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PER: Exploring Problem Solving Approaches and Skills

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

Description:

Call for Papers:

Abstracts Submitted (# 12)

Abstract Title: Concept Recognition as a Bottleneck in Solving Synthesis Problems

Paper Type: Contributed

Author: Daniel R. White
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Speaker Order: FE03

Improving students' skills in solving synthesis problems, which are problems requiring the application of multiple concepts such as energy conservation and kinematics, is typically a key instructional goal. We have previously found that students struggle with synthesis problems more than their single-concept counterparts in part because of difficulty recognizing all the relevant concepts or that multiple concepts are needed. Here we report on an experiment designed to test the effects of different types of hints on helping students apply the necessary concepts in solving a problem combining energy conservation and centripetal acceleration. While we found no statistically significant differences between the effects of different hints, we discuss trends suggesting that discouraging common incorrect solution paths may be more effective than highlighting underused components of a correct solution.

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Abstract Title: Effect of Multimedia Hints on Students' Visual Attention*

Paper Type: Contributed

Author: Xian Wu
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Speaker Order: FE07

To create valuable hints in computer-assisted instruction for physics problems involving graphs and figures, the effect of hint modalities needs to be tested on students' performance and visual attention. Participants in our study solved four sets of conceptual problems, each of them containing one initial problem, six training problems, one near transfer problem, and one far transfer problem. The data showed that the same content in different modalities alters the effectiveness of the hint. Students' eye movement data has also been explored to give insight into how hint modality changes students' visual attention and how multiple hint modalities interact with each other. The results of this study could shed light on generating new principles to guide construction of computer-based physics problem solving instruction.

Footnotes: *This research is supported in part by the U.S. National Science Foundation under Grants 1138697 and 1348857. Opinions expressed are those of the authors and not necessarily those of the Foundation.

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Abstract Title: Effect of Visual Cues and Display Design on Problem Solving*

Paper Type: Contributed

Author: Bahar Modir
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Speaker Order: FE08

Previous studies have shown that visual cues can help students to shift their attention toward relevant features of the conceptual physics problems in graph representation. However cueing does not completely prohibit students from attending to irrelevant features of a problem. In this study with students in an algebra-based class, we investigated the role of cues based on Wickens' proximity compatibility principle that enabled us to adapt cues to particular kinds of questions. This principle states that there is a competition between the proximity of display features and proximity between the information in the mental state of the participants. Further, based on the Gestalt laws of grouping, we manipulated the display design to investigate the influence of the display proximity on the organization of the students' attention toward the relevant parts of a problem and how that affects their response time.

Footnotes: *Supported in part by the National Science Foundation Grant 1348857

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Abstract Title: Effects of Visual Cues and Video Solutions on Conceptual Tasks*

Paper Type: Contributed

Author: Tianlong Zu
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Speaker Order: FE09

Visual cueing is shown to be effective in helping students solve conceptual physics tasks. However, students may have difficulties in solving physics transfer tasks with different surface features. We investigated if instruction provided using videos that contain explanations to the tasks that will improve students' performance in solving near and far tasks. We interviewed students using a think-aloud protocol. Each interview included four sets of tasks. In each set students need to solve one initial problem, four isomorphic training tasks, a near transfer task, and a far transfer task. Based on the conditions, some of the students were provided with visual cues when solving training tasks, and some of them were provided with an instructional video following the training session. We compare students' reasoning patterns and correctness in the two conditions.

Footnotes: *Supported in part by NSF Grant 1348857.

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Abstract Title: Investigating Problem Solving Automaticity Using Eye Movements*

Paper Type: Contributed

Author: Elise Agra
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Speaker Order: FE10

Visual cues have been shown to direct attention to relevant areas of a diagram and facilitate problem solving. We investigate the effect of visual cues on students' visual attention while solving conceptual physics problems with diagrams. The diagrams contained features relevant to correctly solving the problem, as well as features attributed to common incorrect answers. Students enrolled in an introductory mechanics course were individually interviewed using a think-aloud protocol while their eye movements were recorded. Participants worked through four sets of problems containing an initial problem, four isomorphic training problems, and two transfer problems. Students in the cued condition saw visual cues overlaid on the training problems. A second interview was conducted two weeks later, in which students solved the two transfer problems without cues. We compare the cued and non-cued groups with respect to the automaticity of extracting relevant information on the transfer and retention problems.

Footnotes: *This material is based upon work supported by the National Science Foundation under Grant Nos. 1138697 and 1348857.

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Abstract Title: Preparation for Future Learning: Troubleshooting or Problem Solving? Findings

Paper Type: Contributed

Author: Edit Menuha Yerushalmi
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Speaker Order: FE05

Troubleshooting activities engage students in diagnosing/explaining embedded mistakes in teacher-made erroneous solutions for physics problems. We hypothesized that students engaged in troubleshooting activities (aided by principle-based prompts and sample diagnoses when reviewing their own diagnoses) would outperform students engaged in problem-solving activities (aided by sample solutions when reviewing their own solutions) in their preparation for future learning: understanding of the concepts required to solve these problems, as well as inclination to self-repair one's understanding when reviewing his/her work. We will describe the findings of a comparison between two groups of 10th graders from the Arab sector in Israel, one performing troubleshooting activities and the other problem-solving activities in the context of geometrical optics. We will present an analysis of students' articulations that manifest self-repair when reviewing their own work, aided by instructors' diagnosis of an erroneous solution as well as analysis of their performance on transfer problems.

