Centre for Science Education – Aarhus University

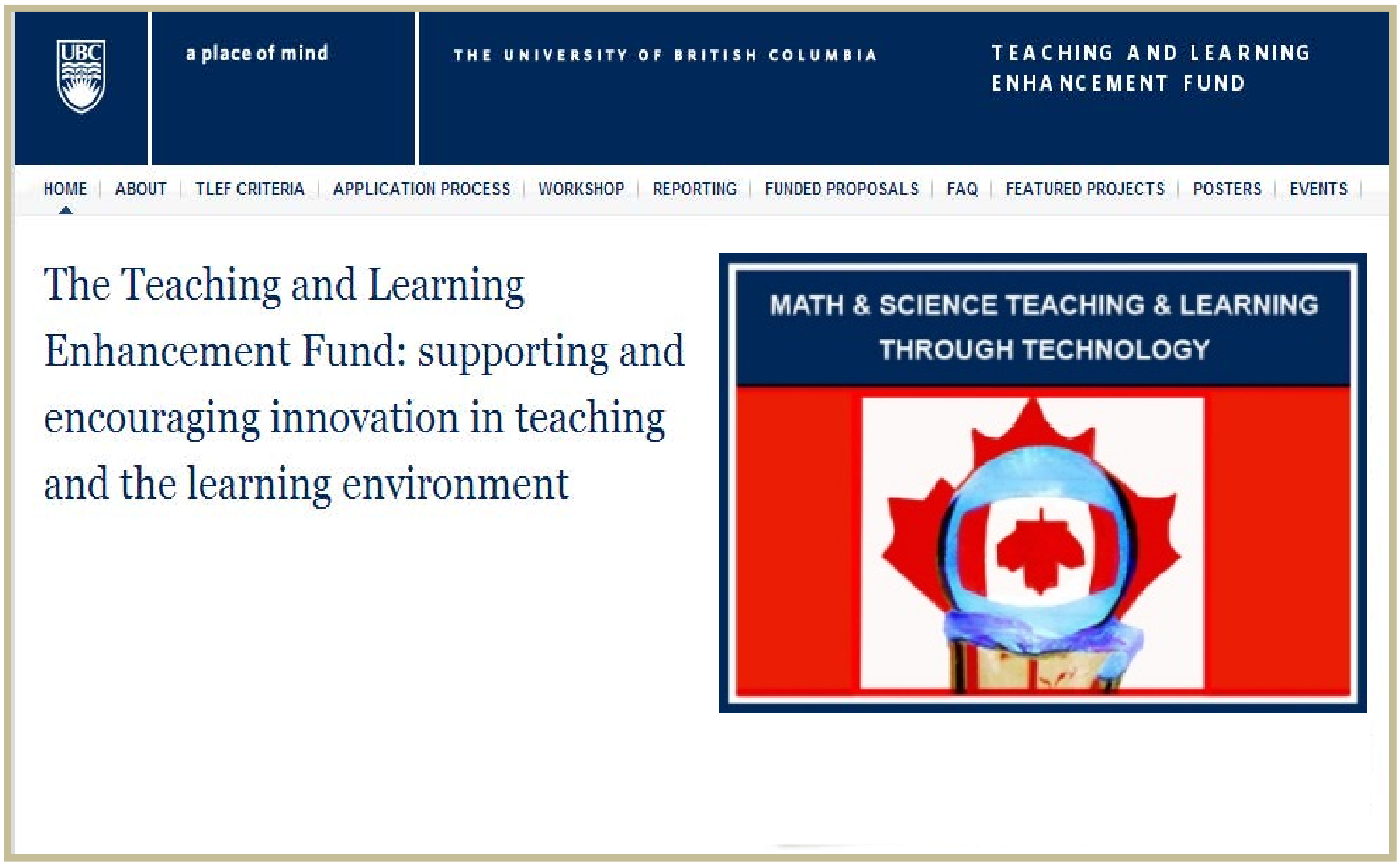
Technology Transforming Math & Science Education: *Are We There Yet?*

UBC FACULTY of Education
THE UNIVERSITY OF BRITISH COLUMBIA
EDCP DEPARTMENT OF curriculum & pedagogy

