Education and Back
8:15pm – 10:15pm Ballroom Level: various rooms	CONTRIBUTED POSTER SESSION Please set up posters between 6 and 6:15 pm. Odd-numbered posters are discussed from 8:15pm – 9:15pm, and even-numbered posters are discussed from 9:15pm – 10:15pm.

THURSDAY, JULY 18

8:00 am – 8:30 am Grand Ballroom I	BREAKFAST
8:30am – 10:00am Grand Ballroom I	PLENARY SESSION Speaker: **Ayush Gupta** Integrating emotions into fine-grained accounts of students' reasoning Speaker: **Marja-Liisa Hassi** From theory to practice: The lengthy way of affect into classrooms and practices
10:00am – 10:30am	Coffee
10:30am – 11:00am	Discussion
11:15am – 12:45pm Plaza Level: various rooms	PARALLEL SESSIONS I
12:45pm – 2:00pm Grand Ballroom I	LUNCH
2:00pm – 3:30pm Plaza Level: various rooms	PARALLEL SESSIONS II

PERC Plenary Speakers

Sian L. Beilock, University of Chicago

Sian L. Beilock is a professor in the Department of Psychology at the University of Chicago. Her research program sits at the intersection of cognitive science and education. She explores the cognitive and neural substrates of skill learning, including embodied cognition of physics concepts, as well as the mechanisms by which performance breaks down in high-stress or high-pressure situations. Her work sheds light on the connections between affect and cognition in learning math and science, in part by exploring the mechanisms of stereotype threat and the effects of anxiety on achievement in math and science classrooms.

Noah Finkelstein, University of Colorado- Boulder

Noah Finkelstein is a professor of physics at the University of Colorado, Boulder. There, he co-directs the Physics Education Research group and directs the Integrating STEM Education program. Noah studies conditions that support students' interests and abilities in physics at multiple levels, with research projects ranging from the dynamics of classroom learning to the institutional level decisions that can support students' learning in the classroom and beyond. His theoretical work seeks to build models of learning that emphasize the critical and inextricable role of context in student learning of physics. His experimental work has revealed some of the affective dimensions of the contexts of physics learning, including the influence of stereotype threat on exam performance and the impact of faculty practices on students' comfort with discussing physics with peers and instructors.

Ayush Gupta, University of Maryland

Ayush Gupta is a Research Assistant Professor at the Department of Physics, University of Maryland, College Park in the Physics Education Research Group. His research interests include cognitive modeling of student thinking and learning, the role of emotions in students' reasoning, and the use of mathematics in physics and engineering. His research aims to unpack the moment-to-moment entanglement of learners emotions, conceptual knowledge, epistemological stances, and identity. This work draws on the knowledge-in-pieces framework as well as interaction analysis methodologies, thus aiming to forge common ground between cognitivist and situated perspectives on learning.

Marja-Liisa Hassi, University of Helsinki

Marja-Liisa Hassi has a Master's degree in mathematics and a Ph.D. in education from the University of Helsinki, Finland. Her research interests include mathematics learning and problem solving, affective factors and learning, motivational processes, and self-regulated learning. She serves as an adjunct professor for the Faculty of Behavioral Sciences at the University of Helsinki, and has worked in the Ethnography and Evaluation Research group at the University of Colorado at Boulder. She has collaborated internationally with education and mathematics education researchers and contributes to faculty professional development and assessment of technical and vocational education initiatives in developing countries.

Kevin Pugh, University of Northern Colorado

Kevin Pugh is an associate professor of psychology at the University of Northern Colorado. His work focuses on investigating transformative experience -- experiences where students actively use curricular concepts to see and experience the world in a personally meaningful, new way. The primary goal of this work is to better address why school learning often fails to make a difference in students' everyday, out-of-school experience. Related to this work are investigations of influences on transformative experience, methods of teaching for transformative experience, and the relationship between transformative experience and enduring understanding in the context of science education. Research on motivation, transfer of learning, and Dewey's theory of aesthetic experience are important influences on his work.

AAPT/PERC Bridging Session: 4:30pm – 6:00pm, Wednesday

Location: Grand Ballroom I
Discussant: Paula Heron
Moderator: Leslie Atkins

Affect not as an afterthought: Coupling content and social-psychological aspects in physics learning

Noah Finkelstein, University of Colorado- Boulder

Learning is a matter of socialization. As such, we can build on efforts over the last couple of decades to further expand the goals of physics teaching and learning beyond the historic measures of content mastery. We are now poised to examine how social and psychological domains impact and are impacted by the traditional content we so dearly love. Drawing from a theoretical tradition that takes play seriously, I explore a few environments where play and 'messing about' simultaneously develop student affect and content mastery. At CU we are involved in: research documenting the engagement of youth in science to promote identity and content mastery; studies linking psychological effects to student performance and retention in college physics; and, investigations of the impacts of advanced undergraduate and graduate experiences that encourage productive messing about as scientists. These studies challenge the historical divides between formal / informal, content/form, and content/ affect.

Having the Journey: Physics Education and Transformative Experiences

Kevin Pugh, University of Northern Colorado

John Dewey argued that the curriculum should be a guide and not a substitute for having our own journey with the content. I agree and believe the purpose of science education should be to transform the way we see and experience the world, an outcome I refer to as a transformative experience. In this talk, I explain the nature of transformative experiences and present a model of fostering transformative experiences in science. This model has roots in Dewey's theory of aesthetic experience and was refined through design-based research. Instructional principles central to the model include: (1) artistically selecting and crafting content, (2) scaffolding re-seeing, and (3) modeling transformative experiences.

PERC Banquet and Keynote: 6:15pm-8:15pm, Wednesday

Location: Pavilion East/West
Moderator: Luke Conlin

From Cognitive Science to Physics Education and Back

Sian L. Beilock, University of Chicago

Principles of learning and performance derived from research in cognitive science can inform how physics is taught and how learning is assessed. At the same time, common practices in physics education can be used to develop better cognitive principles of student learning and understanding. This talk will focus on three main themes. First, I will explore how basic principles of learning can be used to develop optimal labs in physics education settings. Second, I will discuss how we can use psychology and neuroscience research regarding how academic anxiety alters thinking and reasoning to develop assessments that accurately gauge what students know. Finally, I will end by discussing how, together, PER and cognitive science can be used to help students perform at their best when it matters most.

Contributed Poster Session: 8:15pm-10:15pm, Wednesday

Location: Grand Ballroom II, Galleria I,II, II and Parlor A/B/C (map is on last page of the program)

Please set up posters between 6 and 6:15 pm.
Odd-numbered posters are discussed from 8:15pm – 9:15pm, and
even-numbered posters are discussed from 9:15pm – 10:15pm.

