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PER: Examining Content Understanding and Reasoning II

AAPT | **Type:** Con | **Organizer:** AAPT

Description:

Call for Papers:

Abstracts Submitted (# 12)

Abstract Title: "Because Math": Epistemological Stance or Defusing Social Tension in QM?*

Paper Type: Contributed

Author: Erin Ronayne Sohr
Toll Building
College Park, MD 20740
4438123086 (p)
erinsohr@gmail.com

Speaker Order: EI01

Often in environments where students are collaboratively working on physics problems, students need to manage social conflict alongside grappling with conceptual and epistemological differences. At the University of Maryland, our PER group has been developing QM tutorials to help students more carefully navigate between classical and quantum models. In this presentation, we document several outlets that students use as tools for social framing and managing social conflict. These resources include epistemic distancing, humor, playing on tutorial wording and looking ahead to subsequent questions. Our data come from video-records of a focus group at the University of Maryland, where students work through a tutorial on the Particle in a Box. We see evidence of students using mathematics in ways that may normally be interpreted as indicating an epistemological stance, but are actually used as a means of defusing social tension.

Footnotes: *Work supported by NSF-DUE 1323129

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Abstract Title: “Classical-ish”: Negotiating the Boundary Between Classical and Quantum Particles*

Paper Type: Contributed

Author: Benjamin William Dreyfus
University of Maryland, College Park
Department of Physics, 082 Regents Drive
College Park, MD 20742
917-821-2405 (p)
dreyfus@umd.edu

Speaker Order: EI02

Developing physical intuition about quantum mechanics can seem like a departure from our everyday experience of the physical world, but we build new ideas from our existing ones. In this presentation we examine video data from a focus group doing a tutorial about the “particle in a box.” In reasoning about the properties of a quantum particle, the students bring in elements of a classical particle ontology, which are evident not only through the students’ language but through their use of gestures. But this is modulated by metacognitive moments in which the group explicitly takes up questions of whether classical intuitions are valid for the quantum system. Through this reflection, the students find some cases in which classical ideas can be usefully applied to quantum physics, and others in which they directly contrast classical and quantum mechanics. Negotiating this boundary is part of the process of building quantum intuitions.

Footnotes: *This work is supported by NSF-DUE 1323129.

Conflicts: I would like to request to be placed in the same session as Erin Sohr (“Because math”: Epistemological stance or defusing social tension in QM?) and Jessica Hoy (Particle or Wave: Supporting students' ontological development in Modern Physics), since these talks are all part of the same project. Thank you!

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Abstract Title: Changes in Student Reasoning about Graphical Work During Introductory Physics*

Paper Type: Contributed

Author: John R. Thompson
University of Maine
Dept. of Physics & Astronomy, U. Maine

Orono, ME 04469-5709 United States
2075811030 (p)
thompsonj@maine.edu

Speaker Order: EI07

In a study on student understanding of graphical representations of work, students in introductory calculus-based physics were presented with a force-position graph (F-x) that showed two different mechanical processes with identical initial and identical final values for force and position. The task, to compare the works done in each case, was administered at three points along the two-semester instructional sequence to probe differences in student responses and reasoning and compare findings to results from analogous questions in thermodynamics. Response prevalence varied little across administrations; however, the reasoning students used showed variation. Analysis of reasoning used showed a higher use of "area under the curve" for a correct response, and a more prevalent invocation of "path independence" or "conservative forces" for the major incorrect interpretation, with instruction. These findings support earlier speculation that thermodynamics students associate work with conservative forces due to introductory instruction.

Footnotes: *Supported in part by NSF Grant DUE-1323426.

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Abstract Title: Energy in Physics and Chemistry: Helping Students Draw Interdisciplinary Connections

Paper Type: Contributed

Author: Beth A. Lindsey
Penn State Greater Allegheny
4000 University Drive
Mc Keesport, PA 15132
412-675-9148 (p)
bal23@psu.edu

Speaker Order: EI06

Energy is a topic that spans the scientific disciplines. Many studies conducted within the domains of both physics and chemistry demonstrate that potential energy in particular is a difficult topic for students. Previous work has shown that even within physics, students do not necessarily draw on ideas from mechanics when answering questions about potential energy in the context of electrostatics. We have been engaged in a research project aimed at helping students to make productive use of their ideas about gravitational potential energy when asked questions in the context of electrostatics. In this talk, we will report on recent findings regarding what helps students to draw these connections. We will present data from small-group interviews and online surveys, and we will discuss the implications these data have for instruction on energy in introductory courses.