Dr. Marina Milner-Bolotin

March 23, 2015

Acknowledgements



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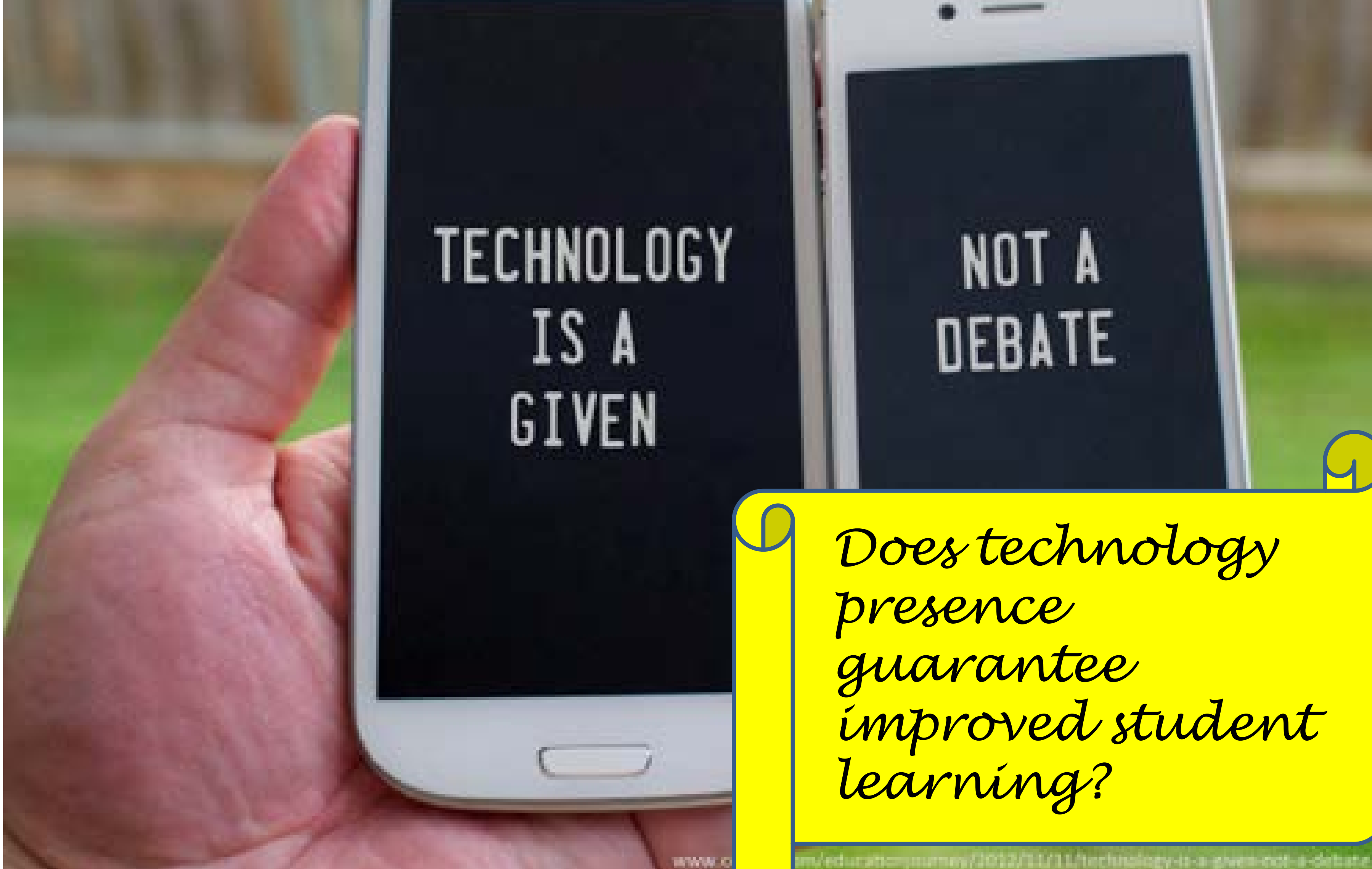

Does technology presence guarantee improved student learning?