Presenters: See pages 19-28 below for details
Posters are listed alphabetically by presenter. There are two identifiers for the location: the room and the poster number.
Grand Ballroom II is abbreviated as GB
Galleria I is abbreviated as G1
Galleria II is abbreviated as G2
Galleria III is abbreviated as G3
Parlor A is abbreviated as PA
Parlor B is abbreviated as PB
Parlor C is abbreviated as PC

Contributed poster abstracts are not included in the program but can be found in the following link. Click on the bullet point labeled "Posters"
http://www.compadre.org/per/perc/2013/

Plenary Session: 8:30am – 11:00am, Thursday

Location: Grand Ballroom I
Discussant: Jon Gaffney
Moderator: Dedra Demaree

From theory to practice: The lengthy way of affect into classrooms and practices

Marja-Liisa Hassi, University of Helsinki

Important studies on affect in mathematics education date back to the early 1970s. Interest on affective issues has continued ever since and also education psychologists have paid serious attention to emotions in learning mathematics. However, transfer of this knowledge to mathematics classrooms, student learning, and teaching practices is still a big challenge. In this presentation I'll shortly highlight the history and scope of research on affect in mathematics education. After this overview, I'll introduce the role of affect in students' interpretations, experiences and learning processes with a specific focus on their self-perceptions and self-regulatory activity in learning and performing. This theoretical approach will be followed by research results of students' affective experiences and gains based on a multi-institution, mixed-method study in college mathematics classes applying active, student-centered instructional methods and set in contrast with the experiences and gains from traditional, lecture-based mathematics classes. Finally, I will briefly discuss implications for classroom practices and social classroom climate.

Integrating emotions into fine-grained accounts of students' reasoning

Ayush Gupta, University of Maryland

Many prominent lines of research on student's reasoning and conceptual change within learning sciences and physics education research have not attended to the role of learners' affect or emotions in the dynamics of their conceptual reasoning. This is despite evidence that emotions are deeply integrated with cognition and documented associations between emotions and academic performance. In this presentation, I will present the case for a research program aimed at integrating affect with models of learners' cognition. I will present a case-study to argue that in physics learning environments learners' emotions can be intertwined with the unfolding conceptual and epistemological reasoning at fine time-scales. This case-study draws on video-taped interactions of a small group of students working on a physics tutorial. The analysis of the conceptual and epistemological substance of students' talk and the associated emotions draws on a combination of methodologies from knowledge analysis, interaction analysis, and conversation analysis traditions. I will also briefly discuss some of the current research on learners' affect being pursued within the PER community. I will end with implications for research, curriculum development, and teaching.

Coffee Break

10:00am – 10:30am

Discussion

10:30am – 11:00am

Parallel Sessions I: 11:15am – 12:45pm, Thursday

(Arranged by location; detailed session abstracts can be found below from pages 9-17)

Title	Location	Organizer(s)	Presenters
Poster Symposium: Helping students acquire functional knowledge in upper-level physics courses	Pavilion East	Chandralekha Singh	Bradley Ambrose, Steven Pollock, Charles Bailey, Bethany Wilcox, Marcos Caballero, Emily Marshman, Michael Loverude, Corinne Manogue, David Roundy
Talk Symposium: Influences of Spatial/Visual Abilities on the Learning Process	Pavilion West	Ximena Cid	Mila Kryjevskaia, Alfonso Hinojosa, Ronald Thornton, Sheryl Sorby
Workshop: Fleeting but powerful: How affect matters for teaching, learning, and doing physics	Broadway 1	Lama Jaber, Vashti Sawtelle	Vashti Sawtelle, Jennifer Richards, Ayush Gupta, Chandra Turpen, Luke Conlin, Jayson Nissen
Poster Symposium: Research directions in PER: Past, present and future	Broadway 2	Sissi Li	Eleanor Sayre, Katharine Anderson, Amy Robertson, Rachel Scherr, Sarah McKagan, Lyle Barbato, Stephen Kanim
Roundtable: That is Cool: the Nature Of Aesthetics in Physics	Broadway 3	Jean Hertzberg	Dewey Dykstra, Noah Finkelstein, Kathleen Hinko, Mel Sabella, Ben Van Dusen, Stamatis Vokos
Roundtable: Purpose, Preparation, and Power of Narratives	Broadway 4	Emily van Zee	Corinne Manogue, David Roundy, Mary Bridget Kustusch, and Novela Auparay

Parallel Sessions II: 2:00pm – 3:30pm, Thursday

Title	Location	Organizer(s)	Presenters
Poster Symposium: Facilitating thinking and learning in physics classrooms	Pavilion East	Andrew Mason	Chandralekha Singh, Jennifer Docktor, Jose Mestre, Brian Ross, David Meltzer, Alex Maries
Custom Format: From Fear to Fun in Thermodynamics: Multiple Research Perspectives for Assessing Learning during a Curricular Sequence	Pavilion West	Corinne Manogue	David Roundy, Mary Bridget Kustusch, Emily van Zee, Tevian Dray, Ayush Gupta, Joseph Wagner
Roundtable: Reasoning Within and the Interactive Practice of Problem-Solving	Broadway 1	Heidi Fencl, Carol Fabby	Heidi Fencl, Carol Fabby
Poster Symposium: Identity Development in Physics	Broadway 2	Paul Irving	Sissi Li, Eleanor Sayre, Steve Potvin, Zahra Hazari, Eleanor Close
Roundtable: Learning in computer games, learning in the classroom: Making important connections	Broadway 3	David Brookes	David Brookes
Talk Symposium: Stop calling me stupid: Failure avoidance versus empowerment in physics learning	Broadway 4	Ben Van Dusen	Valerie Otero, Michael Ross, Enrique Suarez, Angela Cannava, Alisa Grimes

Parallel Session Abstracts: Sessions I

Poster Symposium: Helping students acquire functional knowledge in upper-level physics courses **Pavilion East** **Chandralekha Singh**

In this poster gallery and discussion session, presenters will first discuss research related to helping students acquire a functional knowledge in upper-level physics courses after a brief introduction by the discussant. Then there will be a panel discussion. Topics will include upper-level classical mechanics, quantum mechanics, electricity and magnetism, thermodynamics and mathematical methods. Research in physics education suggestions that students in advanced physics courses often struggle with material covered in these advanced courses. They have many common difficulties in learning different concepts and these struggles are compounded by the mathematical sophistication required to master the required concepts. Helping advanced physics students develop a better knowledge structure and acquire functional understanding can reduce anxiety and make learning fun.

