What can space physics education learn from physics education research?

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What is PER?

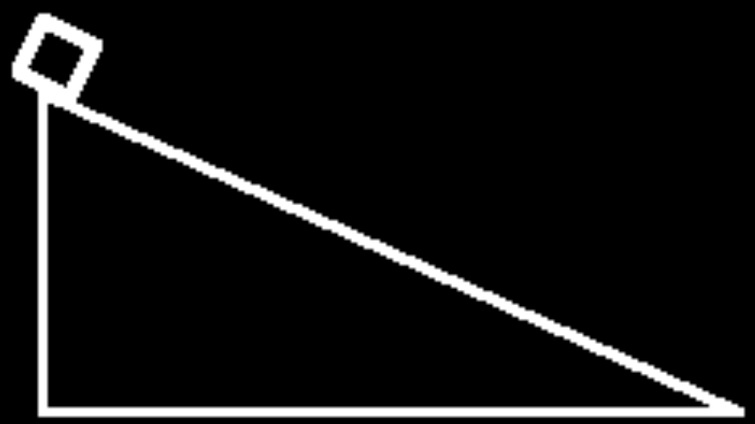
- The study of issues in teaching and learning of physics with a significant literature base
- Done mostly in physics departments by physicists
- A recognized field of physics (APS, 1999), with grants, Ph.D. students, peer-reviewed journals
- Heavy emphasis on developing instruction that quantitatively improves student outcomes
- Some PER is actually applied cognitive science

Experts and novices

- Research has been done into the difference between experts and novices [Chapter 2 of *How People Learn,* 2000].
- The main difference is the way that knowledge is organized.
- Novices focus on surface features of the problem while experts focus on conceptual relationships that organize knowledge.

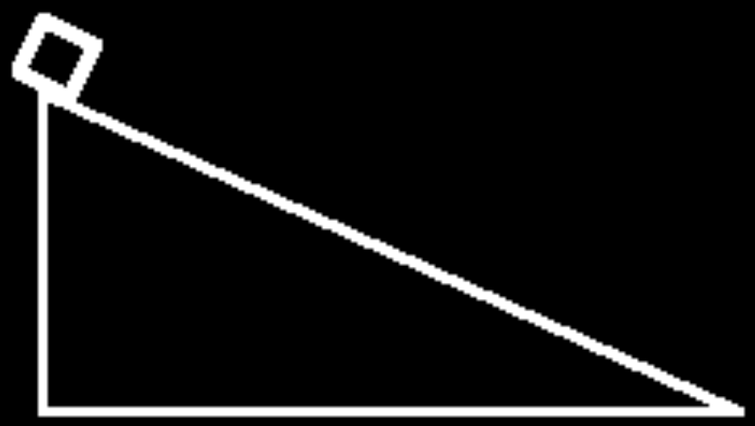
Group the Problems (After Chi et al., 1981)

Calculate the speed of the mass M at the bottom of the ramp (no friction)



Calculate the distance the spring stretches when the mass M hangs without moving

Calculate the coefficient of friction of the ramp so that the mass M does not slide



Novices

…will group problems 1 and 3 together because they both deal with a mass on an inclined plane. Problem 2 is a spring problem.

Experts

…will group problems 2 and 3 together because they are both statics problems. Problem 1 is a conservation of energy problem.

Active Learning Techniques

- They often target known misconceptions
- They draw on the cognitive research base
- It doesn't just mean "We do labs"
- They don't have to be "hands-on"
- Examples include the McDermott "Tutorials", SCALE-UP, and active lecture - Peer Instruction [Mazur, 1997]
- These innovations are portable and reproducible [Finkelstein & Pollock, 2005]

Project ROSE (presentation by S. Sjoberg, 2007, ISSI)

ROSE

ROSE in brief

- Standard survey methods
  (with its strengths and weaknesses!)
- Target population:
  15 year-olds in schools
- Representative sample (N> 1000) in each country
- Some 10 PhD (+many MA students) students base their thesis on ROSE data

Project ROSE
https://roseproject.no

ROSE

All ROSE items have the following format:

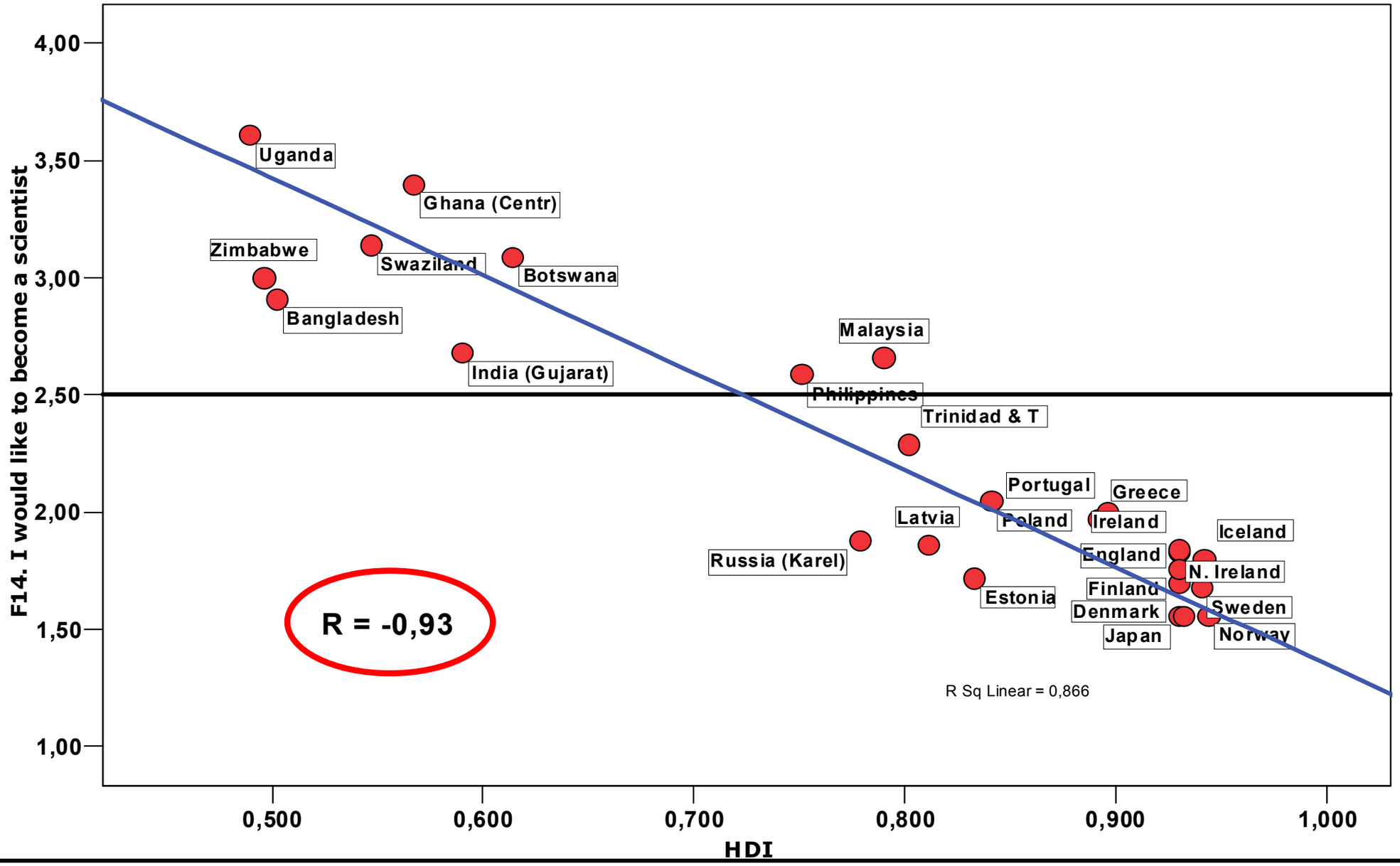
A. What I want to learn about

How interested are you in learning about the following?

(Give your answer with a tick on each line. If you do not understand, leave the line blank.)

		Not interes-ted			*Very interes-ted*
1.	Stars, planets and the universe	☑ 1	☐	☐	☐
2.	Chemicals, their properties and how they react	☐	☑ 2	☐	☐
3.	The inside of the earth	☐	☐	☑ 3	☐
4.	How mountains, rivers and oceans develop and change	☐	☐	☐	☑ 4
5.	Clouds, rain and the weather	☐	☐	☐	☐
6.	The origin and evolution of life on earth	☐	☐	☐	☐

I would like to become a scientist vs. HDI



Interest profile (108 items!):

- **In poor countries:**
  Pupils want to learn about ‘everything’
- **In richer countries:**
  Pupils are more selective, and strongly gendered profile:
- Traditional school science’ at the bottom
- **Girls:** biology and health,
- **Boys:** Explosives, engines, machines
- **Top priority for both:**
  The philosophical, the unsolved mysteries, space science

What about University students, especially STEM majors?

Do they have the same interest in space science?

Can we use this as an effective vehicle for motivating a broad range of physics topics?

NASA funds the NASA Space Science Education Consortium (Alex Young, PI) at Goddard Space Flight Center. Various projects are supported by the NSSEC, including one managed by the AAPT to develop PER-based materials with a space science context.