Dr. Marina Milner-Bolotin

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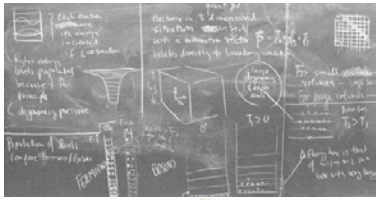
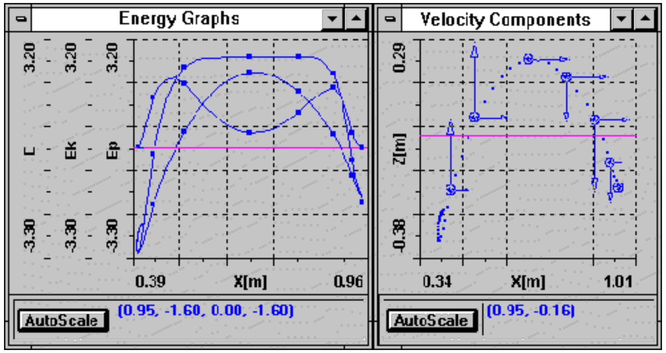
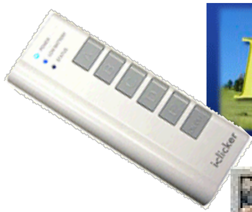
- **Web site:** http://blogs.ubc.ca/mmilner/

My Science Education Trajectory

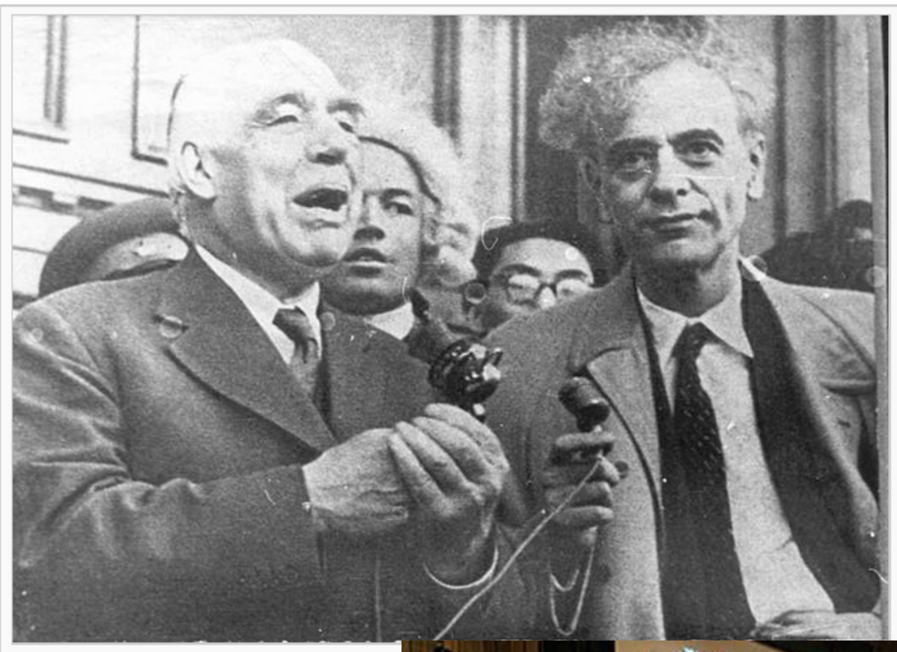




V-scope



Our Science Education Trajectory



From world renowned “schools of physics” led by Bohr, Landau, etc. to the mass production of students in large courses…

6

Science Education in Canada

Science Exposure

K-12

University

Elem

Second

B. Science

Other fields

Teacher Education in Canada

Bachelor Subject + B.Ed.

Elem.

Secondary

B.A.

B.Ed.

B.Sc.

B.Ed.