Presentation 1: Exploring the affective domain in teaching intermediate mechanics: Benefits and challenges arising from a tutorial approach — Bradley S. Ambrose

Intermediate mechanics is often the first undergraduate theory course that physics majors and minors take beyond the introductory level. Unless their introductory courses were substantially reformed by PER-tested teaching and learning strategies, physics students may very likely hold unproductive attitudes, expectations, and habits of mind that have been reinforced from their experiences in introductory physics. Such beliefs and attitudes will not only contribute to challenges they will face in their advanced courses but how they will try to respond to those challenges. This targeted poster is designed to spark discussion about how recent PER and curriculum development efforts can help address such affective issues in the context of a reformed intermediate mechanics course. Examples of teaching and assessment strategies developed in the context of the Intermediate Mechanics Tutorials (IMT) project will be presented.
[1] Examples will include those shared by pilot-site implementers of IMT materials. Emphasized in particular will be the benefits and challenges of resources like IMT that incorporate guided inquiry but that are meant to supplement--not replace--a lecture-based approach.

1. Supported by NSF grants DUE-0441426 and DUE-0442388. For details see Ambrose, Am. J. Phys. 72, 453 – 459 (2004).

Presentation 2: Transforming upper-division E&M: approaches, assessments and outcomes — Steven Pollock, Charles Baily, Bethany Wilcox, and Marcos Caballero

The University of Colorado at Boulder is involved in a systematic program of upper-division course transformations in the context of Electromagnetism I and II. Starting from faculty consensus learning goals, we are developing a suite of research-based materials to engage students in lecture settings, along with a variety of assessment tools at both topical and course levels to investigate student learning and course outcomes. We summarize our ongoing efforts, including preliminary results from our new course-level electrodynamics assessment, and a redesigned multiple-choice version of our electrostatics assessment. We also present early results from an analytical framework on student use of mathematics in these E&M courses which helps us characterize and organize common difficulties. We provide a sampling of materials now freely available on our online dissemination site, and outline ongoing challenges both in terms of student learning, and sustainability of course transformations.

Presentation 3: Improving students' understanding of quantum mechanics — Chandralekha Singh and Emily Marshman

Learning quantum mechanics is challenging, in part due to the abstract nature of the subject. We have been conducting investigations of the difficulties that students have in learning quantum mechanics. To help improve student understanding of quantum concepts, we are developing quantum interactive learning tutorials (QuILTs) as well as tools for peer-instruction. The goal of QuILTs and peer-instruction tools is to actively engage students in the learning process and to help them build links between the formalism and the conceptual aspects of quantum physics without compromising the technical content. They focus on helping students integrate qualitative and quantitative understanding, and discriminate between concepts that are often confused. We will discuss examples of materials and assessment.

Supported by the National Science Foundation.

Presentation 4: Research and curriculum development in upper-division thermal physics Michael Loverude

This poster describes work conducted as part of an NSF-funded project of research and curriculum development in upper-division thermal physics courses. As part of this project, we have described research on student learning of a number of specific topics on which there is relatively little prior research, including elementary statistics and statistical physics (Loverude 2009), entropy and the approach to thermal equilibrium (Loverude 2012), heat engines (Smith 2009), and Boltzmann factors (Smith 2010). A second key thread of this project has involved the underlying mathematics and its impact of student learning of physics (Wagner 2011, Wemyss 2011). In this poster, we will take a broad look at the project as a whole, including research as well as curriculum development efforts, and summarize key findings.

Supported in part by NSF grants DUE-0817335 and DUE-0817282.

Presentation 5: Tangible Metaphors Corinne Manogue and David Roundy

Upper-division physics requires students to use abstract mathematical objects to model measurable properties of physical entities. We have developed activities that engage students in using their own bodies or simple home-built apparatus as metaphors for novel (to the students) types of mathematical objects. These tangible metaphors are chosen to be rich, robust, and flexible so that students can explore several properties of the mathematical objects over an extended period of time. The collaborative nature of the activities and inherent silliness of "dancing" out the behavior of currents or spinors certainly increases the fun in the classroom and may also decrease students' fear of learning about these mathematical objects. We include examples from the electromagnetism, quantum mechanics, and thermodynamics content in the Paradigms in Physics program at Oregon State University.

DUE 1023120

Talk Symposium: Influences of Spatial/Visual Abilities on the Learning Process **Pavilion West** **Ximena Cid**

Studies in various Science Technology Engineering and Mathematics (STEM) fields have suggested that in order to succeed in these courses, students need to have either high spatial/visual skills or have the ability to develop their skills simultaneously while taking their courses. Studies in engineering, conducted by Sheryl Sorby and colleagues, have shown significant gains in retention of students, as well as gains in GPA, by providing instruction to improve spatial skills of incoming undergraduate students. Physics, on the other hand, has focused on targeted areas of correlation instead of courses as a whole. For example, studies have shown that there are correlations between projectile motion and spatial/visualization skills, but there have not been a lot of studies focused on the entire courses. This session is designed to highlight research that was/is conducted in physics and engineering.

Workshop: Fleeting but powerful: How affect matters for teaching, learning, and doing physics **Broadway 1** **Lama Jaber, Vashti Sawtelle**

This workshop will examine affect within interactional moments to explore the significance of fleeting affective events in physics education. Participants will engage, reflect, and share their affective experiences in physics as a way to demonstrate the diversity and universality of affect within teaching and learning physics, and to motivate the need to research affect in physics education. Following the opening discussion, participants will work in groups to build claims with respect to affect through moment-to-moment analyses of video data from physics classrooms, tutorials, and interviews with students. Participants can expect to leave with a refined understanding of the importance of affective experiences within moments of teaching and learning physics and some practice using analytical tools and methods for conducting video-based research on affective dynamics in physics learning environments.

Poster Symposium: Research directions in PER: Past, present and future **Broadway 2** **Sissi Li**

The field of physics education research has expanded in scope and shifted in foci over the last decade. This session aims to examine the path the community has taken in terms of conceptualization of research paradigms, implications of choices in research population, expansion of scope, and trends in collaborations in publications. By considering the research choices made and examining the impact on researchers, those researched and users of research results, we wish to spark discussion about the present research and future directions in PER.

Presentation 1: Paradigms in Physics Education Research — Amy D. Robertson, Rachel E. Scherr, and Sarah B. McKagan

Physics education research (PER) includes three distinct paradigms: quantitative research, qualitative research, and question-driven research. Quantitative PER seeks reproducible, representative patterns and relationships; human behavior is seen as dictated by lawful (albeit probabilistic) relationships. Qualitative PER seeks to refine and develop theory by linking theory to cases; human action is seen as being shaped by the meanings that participants make of their local environments. Question-driven physics education researchers prioritize their research questions over the pursuit of local meanings or abstract relationships. As such, they privilege research methods that match their particular question at hand, rather than methods that attend to the rich details of a particular context or those that emphasize representativeness or reproducibility. We illustrate each paradigm with interviews with physics education researchers and examples of published PER.

Presentation 2: Fragmented divergence - Trends in PER research topic selection — Lyle Barbato

The past decade has seen an astonishing rate of growth in the number of peer-reviewed PER publications. During this time some have come to see the PER field as "fragmented" and "divergent." By analyzing the literature published in PRST-PER and the PERC Proceedings since 2000, trends can be perceived in the research topics selected by PERers. I will discuss these trends in the historical context of PER work.

