RESEARCH ON PROBLEM SOLVING IN INTRODUCTORY PHYSICS

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A problem pair

Problem A
A 0.10 kg arrow is fired from a bow. The bow is pulled back a distance of 0.8 m so that the arrow is released with a speed of 50 m/s as it leaves the bow. The arrow travels 25.0 m before hitting its target. What is the average force exerted on the arrow by the bowstring?

Problem B
A Yankees batter hits a 0.14 kg baseball sending it off into left field, 40 m away from the batter's box. The baseball lands in a Royals fielder's glove, exerting an average force of 300 N, moving the glove backward 0.25 m before coming to rest. What is the speed of the ball just before it is caught?

What are the similarities between these problems?

What are the differences between these problems?

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Outline

- Foundations in Problem Solving
- Case Reuse Project
  - What is Case Reuse?
  - Methodology
  - Results
- What is…
- Why do…
- Who does…

  Physics Education Research

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Problem Solving Research

Expert vs. Novice Approaches

Chi (1981)
- Novices focus on 'surface features' over 'deep-structure' while sorting problems into categories.
- Experts focus on physics principles applicable to approaching and solving a problem.

Nokes & Ross (2007)
- Surface features: context of problem (rollercoaster)
- Deep-structure features: physical principles involved in the problem (friction)

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Rationale for this study

- Many students use less sophisticated strategies [1] to solve physics problems, e.g. 'case re-use'
- We aim to refine a commonly used strategy, case-reuse, such that it incorporates analytic comparison of problems.

[1] (Mestre, 1994)

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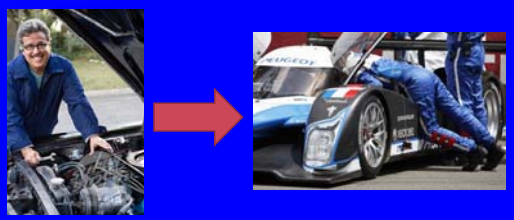
What is 'Case Reuse'?

Appropriate use of conceptual knowledge learned through a previous case (solved example) to assist in solving an unsolved problem



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Group Learning Interviews

General Format

- 10 students from algebra-based physics
  - 7 women, 3 men
  - 2 Hispanic, 8 Caucasian
- 8 weekly focus group meetings
  - 75 minutes each
- Final protocol not finalized until the 4th week

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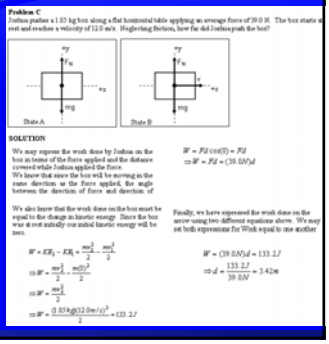
Group Learning Interview

Methodology (1 of 2)

Students are asked to:

- review a solved example related to concepts covered in class.



Group Learning Interview

Methodology (2 of 2)

Problem A
A 0.10 kg arrow is fired from a bow. The bow is pulled back a distance of 0.8 m so that the arrow is released with a speed of 50 m/s as it leaves the bow. The arrow travels 25.0 m before hitting its target. What is the average force exerted on the arrow by the bowstring?

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Students are prompted to:

- articulate the principles underlying the unsolved problems
- work out a solution to one of two unsolved problems
- rate the usefulness of the solved example
- rank similarities / differences between problems that are…
  - Different in surface features,
  - Similar in deep-structure to the example.

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Summary of Group Learning Interviews

General Observations

- Similarities
  - Focus on deep structure
  - Surface features rank lower than deep structure
- Differences
  - Focus on surface features
- Usefulness
  - Mathematical complexity decreases usefulness of solved example

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Assessment

Look to determine whether asking students to explicitly contrast problems on a regular basis will result in difference in performance on their in class examinations as compared with the general class.

Participants

- All students in 1st semester algebra-based physics (N = 283)
- Includes students in Group Learning Interviews (N = 9)

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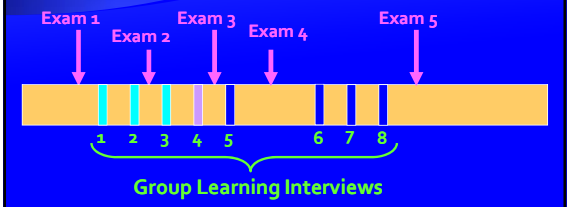
Assessment

Collected examination data:



- Five multiple choice tests
- Three (extra credit) non-traditional problems at end of each exam

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Non-Traditional Problems

Research-based problem solving methods

Text Editing

Low & Over (1990)

Students given problem statement, asked to find irrelevant information

- 'Text editing can be a measure of mental organization of knowledge'

Problem Posing

Mestre (2002)

Students given a statement describing a situation, asked to add a question that would turn it into a problem that uses specified principles (equations)

- 'Probing students' understanding of physics concepts'
- 'Ability to transfer their knowledge to novel contexts'

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Non-Traditional Problems

Research-based problem solving methods

Physics Jeopardy

Van Heuvelen (1998)

Students given fragment of solution to a problem, asked to identify scenario that correspond to solution.

- 'Effort to represent a physical process in a variety of ways'

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Summary of the Assessment

- Non-Traditional Problems

  Jeopardy > Text Editing > Problem Posing

  (63% correct) (53% correct) (31% correct)

- Traditional Problems (70% correct)

Treatment (focus group) vs. **Control** (rest of class)

- No significant difference on traditional problems.
- Significant difference on Problem Posing & Jeopardy on last two exams i.e. after finalized protocol.

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Conclusions

- How do students determine whether a solved example is useful for solving an unsolved problem?
  - Focus on deep structure similarities over surface differences.
  - Avoid using examples with mathematical complexity.
- To what extent are these strategies successful as measured by traditional and non-traditional problem performance?
  - No improvement on traditional problems, but improvement on some non-traditional problems (after finalized protocol)

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What is PER?

Research done with respect to the teaching and learning of physics

WE…

- Define the Research Question
- Gather information and resources through observation
- Form hypothesis.
- Perform experiment and co… data using multiple methods
- Analyze data
- Interpret data and draw conclusions that serve as a starting point for new hypothesis.
- Retest
- Publish results

(You may ground your work on …

(Propose an explanation for misunderstanding or problem

(Develop and Assess effective teaching methods and/or curriculum.)

(Replication ensures some level of consistency in measurements.)

Why do PER?

To improve student …

- interest and views of physics and its importance in society.
- conceptual understanding and problem solving in physics
- Problem solving skills necessary in physics are transferable to other analytical thinking activities.

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Who does PER?

Physics Education Research is a growing field

- 50+ institutions with PER groups or individual faculty
- Annual National conferences
- NSF / Dept. of Education Funding opportunities
- Physics Journals : Am. J. Phys., Phys. Rev. – Special Topics

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What do PER undergrads do?

- Design and implementation of data collection
  - Interviews
  - Surveys
  - Pre and Post examinations
- Analyze data collected
  - Transcribe & 'code' data (look for commonalities in data)
  - Statistical analysis (i.e., t-test)
- Develop and test curricular innovations
  - Determine how to best utilize students' prior knowledge and experience as observed in data
  - Examine whether your strategies or curricular materials may facilitate learning
- Communicate your work: Presentations and publications!

Thank You

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