Teacher Education in Canada

Promoting Research-Based Physics Teacher Education in Canada: Building Bridges between Theory and Practice

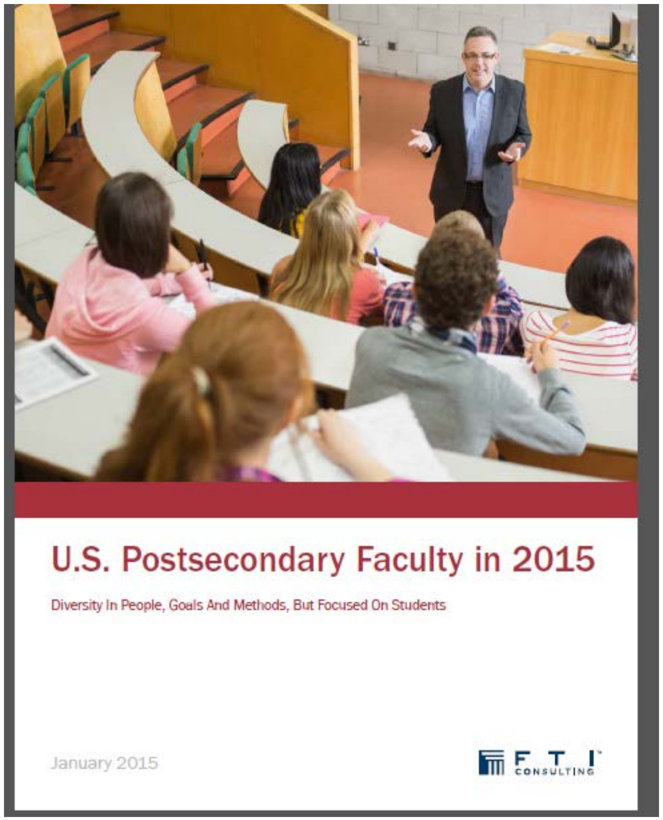
by Marina Milner-Bolotin

More than 25 years ago, Lee S. Shulman, then president of the American Educational Research Association [1], challenged us to re-think how we prepare teachers through focussing on *Pedagogical Content Knowledge* (PCK) - the knowledge of content and content-specific pedagogies. Shulman pointed out that in their attempt to incorporate generic educational research, many Teacher Education Programs suffered from the "missing paradigm" problem. They neglected the nature

content-specific professional development, teacher education programs should emphasize the development of teacher-candidates' PCK.

Lastly, there is a significant gap between the findings of Physics Education Research (PER) [4] and current physics teaching practices. In the words of ph...
Laureate, Prof. Carl Wiem...

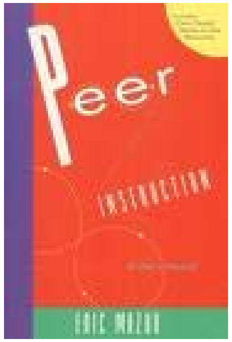
Gates' Foundation 2015 Report (January 2015)



This framework identifies two distinct segments that account for over 40% of the faculty and are well poised to be adopters of techniques, tools, and behaviors which will benefit students. Of this entire group, half are already adopting some emerging practices, and may serve as exemplars to others. (p. 5)

[FTI Consulting. (2015). U.S. Postsecondary Faculty in 2015: Diversity in people, goals and methods, but focused on students: FTI Consulting.]

Our Research on Technology Use in Science Education



1. Peer Instruction **(clickers)**

2. Collaborative student work **(PeerWise)**

3. Live Data collection and analysis **(Logger Pro)**

4. Computer simulations **(PhET)**

I. Peer Instruction

Electronic response systems (clickers) in science classrooms…

Peer Instruction

A clicker question is posed

Students work individually for about a minute to figure out the answer that they submit using clickers

Students' responses are displayed to the class without revealing the correct answer

Many of the students answered incorrectly.

Students work in groups of 2-3 to discuss the question.

Students resubmit individual answers using clickers.

Most of the students provided a correct response. Correct answer revealed.

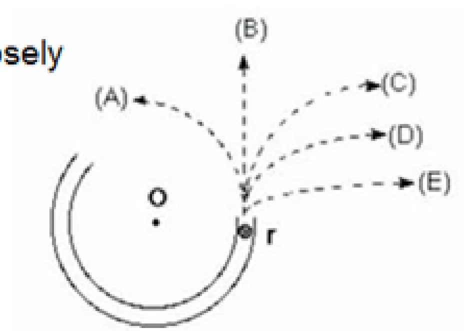
An instructor leads a summary discussion with the class: the reasons for correct answer as well as the reasons for choosing the incorrect answers are elicited from the students.