Presentation 3: Who we study, who we teach — Stephen Kanim

How confident should I be that a published PER result will be useful in my classroom? To a large extent this depends on how similar my students are to the students who have been described by the research. Based on published results, I have tried to categorize the student populations that have been studied by physics education researchers. I will compare these students to data about who takes introductory physics courses, and what courses they take. In general, the students we study are taking more advanced classes and are better prepared than the overall introductory course population. Our research focus on a select student population has been beneficial because it has demonstrated the usefulness of research-based curriculum development. Moving forward, the PER community needs to better understand the needs and challenges of more typical student populations.

Presentation 4: Who are we? A network analysis of PER — Eleanor C Sayre, Katharine A. Anderson

Studying the participants in a field tells us about the shape of the research community and the development of its members and practices. Who are the researchers in physics education (PERers)? For this project, we operationalize PERers as people who have published in PRST-PER, the PERC proceedings, or PER papers in AJP since 1980. We use network analysis methods to show how the community has changed and grown over time. We investigate how individuals' participation changes in response to new collaborators, and how different research groups and publication venues have influenced the shape of the network.

Roundtable: That is Cool: the Nature Of Aesthetics in Physics **Broadway 3** **Jean Hertzberg**

Aesthetics is often defined as the study of beauty. In the context of physics, what is beautiful? What elicits a 'Wow! Awesome! Cool!' response versus a snore? Can we use aesthetics to deepen or change students' perceptions of physics and/or the world around them?

We propose three tables:
1. Visual Beauty of Physics. Can appreciation of the beauty of physics (e.g. sunsets or fractals) be increased by deeper understanding of the physics, or does it spoil the fun?
2. Aesthetics of Science Practice. What aesthetics might either drive or prevent the transformation from observer to practitioner? What are the aesthetic qualities that might entice students or teachers to claim identity as scientists, even physicists?
3. Cultural Aspects of Physics Aesthetics. The contrast of a Western reductionist approach with a holistic Eastern thought approach can be cast as a difference in aesthetic. How does one's cultural perspective influence aesthetic responses to physics?

Roundtable: Purpose, Preparation, and Power of Narratives **Broadway 4** **Emily van Zee**

How can one convey to interested teachers and researchers nuances in the ways in which an instructor teaches? In the ways students learn within that instructional context? In the details of that student learning? What aspects of these issues, motivated by the need to communicate a culture of teaching and learning, contribute to a culture of research? One communicative approach involves the use of narratives, by which we mean documents that tell the stories of interesting incidents that occurred during class. A narrative presents what the students and instructor said and did, with commentary based upon insights articulated by the instructor and perhaps colleagues while watching a video or listening to an audio recording of the interaction (see example narratives from the Paradigms Program at http://physics.oregonstate.edu/portfolioswiki/start). We discuss the purpose, preparation, and power of such narratives.

*Supported by NSF DUE0618877 and DUE1023120.

Parallel Session Abstracts: Sessions II

Poster Symposium: Facilitating thinking and learning in physics classrooms **Pavilion East** **Andrew Mason, Chandralekha Singh**

Learning physics is challenging because there are only a few fundamental principles in physics that are condensed in compact mathematical forms. Learning physics requires unpacking these fundamental principles and understanding their applicability in a variety of contexts. Cognitive theory can be used to design instruction and facilitate thinking and learning in the physics classrooms. In this poster gallery and discussion session, we will showcase research-based strategies that can be effective in improving students' problem solving and meta-cognitive skills. These approaches include helping students use different representations of knowledge and helping them learn to categorize physics problems appropriately. Improved cognitive abilities can make learning physics a positive experience for students.

Presentation 1: Problem Solving and Motivation – Getting our Students in Flow N. Sanjay Rebello

Csíkszentmihályi proposed the psychological concept of flow as signifying a state of complete involvement and enjoyment in an activity. When learners are in flow they are motivated, engaged, and completely focused on the task at hand, resulting in effortful learning. In this poster we explore the connections between the concept of flow and our model of transfer of learning as applied to problem solving. Our model of transfer purports two cognitive mechanisms – horizontal and vertical – that learners use to construct knowledge. Further, it proposes that carefully designed sequences of horizontal and vertical learning which provide scaffolding within a learner's zone of proximal development can facilitate learners to navigate an optimal adaptability corridor and foster progress toward adaptive expertise as characterized by Bransford & Schwartz. By exploring the connections between flow and our model of transfer, we hope to gain insights into what can motivate learners to become better problem solvers.

Presentation 2: Using categorization task to improve expertise in introductory physics — Andrew Mason and Chandralekha Singh

The ability to categorize problems based upon underlying principles, rather than surface features or contexts, is considered one of several proxy predictors of expertise. Giving students categorization task and then discussing experts' ways of categorizing problems can be used to help students develop expertise in physics and help them focus on deep features of problems. Inspired by the classic study of Chi, Feltovich, and Glaser [1], we revisited categorization study in large introductory physics classes. Some problems in the categorization task posed to students included those available from the prior study by Chi et al. Our findings, which contrast from those of Chi et al., suggest that there is a much wider distribution of expertise in mechanics among introductory students than previously believed. Implications for pedagogical interventions will be discussed.

[1] M.T.H. Chi, P. J. Feltovich, and R. Glaser, Categorization and representation of physics knowledge by experts and novices. Cognitive Science, 5, 121-152 (1981).

Presentation 3: Teaching problem categorization using computer-based feedback — Jennifer Docktor, Jose Mestre, and Brian Ross

Categorization tasks are commonly used as a measure of problem solving expertise, but they might also be useful pedagogical tools for highlighting the concepts and principles needed to solve problems. In this study, introductory physics students viewed several pairs of problems on a computer screen and were asked to judge whether the problems would be solved similarly. We found that students who received elaborate principle-based feedback on their answer then increased their use of physics principles when explaining their choices, whereas students who did not receive detailed feedback continued to make decisions based on quantities and surface-level problem features. Additional study findings will be discussed and instructional implications will be proposed.

Presentation 4: The role of representations in research-based instructional practice in physics — David E. Meltzer

Decades of physics education research and of research-based instructional practice have demonstrated convincingly the crucial role played by multiple representations in the learning of physics. Conceptual understanding is both reflected in and promoted by facility in the use of graphical, mathematical, diagrammatic, and verbal representations as well as in the ability to translate between and among different representations. Similarly, familiarity with topic-specific representations such as PV diagrams, free-body diagrams, motion graphs, and field-vector and potential-line diagrams is virtually indispensable for thorough understanding of particular concepts. I will review examples of research that illustrate some of the learning issues that arise with use of multiple representations, and will present examples of instructional strategies that have proved effective in guiding students to deeper understanding through use of representations in different contexts.