NASA/AAPT Team Organizations

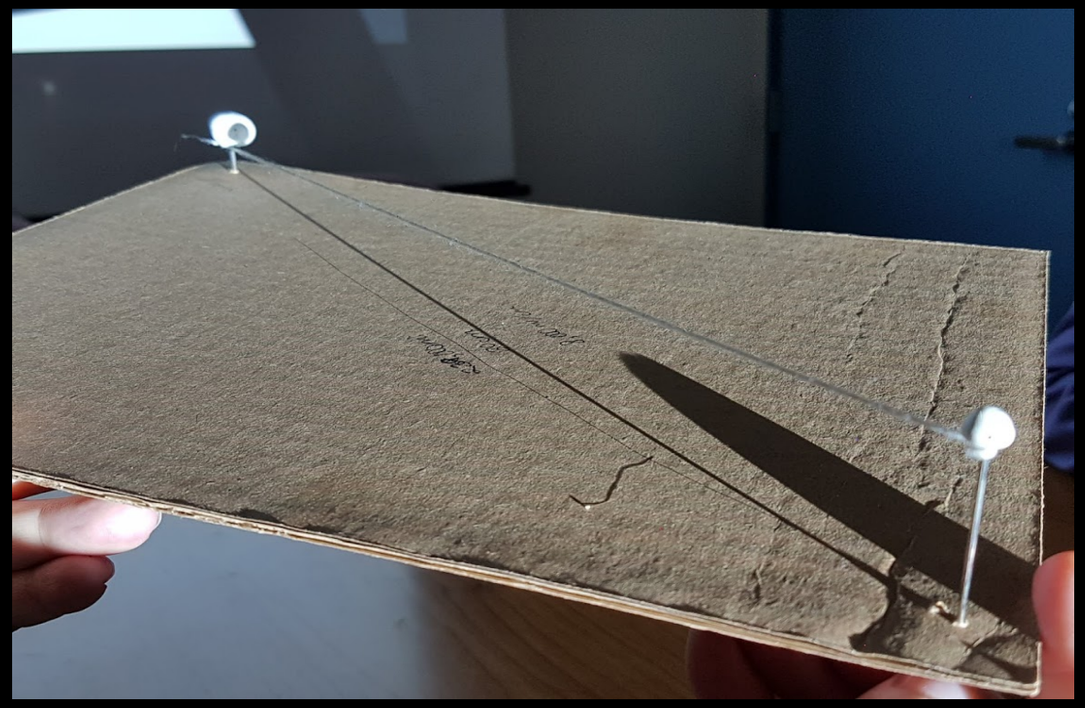
Temple University
American Association of Physics Teachers

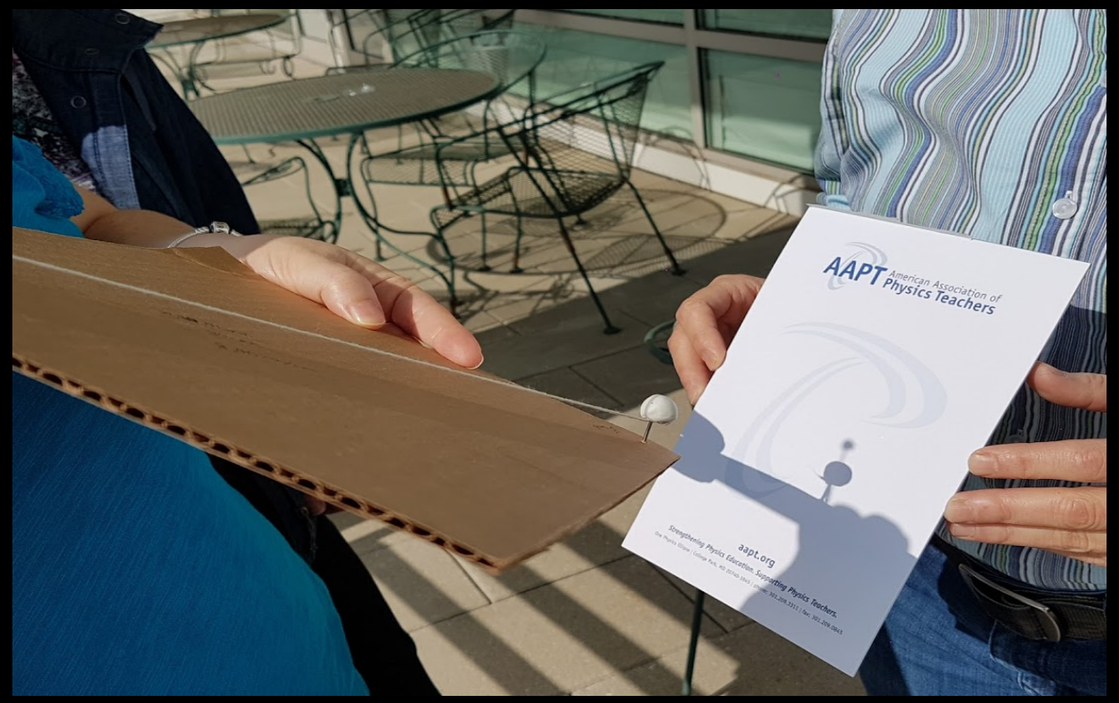
NASA/AAPT Team Members

Ramon E. Lopez, University of Texas at Arlington, lead
Janelle M. Bailey, Temple University
Rebecca Vieyra, AAPT (ex) and OAS
Ximena Cid, California State University Dominguez Hills
Brad Ambrose, Grand Valley State University
Shannon Willoughby, Montana State University

