Physics Education Research: History and Methods - Studying Electronic Media

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Outline

► History of Physics Education Research
   When, Who, Why?
   Key Findings
► Electronic Media and Educational Research
   State of the Field
   Computers in Labs
► Methodology
► Spreadsheets
► An Example
History of PER

- The Early Years, A Subtle Shift
- A Science of Teaching and Learning
- Misconceptions and Inquiry Learning
- The FCI
- Now

Homer Dodge  
Paul Klopsteg  
Floyd Richtmeyer
A Subtle Shift: How to Teach vs. How Do They Learn?

► Arons (To Teachers): “You have two ears and one mouth, and should use them in that proportion.”

► Karplus: “I believe that students become vitally interested in their studies and learn best when direction and guidance from a source of authority are combined with ample opportunity for students to direct and control their own learning.”
Example Problem 1

A heavy ball is attached to a string and swung in a circular path in a horizontal plane as illustrated in the diagram to the right. At the point indicated in the diagram, the string suddenly breaks at the ball. If these events were observed from directly above, indicate the path of the ball after the string breaks.
A boy throws a steel ball straight up. Disregarding any effects of air resistance, the force(s) acting on the ball until it returns is (are):

(A) Its weight vertically downward along with a steadily decreasing upward force.

(B) a steadily decreasing upward force from the instant it leaves the hand until it reaches its highest point beyond which there is a steadily increasing downward force of gravity as the object gets closer to the earth.

(C) a constant downward force of gravity along with an upward force that steadily deceases until the ball reaches its highest point, after which there is only the constant downward force of gravity.

(D) a constant downward force of gravity only.

(E) none of the above, the ball fall back to the earth simply because that is its natural action.
State of the Field

Types of ongoing PER:

- Attitude evaluations/Epistemological beliefs
- Student Conceptions/Cognitive Processing
- Expert/Novice studies
- Changes in ... by gender, background, etc.
- Curriculum Development
Active PER Groups
Key Findings

- Constructivism
- Misconception
- Abatement
- Interactive engagement
- Technology
Electronic Media: The Role of Technology

- Although technology can efficiently carry the information, the evidence seems to suggest that the content and administration, not the platform, is the deciding factor.
Animated FCI

Example questions
PER Methodology

- Educational Research
  - Pre-Post Testing: Changes
  - Interviewing/ Videotaping
  - Data Analysis
- Student Conceptions
- Attitudes
Spreadsheets

► Why Spreadsheets?
* Spreadsheets are ubiquitous
* Spreadsheets are simple and logical
* Spreadsheets use basic and universal computer skills useful in the workplace

► What’s been done?
You name it!
Using Spreadsheets

Double Slit Interference
Example Research Project

► Conducted at USU Fall 2002
Research Design

► Format
  Spreadsheets in some topic areas, but not others, pre-lab/orienting activity, student-generated.

► Thought Questions
  directly confront common misconceptions, guide use of simulations

► Evaluation:
  Understanding – Exam Problems
  Attitudes – Pre-Post Surveys (modified, shortened version of MPEX (Maryland Physics Expectations survey)), SALG (Student Assessment of Learning Gains)³

► Interviews (TAs, Students), Think Aloud
Results

Strongest Correlations:

- Physics view (attitudes, career goals, etc.)
- year/gender
- TAs
USU first-year physics enrollment F2002

Number of students

Enrollment by gender

- Males
- Females
Year in School by gender

- Male (average: 2.82)
- Female (average: 3.25)
Problem results

average %score

topics w/o spreadsheet activities
2110 (d=0.06 %diff=11.6 t=2E-4)
2200-10 (d=0.31 %diff=22.9 t=0.08)
2220 (d=0.59 %diff=29.0 t=5E-20)

topics w/ spreadsheet activities

d=effect size = difference in means/standard deviation
Correlations

How much did the spreadsheet activities help your learning?

'Attitudes' includes: applicability, confidence, enthusiasm, interest, etc.
How much did the spreadsheet activities help your learning in this course?

ANOVA p-value: 2.49E-23 $\alpha=0.05$
How much did the spreadsheet activities help your learning in this course?

Average (1:None - 5:A great deal)

Males (ave: 2.014)
Females (ave: 1.73)

ANOVA p-value = 0.0374
Studying physics will really help me understand the world better.

ANOVA (α=0.05)
Significant?
M pre-post: Y (p=0.007) F pre-post: Y (p=0.0043)
M-F pre: N          M-F post: Y (p=0.00255)
I think physics will be applicable to my life/career.

ANOVA (α=0.05)

Significant?
M pre-post: N  
M-F pre: Y (p=0.001)  
F pre-post: N  
M-F post: Y (p=0.002)
pre-post efficacy ("I am confident in my ability to succeed in physics.")

1) ANOVA ($\alpha=0.05$)
   Significant?
   M pre-post: Y (p=8.92E-6)  F pre-post: Y (p=0.0028)
   M-F pre: N  M-F post: Y (p=0.012)
2) Correlation with spreadsheets help learning and post-efficacy is +0.128 significant at p=0.007
Effect of TAs

"How much did the spreadsheet activities help your learning in this class?"

average response (1:None - 5:A great deal)

lab1  lab2  lab3  lab4  lab5  lab6  lab7  lab8

2110  2200  2210  2220
Attitudes Comparison
Data from Redish, Saul and Steinberg, 1998

Student Attitudes

Percent change

School

UMD
UMn
OSU
DC
PLA
TYC
USU
Conclusion

- Results of PER can be profitably used to guide instruction.
- PER has a meaningful contribution to make, and belongs in Physics.

“You are NOT doing something intellectually exciting if the majority view sees the point of it.” - John Belcher
References


3. online at: http://www.wcer.wisc.edu/salgains/instructor/default.asp