*Supported in part by NSF DUE #0817282 and DUE #1256333

Presentation 5: Challenges in developing effective scaffolding supports to help introductory students learn physics — Alex Maries and Chandralekha Singh

Helping students develop facility with problem representation is a major goal of many introductory physics courses. We discuss two studies related to representations in which we investigated strategies for improving students' performance on problem solving. In one study, we investigated students' difficulties in translating between mathematical and graphical representations and the effect of scaffolding on students' performance. Analysis of the student performance with different levels of scaffolding reveals that the appropriate level of scaffolding is not necessarily the one that involves lots of guidance and support from an expert's perspective and that the optimal level of support for a given student population can only be determined by research. In another study, we investigated whether students perform better when a diagram is provided with the problem or when they are explicitly asked to draw a diagram. We find that students who draw a good diagram perform better regardless of whether they use a diagrammatic approach to problem solving or mainly use a mathematical approach to problem solving. Instructional implications will be discussed.

Custom Format: From Fear to Fun in Thermodynamics: Multiple Research Perspectives for Assessing Learning during a Curricular Sequence	**Pavilion West**	**Corinne Manogue**

The complexity of thermodynamics challenges many students as well as faculty. Understanding what a partial derivative represents may be key to reducing the anxiety associated with this topic. In this session, participants will engage with a sequence of activities designed to elucidate the mathematics of thermodynamics through multiple representations of partial derivatives and with students who have experienced these activities. Activities include:

- an analogical device for physically representing changes that hold specific quantities fixed,
- experiments that provide exemplars of measuring thermodynamic quantities involving partial derivatives,
- thought experiments where students design ways to measure particular partial derivatives representing thermodynamic quantities, and
- an algebraic formulation of a partial derivative chain rule.

Several discussants --- including Ayush Gupta and Joseph Wagner --- will each then comment on how their different research perspectives can contribute to and are necessary for a holistic understanding of what happens during this kind of curricular sequence.

Roundtable: Reasoning Within and the Interactive Practice of Problem-Solving	**Broadway 1**	**Heidi Fencl, Carol Fabby**

Physics education research has a long history addressing the process of physics problem solving--both by looking at students and what they bring to the process and by looking at what it means to support effective problem solving. Discussion in this round table session will focus on both of those pieces. We will begin with a focus on students and then look at the question of effective resources for physics homework help, and will conclude with open discussion across the intersection of these topics.

Poster Symposium: Identity Development in Physics	**Broadway 2**	**Paul Irving**

Research into the identity development of physicists has seen significant growth in the recent past. This growth is largely associated with the assertion that the development of a professional identity is a fundamental part of student development and the development of an appropriate subject specific identity had been asserted to be a strong influence on the retention of students in a discipline (Pierrakos et al. 2009). Encouraging the development of a student's physics identity may help tackle the underdeveloped growth rate (National Science Board, 2008) of physics degrees awarded. This symposium presents research into physics identity development from several different contexts with a focus on the current popular research frameworks within physics identity research. Each presenter will discuss the aspects of identity they feel are important to study, why those aspects in particular are the ones they are interested in and how these choices inform the results of their studies.

Presentation 1: Learning Assistants' Development of Physics (Teacher) Identity	Eleanor Close

The physics department at Texas State University-San Marcos is developing a Learning Assistant (LA) program with reform-based instructional changes in our introductory course sequences. We are interested in how participation in the LA program influences LAs' identity both as physics students and as physics teachers; in particular, how being part of the

LA community changes participants' self-concepts and their day-to-day practice. We analyze both written artifacts and video data; our analysis of self-concepts is informed by the identity framework developed by Hazari et al. [1] and our analysis of practice is informed by Lave and Wenger's theory of Communities of Practice [2, 3]. Preliminary experience suggests that engagement in the collaborative physics education community elements of the LA program blurs the distinction between learner and teacher practice and increases LAs' engagement in negotiation of meaning in both contexts.

Work partially supported by NSF grant DUE-1240036

[1] Hazari et al., JRST 47(8), 2010.
[2] Lave, J., & Wenger, E., 1991.
[3] Wenger, E., 1998.

Presentation 2: The Development and Measurement of Identity across the Physical Sciences Geoff Potvin, Zahra Hazari

Drawing from earlier work of Gee (1999), Carlone (2004), and Shanahan (2009), we developed a framework for "good physics student role identity" or, more simply, "physics identity" which is a reliable proxy for students' affinity towards physics and is predictive of students' career choices. This framework was postulated to be comprised of performance beliefs, competence beliefs, recognition beliefs, and interest (Hazari et al, 2010). Subsequent investigations showed that performance and competence beliefs are not distinct (Potvin et al, 2011; 2012) and the combined performance/competence construct is somewhat akin to Bandura's self-efficacy (Bandura, 1986). Recent work has extended this framework to mathematics (Cribbs et al, 2012) and engineering (Godwin et al, 2013). We conclude with a discussion of the future of the framework for understanding "best practices" in STEM classrooms.

Presentation 3: Multiple pathways to the development of a physics identity Paul Irving, Eleanor Sayre

In an ongoing investigation into identity development in upper-level physics students we present three case studies illustrating the relationship between identity development and a students pathway through physics. Sally is a physics minor who gradually transforms into a physicist through her undergraduate research experiences and a developing affinity for physics as a discipline. Bob is a mechanical engineering and physics double major who attests a great affinity for physics but ends up dropping it as a major due to practical career concerns. Larry is a physics major who intends to be a teacher and repeatedly identifies himself a physicist. In this talk we talk about this group of students development in light of a framework which conceptualizes identity as having three integral aspects -- personal, practice, and participation -- by examining both interview and observational data. We conclude that discussions about physics identity development should not be reserved for physics majors.

Presentation 4: Students navigation between multiple physics identities Sissi Li

Becoming a physicist involves learning to be part of multiple physics communities. In this enculturation process, students socially interact with these communities to develop physicist identities and understanding of what it means and takes to be a physicist. At the same time, students also mediate potential mismatches that can cause conflict between their physics communities and personal communities. In each of these communities, students develop identities that inform and are influenced by their participation and membership. However, because the students are physicist in multiple communities, we use the notion of a nexus of multi-membership to consider their collection of identities and how students navigate between them. In this study, we present case studies of five female students from underrepresented groups in physics in ethnicity or as first-generation college students. By examining the collection of identities, the impact of family and cultural conflicts on their identity development is highlighted.