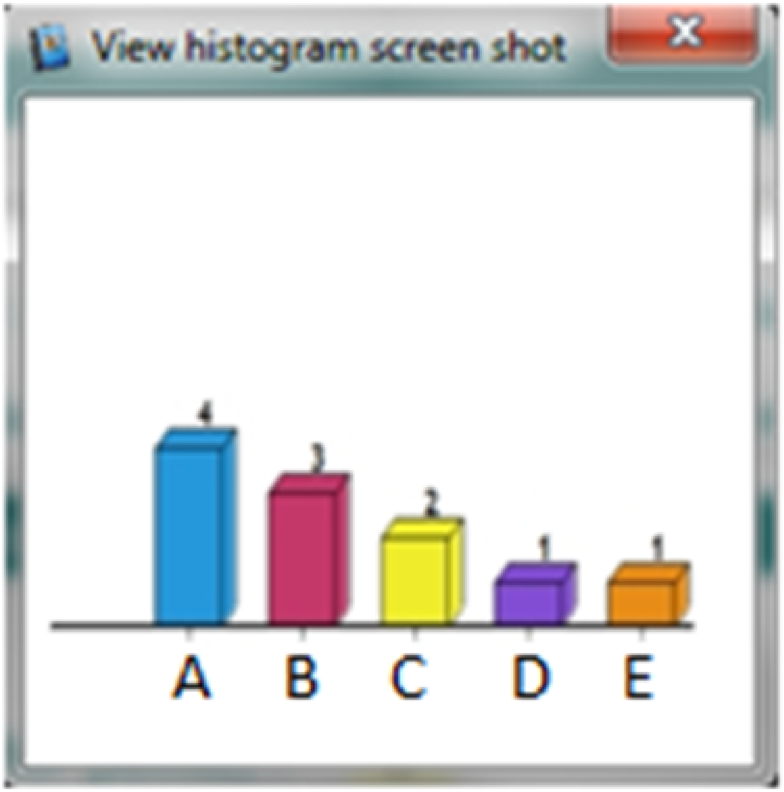
PI: Challenging Assumptions

Question

A ball travels through the circular track until point r, at which point it leaves the channel to travel across a frictionless floor. Assume a bird's eye view, and that all motion is in the horizontal plane.

Which path will the ball most closely follow after it exits the channel?





Answers given by pre-service physics teachers

Peer Instruction Example

The work needed to stretch a spring **10 cm** from equilibrium (from $x_1 = 0$ m to $x_2 = 0.1$ m) is **10 J**. How much work needs to be done to stretch the spring additional **10 cm** (from $x_2 = 0.1$ m to $x_3 = 0.2$ m) ?