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Abstract Title: Preparation for Future Learning: Troubleshooting or Problem Solving? Methodology

Paper Type: Contributed

Author: Sawsan S. Ailabouni
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Speaker Order: FE04

Troubleshooting activities engage students in diagnosing/explaining embedded mistakes in teacher-made erroneous solutions for physics problems. We hypothesized that students engaged in troubleshooting activities (aided by principle-based prompts and sample diagnoses when reviewing their own diagnoses) would outperform students engaged in problem-solving activities (aided by sample solutions when reviewing their own solutions) in their preparation for future learning: understanding of the concepts required to solve these problems, as well as inclination to self-repair one's understanding when reviewing his/her work. We will describe the methodology used to examine this hypothesis, comparing two groups participating in online year-long interventions, a troubleshooting and a problem-solving intervention, both focused on the same problems. Students' performance before and after the interventions were examined using the double transfer methodology: Solving a transfer problem after studying a learning resource: instructors' diagnosis and correction of an erroneous solution to an isomorphic problem.

Conflicts: Note: This is one of two sequential presentations. Please place it before: "Preparation for future learning: troubleshooting or problem-solving? Findings"

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Abstract Title: Some Unintended Consequences of Prompting Students to Construct Force Diagrams

Paper Type: Contributed

Author: Luke D. Conlin
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Speaker Order: FE11

As physics instructors, we often scaffold problem solving by prompting students with a series of intermediate steps. The consequences, good or bad, of such scaffolding are often left uninvestigated. We report on results of a study partially replicating and extending research by Heckler (2009) in which we asked undergraduate students to solve Newton's laws problems. Half of the students were prompted to draw a force diagram before finding a solution. We found that the diagram prompt drove students away from an intuitive strategy, toward more lengthy formal strategies with lower success rates. In another measure, students were more likely to find fault with the informal nature of an intuitive solution if the problem statement included a diagram prompt. These results suggest that such problem-solving scaffolding affects students' solution approach, possibly by cuing different epistemological stances on what counts as a good answer.

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Abstract Title: Student Epistemologies and Resource Use in a Conceptual Physics Problem

Paper Type: Contributed

Author: Tyler D. Scott

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Speaker Order: FE02

A significant goal of STEM education research has been to understand how students solve problems. An important aspect of students' approaches to problem solving is their epistemologies, or beliefs about knowledge. In this study, students in a calculus-based, introductory physics course were presented with a problem on a test that asked them to find the mass of a simple pendulum given its equation of motion. Later, students were asked to write a short reflection on their problem-solving strategies and feelings as they wrestled with the problem. Understandably, students were frustrated by their inability to obtain a numerical answer. Reflections and test answers give insight into the students' beliefs about the complexity and source of knowledge. Results show that most students relied heavily on their equation sheets. However, frustration with that method led some to progress to other considerations including lab experiences and their own conceptual understanding.

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Abstract Title: Students' Use of Representations in Modeling Instruction Introductory Physics

Paper Type: Contributed

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Speaker Order: FE12

We present the preliminary results of a study of student use of representations in problem solving within the Modeling Instruction – Electricity and Magnetism (MI-EM) course. Representational competence is a critical skill needed for students to develop a sophisticated understanding of and success in college science topics. In this study, 70 students were given a survey of 25 physics problem statements both pre- and post- instruction, covering both Newtonian Mechanics and Electricity and Magnetism (EM), and asked which representations they would use in that given situation. We analyze the results by comparing the preponderance of these representations. We also compare student representation use for those who had already taken the first-semester Modeling Instruction Mechanics course and those students who had taken a non-Modeling Mechanics course. In addition, we look at how students representation use changed by context of problem (Mechanics vs. EM).

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Abstract Title: Synthesis Problem Solving: Concept Recognition and Application*

Paper Type: Contributed

Author: Bashirah Ibrahim
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Speaker Order: FE06

The study explores the effects of incrementing the mathematical complexity of a synthesis problem on students' ability to recognize the relevant concepts and appropriately apply the identified concepts. The task highlights the situation of a block propelled from a spring on an inclined ramp. It undergoes projectile motion and lands on another inclined surface. Three versions of the task with different mathematical complexity were designed, requesting for the horizontal distance traveled by the block, spring compression, and projection angle respectively. A cohort of 105 physics students in three groups completed one version of the problem. Across the three tasks, more than a half of the sample succeeded in recognizing the appropriate concepts and committed to using solely the identified concepts. However, regardless of the mathematical complexity level, the majority of the students failed to correctly apply the physics concepts, with the occurrence of similar types of conceptual mistakes.

Footnotes: *The study is supported by NSF DRL-1252399.

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Abstract Title: The Equation-Based Analytical Epistemic Game for Solving Mathematically-Based Physics Problems

Paper Type: Contributed

Author: Rabindra R. Bajracharya

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Speaker Order: FE01

We have been investigating student strategies while dealing the graphically-based problems with different physics contexts involving the Fundamental Theorem of Calculus. In this study, 14 introductory physics students were administered task-based,semi-structured individual interviews. Student strategies were analyzed using the perspectives of epistemological framing and epistemic games. We identify a new epistemic game that was commonly observed in our data, the equation-based analytical game. This game involves deriving an equation through symbolic manipulation and routine mathematical operations. Usually, this epistemic game is necessary to deal with most mathematically-based physics problems, but is not always sufficient for solving them completely and correctly. Our analysis shows that students tend to solve even those problems that do not involve any algebraic functions simply by using this strategy. The equation-based analytical game appears to be the first choice of strategy for many students in solving mathematically-based physics problems.

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