Roundtable: Learning in computer games, learning in the classroom: Broadway 3 David Brookes

Making important connections

College students may devote many hours a week to computer gaming while giving their physics homework short shrift. When people play games, they are doing a lot more than having mindless fun. They are learning, becoming experts in the game, building an understanding of the rules of the game and developing strategies for success in game-play. How does this come about? What is it about the nature of games that compels people to work and learn with such dedication? What can we learn about game design that has implications for how we design learning environments? It would be great if our students worked as hard on physics as they work at being good at a particular computer game. And yet school learning seems so distantly removed from a computer game. Can we make school learning more like learning in a computer game? The goal of this round table will be for the participants to a) identify features of computer games that promote such intense learning, and b) brainstorm ways in which they believe physics courses and physics learning environments can be tailored to produce the same type of intensive, highly-motivated learning that we see when our students play computer games.

Talk Symposium: Stop calling me stupid: Failure avoidance versus empowerment in physics learning	**Broadway 4**	**Ben Van Dusen, Valerie Otero**

Research presented by panel participants explores the hypothesis that high school physics classrooms often promote fear of failure rather than the spirit and excitement of scientific investigation. How do teachers of physics create environments that invite students to engage openly in communal efforts to make sense of the natural world rather than causing students to retreat due to internal fears of failure? Data will be presented that begin to extract particular strategies for promoting empowerment and agency rather than fear and alienation. We begin to outline the characteristics of classroom environments can leverage the natural curiosity of students so that the very process of scientific inquiry can serve as the mechanism through which agency and empowerment is achieved. This, we claim, is the missing link in building what could be a very strong connection between the students' intellectual, inquisitive, and social selves and the playful, social, and systematic world of science.

Presentation 1: Boundary Objects that Mediate Student Physics Motivation — Ben Van Dusen

This research examines how specific tools can serve as boundary objects that mediate contexts in which students feel motivation to engage in physics. In this study I examine student motivations toward physics and the role of tools in reorganizing social practices in the classroom environment and culture--specifically iPads acting as boundary objects, bridging the cultural practices of students' peers, the physics classroom, and the physics community. The act of creating screencasts arises as a central example of how the iPad can be used to generate and share physics knowledge, while allowing students to incorporate references that are meaningful in their peer cultures. The social construct of a boundary object will be elaborated to demonstrate how learning physics is, at its heart, a socio-cultural cognitive task.

Presentation 2: Changing the Locus of Evaluation to Promote Scientific Induction — Michael J. Ross

This study investigates the impact of nontraditional evaluative structures in the physics classroom on student affect. Typically, physics students' answers in discussions and on exams are evaluated by the instructor as right or wrong. In the learning environment that was the subject of this study, students were expected to reconcile their own ideas with available laboratory evidence and reach consensus with their peers. The overwhelming majority of the 15 students interviewed expressed positive attitudes towards learning physics and positive identification with physics. Video analysis suggests that this nontraditional evaluative practice resulted in authentic scientific reasoning, persistence, and enjoyment among students as they engaged in scientific induction. These findings suggest that the relocation of evaluative authority of students' ideas and explanations to laboratory evidence and social consensus, rather than with teacher and text, can promote more authentic engagement, enjoyment, and a sense of identification with physics.

Presentation 3: Supporting engagement and confidence of ELLs through physics — Enrique Suarez

English Language Learners (ELLs) are frequently left on the periphery of classroom interactions. Due to limited language skills, teachers and peers communicate with these students less often, decreasing the number of opportunities to engage. Exclusion can be avoided with learning activities that invite all students to participate and contribute their thinking. We argue that environments and activities that privilege scientific inductive reasoning increase possibilities for emerging bilingual students to engage. This study investigated third-grade students' discussions about factors that affect how objects make sound. Students came from a variety of language backgrounds; all were considered beginner/intermediate ELLs. Results show that the goal of inducing principles from actual phenomena encouraged students to communicate their ideas and reasoning, boosting students' confidence in expressing themselves. Following the hybrid space argument of Vygotsky's theory of concept formation, we see how external expression could lead to internalization of science concepts, and to develop English language skills.

Presentation 4: Capitalizing on digital natives' technological skills — Angela Cannava

The PER community has developed materials that build on students' conceptual and epistemological resources. However, little attention has been given to students' technological resources, which are becoming increasingly important. As "digital natives" make up the majority of our student population, a simple change of replacing paper and pencil lab notebooks with digital notebooks may have a dramatic impact on the extent to which students feel valued and respected. Additionally, digital notebooks are more aligned with the way digital natives have learned to do their work. Initial results suggest that digital lab notebooks lead to increased student achievement, engagement, and quality of work. Survey results revealed that students preferred digital notebooks because they allow for "easier data sharing" and increased "versatility." These results will be discussed along with implications for instruction and further research.

Presentation 5: Effects of Flexibility on Homework Completion and Student Performance — Alisa Grimes

Research has shown that student choice and flexibility in the learning environment are linked to motivation and agency. This education research investigates the effect of choice and flexibility in impacting homework completion rate. Two different classroom treatments were applied over two terms of an urban high school chemistry course. The first treatment involved flexible, supportive classroom structures that theoretically would lead to a greater homework completion rate. The second treatment (or control) involved the traditional, authoritative structures that had been in place--students were penalized for not completing homework within the designated timeframe. Initial results suggest that the flexible supportive structures led to greater homework completion rates and to higher performances on the district assessment over the non-flexible homework condition. These results will be discussed along with instructional implications, explanatory conjectures, and lessons learned.

Contributed Poster Locations

Presenter	Location (Room, Poster #)	Contributed Poster Title
Adams, Wendy K.	PC, 136	Listening to Students: How We Investigate the FCI
Aiken, John M.	G2, 39	An Introductory Physics MOOC with Video Lab Reports: Design, Implementation, and Challenges
Alvarado, Carolina	G1, 5	Responsiveness among peers leads to productive disciplinary engagement
Aryal, Bijaya	G3, 56	Effect of Self-created and Instructor-created Equation sheets on Students' Problem Solutions
Atkins, Leslie J.	PA, 88	Features that support transformative experiences in physics education
Aubrecht, Gordon	GB, 151	Teacher behavior change in middle and high school
Auparay, Novela	PA, 91	Affordances of Small White Board Questions(SWBQ) for Increasing Interactivity in Upper-Division Physics
Baily, Charles	G1, 6	Developing Tutorials for Advanced Physics Students: Processes and Lessons Learned
Barniol, Pablo	PB, 109	Testing students' understanding of vector concepts
Bartley, Jessica E	PA, 86	A Meta-analysis of Brain-behavior Correlations in Problem Solving
Bates, Simon	GB, 173	Students as producers of effective assessment content, even non-majors!
Belleau, Shelly	GB, 172	Scientific Practices: Equalizing Opportunities for Linguistically Diverse Students
Benson, Mishal	G3, 70	Coaching a Problem-Solving Framework: Evaluation from High School Physics Teachers
Blue, Jennifer	PB, 103	Student Difficulties with the Car and Passenger Problem
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Brookes, David	PA, 79	Characterizing student participation in an ISLE physics class
Burciaga, Juan R.	G2, 40	Designing Inclusive Learning Environments Using Play Theory
Caballero, Marcos D.	PC, 128	Assessing Student Learning in Middle-Division Classical Mechanics/Math Methods
Cannava, Angela	G2, 28	Capitalizing on digital natives' technological skills
Cerny, Leonard	G3, 68	Plastic vs. Solid Resources in Upper-division E&M
Chasteen, Stephanie V.	G1, 25	"Framing" approaches for promoting a productive non-traditional classroom
Chen, Ying	G2, 51	Pervasive metaphors in mathematics-in-physics: Fictive Motion and Animation of Inanimate
Chini, Jacquelyn J.	PA, 85	Expectancy Violation in Traditional and Studio-mode Introductory Physics Courses
Close, Hunter G	PC, 124	Students' dynamic geometric reasoning about quantum spin-1/2 states
Cochran, Geraldine L.	G1, 9	Physics Las' Views on Expert Teaching: Understanding PCK's Role
Coletta, Vincent P.	PC, 135	Reducing the FCI Gender Gap
Conlin, Luke	PA, 89	Three views of an Aha! moment: Comparing tutorial groups' affective responses to a moment of sudden conceptual insight
Corbo, Joel C.	G2, 38	Building Modeling Skills and Developing Science Identity in Physics Freshmen
Crouch, Catherine H.	PB, 98	The role of interest in the effect of including life science contexts in introductory physics
Crouch, Catherine H.	GB, 145	A CLASS Study of Introductory Physics for Life Sciences (IPLS) at Swarthmore College
Cummings, Karen	GB, 162	Attitudes of Non-Science Students in a General Education Physics Course
Daane, Abigail R.	G1, 2	Learner Understanding of Energy Degradation