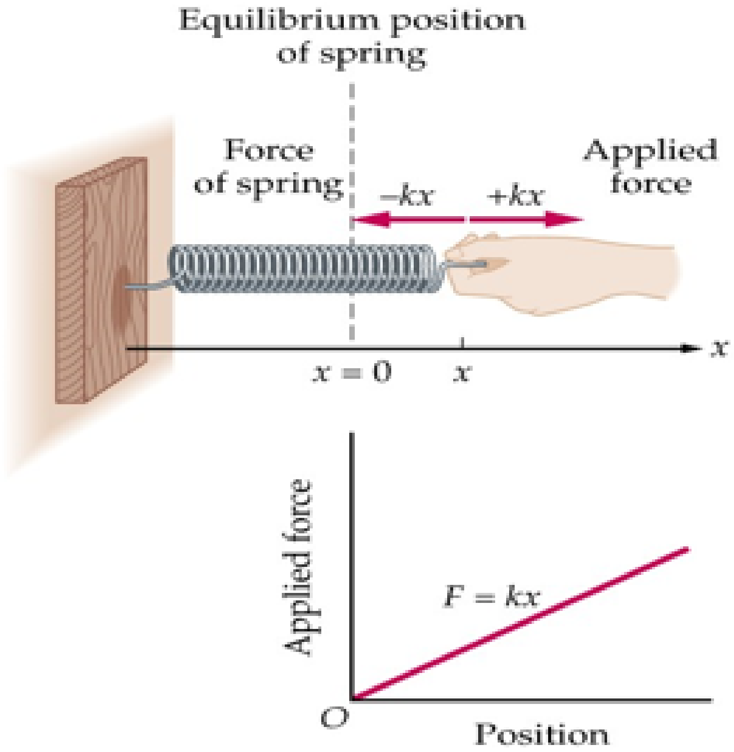
A. 5 J

B. 10 J

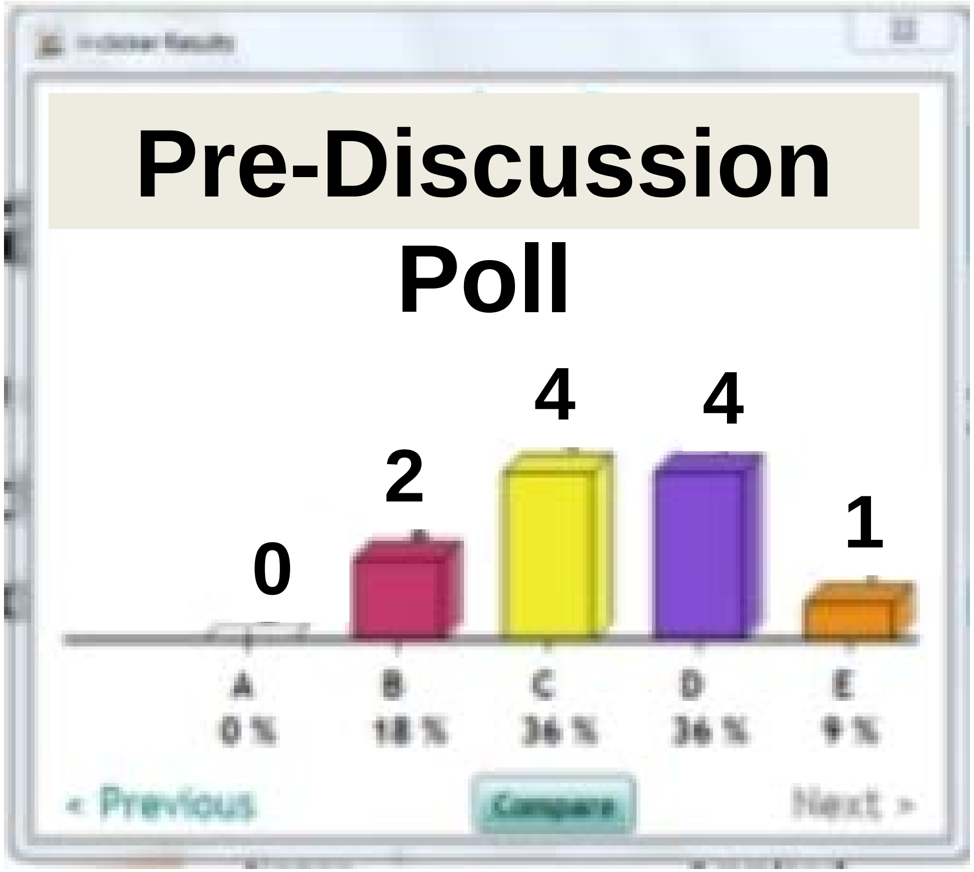
C. 20 J

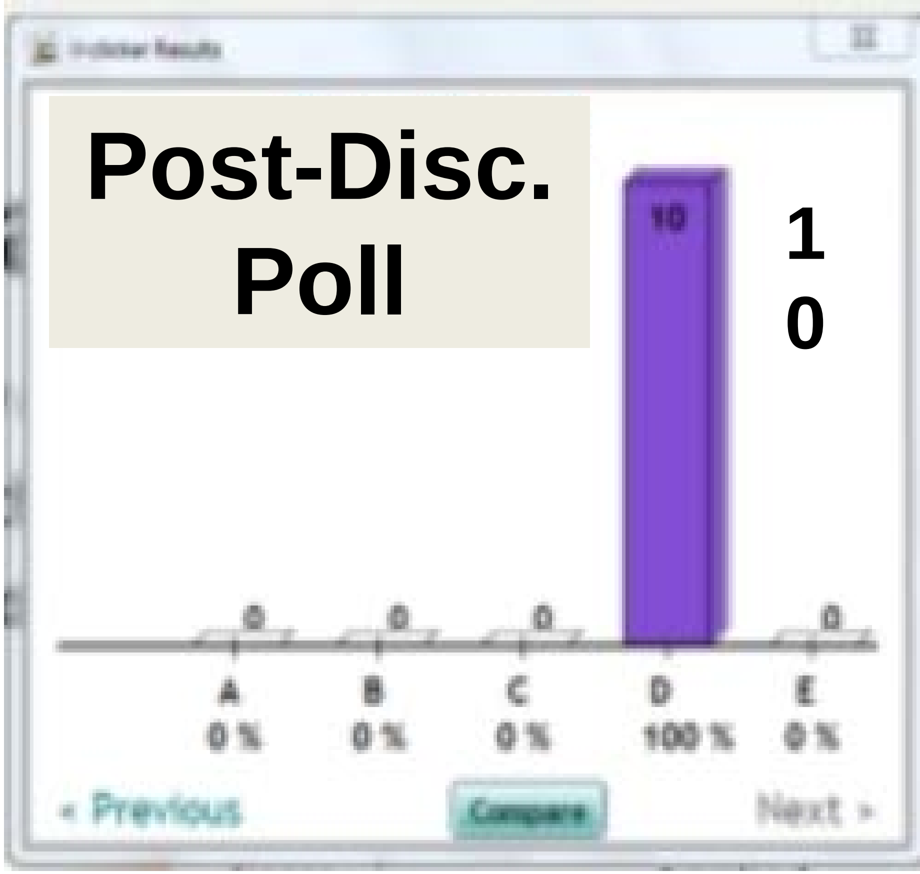
D. 30 J

E. 40 J



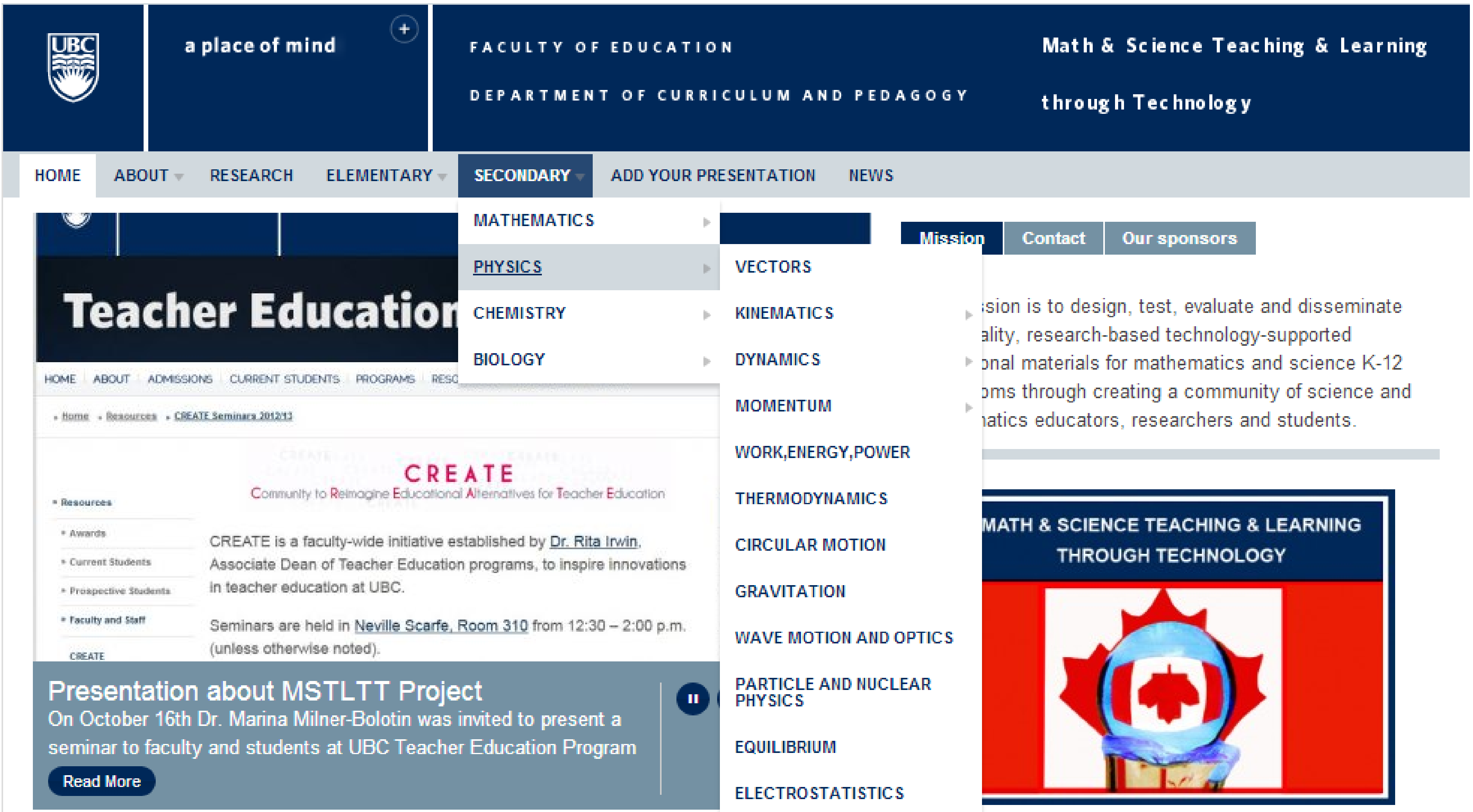
Peer Instruction in Action





Respondents: Physics Teacher-Candidates

Math & Science Teaching & Learning through Technology



Navigating the Resource

a place of mind

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Math & Science Teaching & Learning through Technology

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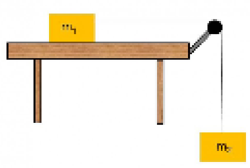
» Home » Secondary » Physics » Dynamics » Forces

FORCES

Blocks and a Pulley

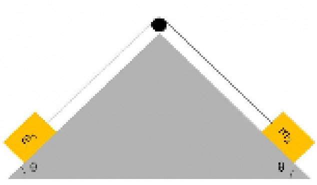