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Abstract Title: Investigating Physics and Engineering Students' Understanding of Diode Circuits*

Paper Type: Contributed

Author: MacKenzie R. Stetzer
University of Maine
5709 Bennett Hall, Rm 120
Orono, ME 04469-5709
(207) 581-1033 (p)
mackenzie.stetzer@maine.edu

Speaker Order: EI04

As part of a larger project at the University of Maine to investigate the learning and teaching of concepts in thermodynamics and electronics that are integral to both undergraduate physics and engineering programs, we have been examining student learning in electrical engineering and physics courses on electric circuits and electronics. A major goal of this work at the physics-engineering interface is to probe the extent to which the nature of student understanding (including the prevalence of specific difficulties) depends upon the disciplinary context. In this talk, I will focus on our efforts to probe student understanding of basic diode circuits using free-response questions. Preliminary results from questions administered in both physics and engineering courses will be presented.

Footnotes: *This work has been supported in part by the National Science Foundation under Grant Nos. DUE-1323426, DUE-1022449, and DUE-0962805.

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Abstract Title: Learning Introductory E&M: A 50+ Institution Meta-analysis

Paper Type: Contributed

Author: Ulas Ustun*
Kansas State University Cardwell 401
Manhattan, KS 66506

7853201956 (p)
ulasustun@gmail.com

Speaker Order: EI11

The DEAR-Faculty project is a large, international, multi-methods study to investigate student learning in introductory physics. As part of this project, we conduct meta-analyses of published data using popular research-based conceptual assessments such as the Force Concept Inventory (FCI). In this talk, I present a meta-analysis of student learning in electricity and magnetism. We concatenated data from a comprehensive literature search of papers published in PhysRevST-PER, AJP, and the PERC proceedings, and/or indexed in ERIC, Scopus, or Web of Science. We selected all primary studies that present sufficient data on the two most popular EM assessments: the Conceptual Survey of Electricity and Magnetism (CSEM), and the Brief Electricity and Magnetism Assessment (BEMA). Our data set includes 50 studies representing about 60 schools. We calculated the effects of institution and teaching methods on student learning, as well as some overall statistics on the heterogeneity of the data set.

Footnotes: *Sponsored by Eleanor Sayre

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Abstract Title: Particle or Wave: Supporting Students' Ontological Development in Modern Physics*

Paper Type: Contributed

Author: Jessica Hoy**
University of Colorado Boulder
680 S Lashley Ln #110
Boulder, CO 80305
303 522 0601 (p)
jessica.hoy@colorado.edu

Speaker Order: EI03

Learning quantum mechanics requires students to develop not only new mathematical skills but also conceptual understanding. Towards this instructional goal, the Modern Physics for Engineers course at the University of Colorado Boulder explicitly addresses interpretation of quantum phenomena. Research indicates that when instruction does not explicitly address student beliefs about the nature of a subject, the students' ideas tend to become less expert-like (Atman, et al., 2007). We present new data from focus groups of students enrolled in this course. During recorded discussions, they negotiate the tension between reasoning about light in terms of classical (wave-like) and quantum (particle-like) ontologies. We examine transitions in students' ontological reasoning about light as well as their use of energy as a bridge between classical and quantum ideas. Finally, we consider fostering students' metacognitive awareness as a route to expert-like behaviors in quantum mechanics.

Footnotes: *Work supported by NSF **Sponsored by Noah Finkelstein

Conflicts: Unable to present on Monday, July 27. (I can arrive in Maryland Monday afternoon at the earliest)

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Abstract Title: Student Generation of General Rules Supports Learning of Physics Principles

Paper Type: Contributed

Author: Eric Kuo
Stanford University
450 Serra Mall, Bldg 160
Stanford, CA 94305 United States
9787931963 (p)
erickuo@stanford.edu

Speaker Order: EI10

Through a classroom study, we investigated whether student attempts to invent general physics principles support both discovery and future learning of those principles. In introductory physics discussion sections, small groups of students used a PhET simulation to connect ideas from topographic contour maps to electric equipotential lines for two sample charge configurations. The goal was for students to find the relationship between the electric field and the equipotential lines. On a conceptual survey administered immediately after this activity, students directed to create general rules performed better than students led through case-by-case predictions. This differential was maintained some days later, after both groups had received instruction in lecture and lab on the topic. This indicates that the task of explicit generalization not only supports discovery of general physics principles, but also prepares students for improved future learning from instruction.