Presenter	Location (Room, Poster #)	Contributed Poster Title
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Day, James	GB, 154	Finding Evidence of Transfer with Invention Activities
Demaree, Dedra	PC, 119	Re-Writing the FCI; Will reduced threat significantly change students' scores?
DeVore, Seth	PC, 134	On Ramp: Improving graduate students' understanding of the lock-in amplifier
Dietz, R. D.	PC, 131	Factor Analysis of Force Concept Inventory Results
Ding, Lin	GB, 164	Progression of hypothesis generation and evidence evaluation skills among university students
Docktor, Jennifer	GB, 159	Eye movements while interpreting graphical representations of motion
Dominguez, Angeles	G2, 29	Studentsopinion on the use of a graphing calculator in a physics context based math course
Donnelly, David	GB, 148	Winter Break Effect in General Education CLASS Results
Donnelly, Robyn	GB, 167	Attitudes and Beliefs about Physics from a UK Academics' Perspective
Dougherty, Andrew W.	G1, 3	Developing High Quality Common Formative Assessments with Middle School Teachers
Dowd, Jason E.	PB, 101	Impacting Learning across Disciplines through Undergraduate Thesis Writing
Dreyfus, Benjamin W.	PB, 95	Negative Energy: Why Interdisciplinary Physics Requires Multiple Ontologies
Dwyer, Hilary A.	G1, 10	Computational Thinking for Physics: Programming Models of Physics Phenomenon in Elementary School
Emigh, Paul	PC, 130	Student Understanding of Blackbody Radiation and Its Application to Everyday Objects
Fischer, Susan M.	PB, 112	An Embodied Physics Lab on Center of Gravity
Frank, Brian W.	PA, 78	Adapting Transformative Experience Surveys to Undergraduate Physics
Franklin, Scott	PA, 92	Faculty Discourse in the Classroom: Meaning in the Math

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Georgiou, Helen	GB, 153	Physics knowledge and its effects: a study of student responses in thermodynamics using Legitimation Code Theory
Goldberg, Fred	PA, 82	Development and evaluation of large-enrollment, active-learning physics curriculum
Gouvea, Julia	PB, 105	Developing biologically relevant mathematical competence in introductory physics
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Grimes, Alisa	GB, 138	Effects of Flexibility on Homework Completion and Student Performance
Guisasola, Jenaro	PB, 102	How to get first-year university students show interest on electromagnetic induction?
Haddard, Robert	PC, 133	Exploring Instructor Knowledge of Student Ideas with the FCI
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Harlow, Danielle B.	GB, 147	Applying Latent Class Analysis to Explore Patterns of Student Responses in Physics Education Research
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Hazelton, Ryan	G2, 45	Assessing the impact of a computer simulation in conjunction with Tutorials in Introductory Physics on conceptual understanding
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Hinko, Kathleen	GB, 163	Characterizing Epistemological Frames of Scientific Communication between Physicists and Non-experts
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Hu, Dehui	GB, 149	Assessing Transfer of Learning in Problem Solving from the Preparation for Future Learning Perspective Using a Computer Assessment
Ishimoto, Michi	PC, 129	An Evaluation of the Translated Version of the FMCE and Japanese Students' Conceptual Understanding of Newton's Laws of Motion
Jääskeläinen, Markku	GB, 165	Does a the worldview of a physicist require scientific reasoning skills?
Jaxon, Kim	G1, 14	Composing Scientific Inquiry
Johnson, James K	GB, 155	Attitudinal Assessment of Curriculum on the Physics of Medical Instruments
Jones, Darrick	G2, 34	Resource Activation Patterns in Expert Problem Solving
Jones, Dyan L.	G3, 61	Students' Views of Math and Physics Problems: Structure vs Context
Julin, Sara	G2, 47	Physics is more FUN if you have authentic relationships with more of your classmates!
Keiner, Louis E.	PB, 107	Students' Mental Models of Light and Color Mixing
Khatri, Raina	G2, 44	Over 110 Million Simulations Delivered: A Case Study of the PhET Interactive Simulations
Knapp, Emily	PA, 81	Adapting a Novel Curriculum in a Traditional High School Environment
Kohnle, Antje	G2, 30	Optimization of simulations and activities for a new introductory quantum mechanics curriculum
Krinks, Kara	G2, 41	Conceptual Change in Physics Through Use of Digital Games
Kuo, H. Vincent	PA, 84	Participant Perspectives on Studio Physics Implementation in Abu Dhabi
Lewandowski, Heather	GB, 152	A National Assessment of Undergraduate Physics Labs: First Results
Lin, ShihYin	G2, 48	Evaluations of video lab reports in an introductory physics MOOC