This team has expertise in astronomy and physics education research, heliophysics content, and access to post-secondary classrooms to field test all materials.

Preservice teacher lab on Eclipses





Other topics include:

- Auroral Currents Tutorial (application of Ampere's Law)
- Orbits and eclipse concept questions (angular momentum, energy in orbits)
- Tracking a CME (kinematics)
- Sunspot cycles (oscillations)

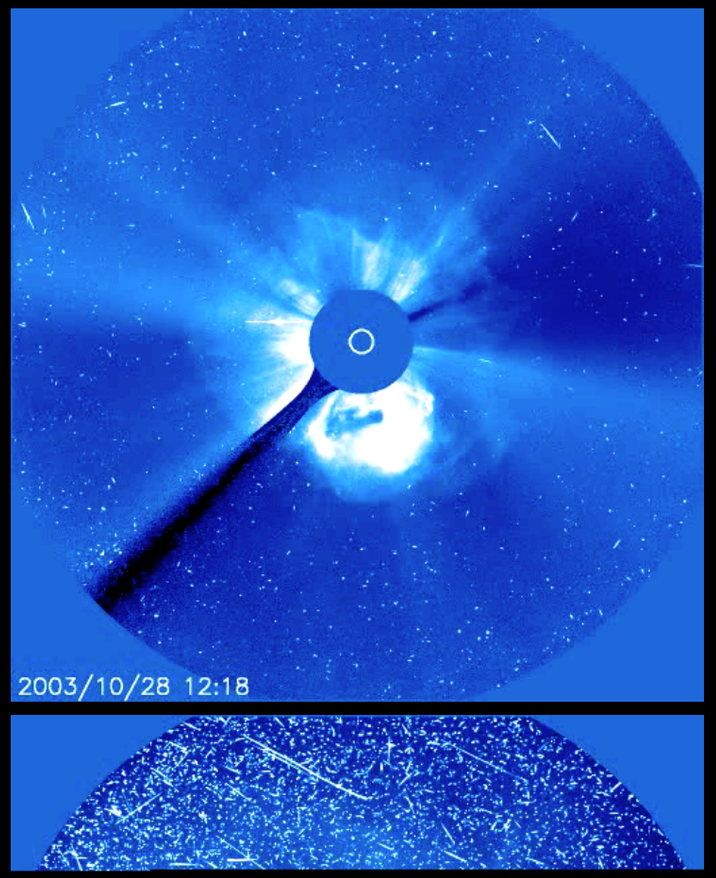
CME activity for Modern Physics

- Students used SOHO observations to determine the arrival time at L1 of solar energetic protons.

- They then used relativistic kinematics to determine when the particles would have left the Sun.

- Assuming the particles were accelerated at an interplanetary shock, the students identified the position of the shock using coronagraph images to determine how far away from the Sun the particles were accelerated.

- The activity was field-tested in class with students working in groups.



Solar energetic particles hitting the C3 coronagraph

	This activity helped me learn how to use the formula for determining relativistic momentum and velocity	I found the use of a space science example for relativistic particle motion interesting	I would like to see more space science examples to used to teach basic physics concepts	I would like to see more space science examples to used to teach advanced physics concepts	Working with a partner and collaborating on problem solving helped me understand the material better than a traditional lecture on the material	Working with a group in class on the problem helped me understand the material better than solving homework problems on my own	I am interested in learning about space science content
Mean:	3.154	4.385	4.154	4.269	3.654	3.385	4.615
StDev:	1.190	0.637	0.925	0.874	1.263	1.329	0.697
N:	26	26	26	26	26	26	26
P-value	0.5097	0.0000	0.0000	0.0000	0.0083	0.1400	0.0000

Summary

Concept Questions

Tutorials

Labs

Homework Questions

- PER has provides a research base as a guide for developing high quality instruction, and it has proved useful (CISM summer school, Lopez and Gross [2008]).
- NASA is supporting an AAPT team to create research-based undergraduate instructional materials for physics with space science themes.
- Future topics will include astrobiology themes
- http://aapt.org/resources/SSEC/