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Abstract Title: Student Inferences from Two-Dimensional Graphs with Multiple Independent Variables

Paper Type: Contributed

Author: Abigail M. Bogdan
The Ohio State University
191 West Woodruff Ave

Columbus, OH 43210-1168
(402)599-0199 (p)
bogdan.22@osu.edu

Speaker Order: EI09

In this study, students' ability to draw inferences from graphs was explored. Approximately 300 students, in either the first or second semester of an introductory, calculus-based physics course, were given simple two-dimensional graphs and asked to draw inferences about the relationship between the dependent variable and each of three independent variables shown in the graph. The common strategies students employed and the pitfalls they encountered in doing this were observed. Additionally, the effect of students' prior belief on their ability to draw valid inferences was assessed by presenting graphs either in a familiar physical context or in a more generic context. We found students were generally able to read simple graphs; however, their ability was affected by the consistency of their prior beliefs with the data, their numeric ability, and the complexity of the graph. These results are consistent with previous studies done with data tables.

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Abstract Title: Student Understanding and Construction of Differentials in Introductory Physics

Paper Type: Contributed

Author: Nathaniel Amos
Ohio State University
4751 Blairfield Dr. C
Columbus, OH 43214
8503226171 (p)
amos.93@osu.edu

Speaker Order: EI08

Introductory university physics frequently involves the construction of integrals. There is evidence to suggest that a major obstacle to student success in the construction of physics integrals is an inability to formulate and interpret differentials and products involving differentials. We provided introductory calculus-based physics students with several physics problems featuring infinitesimal quantities in a variety of contexts in order to identify potential misconceptions regarding physical differentials. Our results demonstrated several broad, recurring student difficulties. To address these issues, we conducted a controlled experiment at the introductory level to help students practice the construction and explore the physical meaning of differentials. This between-students design featured pairs of similarly-styled training tasks that varied by physical context, either on paper without feedback or on a computer with electronic feedback. A post-test was given to all conditions. We will discuss and analyze the results of these studies.

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Abstract Title: The Pedagogical Value of Conceptual Metaphor for Secondary Science Teachers*

Paper Type: Contributed

Author: Abigail R. Daane
Seattle Pacific University
3307 3rd Ave West
Seattle, WA 98119 United States
5104075239 (p)
daanea@spu.edu

Speaker Order: EI05

The abstract nature of energy encourages the use of metaphorical language in educational settings. K-12 teachers and students use conceptual metaphors implicitly to express their ideas about what energy is or how it functions in particular scenarios. Attending to the use of conceptual metaphors in the classroom can expand teachers' repertoire for formative assessment of student ideas. Yet science education research on analogies and metaphors has predominately focused on explicit, instructional analogies, rather than attending to such implicit, ubiquitous features of natural language in science. In a secondary science teacher professional development course, we observe teachers engage in an instructional activity designed to increase awareness of conceptual metaphor in everyday language and in descriptions of energy. These teachers come to value the application of conceptual metaphor in educational settings; they acknowledge that if they identify metaphors present in their students' science language, they will better understand their students' ideas about energy. We present possible mechanisms for teacher growth in learning and valuing the use of energy metaphors and illustrate how to support teachers in noticing, understanding, and valuing metaphors for energy.

Footnotes: *This material is based upon work supported by the National Science Foundation under Grants No. 0822342 and 1222732.

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Abstract Title: University Student Conceptual Resources for Understanding Energy

Paper Type: Contributed

Author: Hannah C. Sabo
Seattle Pacific University
3307 3rd Ave W
Seattle, WA 98119 United States
(949)394-8423 (p)
saboh@spu.edu
Speaker Order: EI12

On the basis of our analysis of responses to written questions administered to large numbers of introductory physics students at several universities across the United States, we report the specific, recurring conceptual resources that students use to reason about energy. This work responds to a need for large-scale, resources-grounded research on students' conceptual understanding and supports the development of an underexplored dimension of pedagogical content knowledge – knowledge of student resources for understanding energy, in contrast to misconceptions or misunderstandings about energy. We aim to promote instructor take-up of the resources theory of knowledge, and we suggest a number of ways in which instructors might capitalize on the resources we report.

Footnotes: *This material is based upon work supported by the National Science Foundation under grant #122732

Conflicts: Due to medical reasons, the presenter prefers not to present before 11:00 am. If possible, please schedule in a session after 11:00 am.

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