Presenter	Location (Room, Poster #)	Contributed Poster Title
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Lindow, Ashley	PC, 116	Similar Density Questions with Very Different Results
Little, Angela	GB, 141	Undergraduate Competences in Defining: The Interplay Between Examples, Criteria, and Crafted Definitions
Lovegren, Clarissa E.	G1, 7	Development of Novice Teachers' Views of Students Ideas as Productive and Resourceful
Loverude, Michael E.	G3, 69	"Surprisingly, there is an actual physical application"
Lung, Florin	G2, 35	Gender-specific career outcome expectations in college vs. interest in pursuing careers in sciences and engineering
Lunk, Brandon	G2, 32	Resources: A Framework for Understanding Students' Computational Modeling Practices
Lynch, Robert B.	PB, 110	Timing effects of starting introductory Physics sequence on science GPA
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Marshman, Emily	G3, 62	Investigating student difficulties with time-dependence of expectation values in quantum mechanics
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Mills, Mary Elizabeth	G2, 42	What does it mean to be a Physicist? Exploring the Identity Development of Female Physics Majors
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Oakley, Christopher	G3, 59	Faculty and Undergraduate Student Perspectives on Evaluation in Upper-Division Courses
Passante, Gina	PC, 123	Student ability to reason about basic quantum mechanics ideas in the context of time-dependent perturbation theory
Phillips, Jeffrey A.	GB, 158	Examination of students' self-monitoring in problem solving
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Sadaghiani, Homeyra R.	G3, 65	Converting an open-ended assessment for upper-division quantum physics to multiple-choice format
Sams, William R.	G2, 50	Portable Labs and Smartphones in Introductory Physics Labs
Samuels, Natan	G1, 21	Cogenerative Physics Reform Through CMPLE
Sanjay Rebello, N.	G1, 20	Assessing Pedagogical Content Knowledge of Future Elementary Teachers
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Stanley, Ethan C.	G3, 63	Different student populations and the Lawson Test of Scientific Reasoning
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Von Korff, Joshua	PC, 126	Student Epistemology About Mathematical Integration In A Physics Context: A Case Study
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Presenter	Location (Room, Poster #)	Contributed Poster Title
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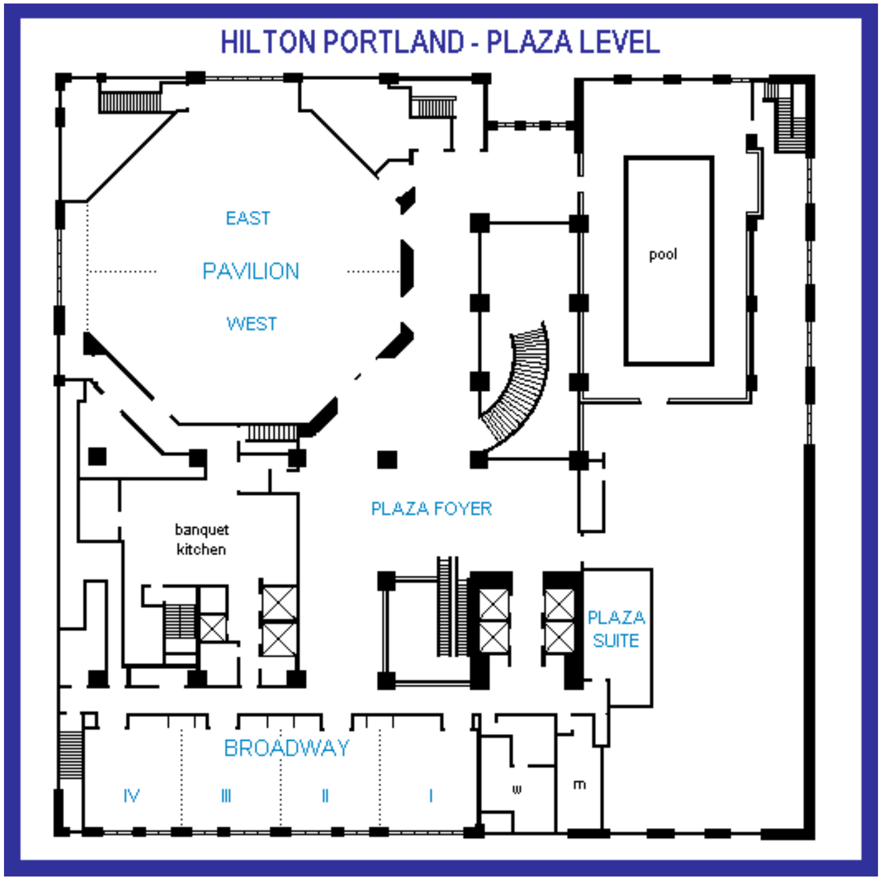

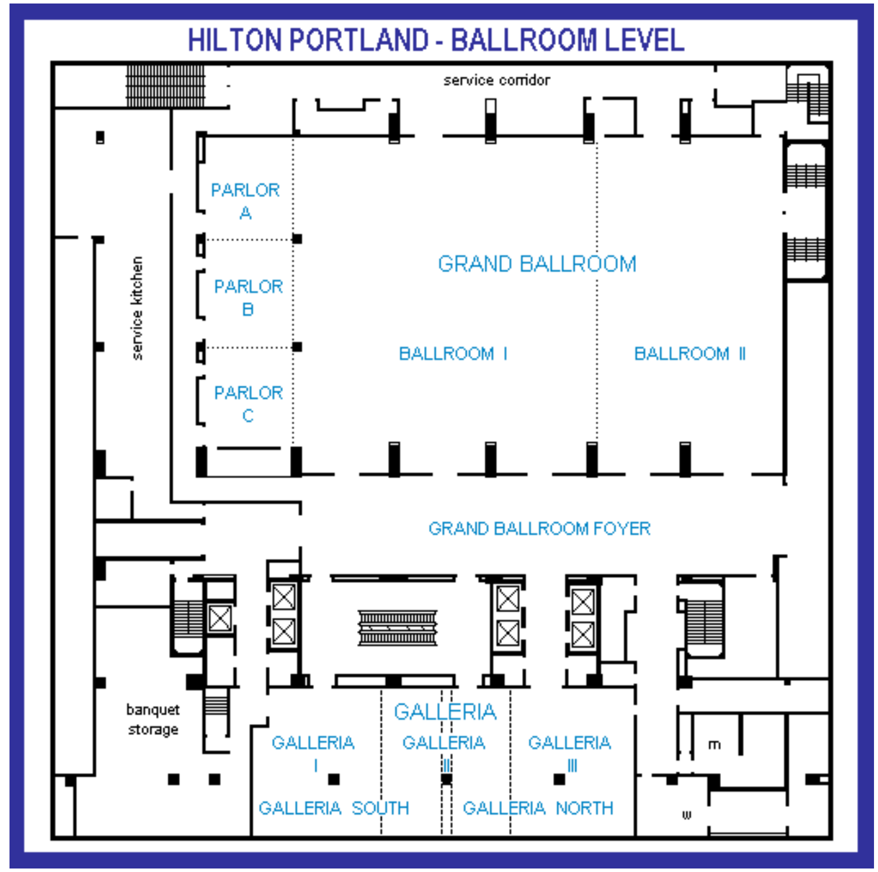

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***Vice Chairs:** Duncan Brown, Syracuse University, & Dean Zollman, Kansas State University.*

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