Exploration of free body diagrams, two body acceleration, and Newton's law through the system of two blocks attached through a pulley and one of them resting on a table.

acceleration, forces, friction, Newton`s laws, pulleys, string tension

rating (No Ratings Yet)

Blocks on a Pyramid



Exploration of free body diagrams, two body acceleration, and newton's laws through the system of two blocks resting on a pyramid and attached by a pulley.

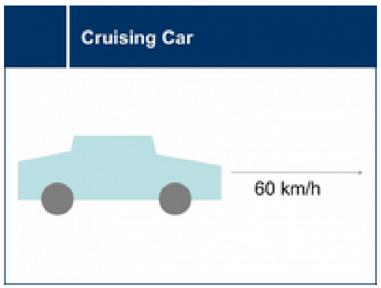
acceleration, forces, friction, gravitational acceleration, net force, normal force, weight

rating (No Ratings Yet)

- Mathematics
- Physics
  - » Vectors
  - Kinematics
  - Dynamics
    - » Forces
    - » Springs
    - » Newton's Laws
  - Momentum
  - » Work,Energy,Power
  - » Thermodynamics
  - » Circular Motion
  - » Gravitation
  - » Wave motion and Optics
  - » Particle and Nuclear Physics

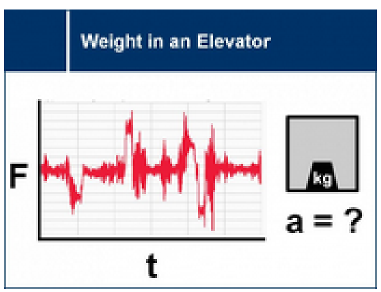
Navigating the Resource

rating (No Ratings Yet)



An introduction to acceleration and newton's laws using a demonstration of a commuting car.
acceleration, displacement, distance, forces, net force, velocity

rating (No Ratings Yet)



How does a reading on a scale change when on a moving elevator? Scenarios with an elevator moving at different velocities and acceleration will be considered. The concepts learned will then be used to analyze data from a real-life experiment.
acceleration, gravitational acceleration, mass, net force, normal force, real-life data, velocity, weight

rating (No Ratings Yet)

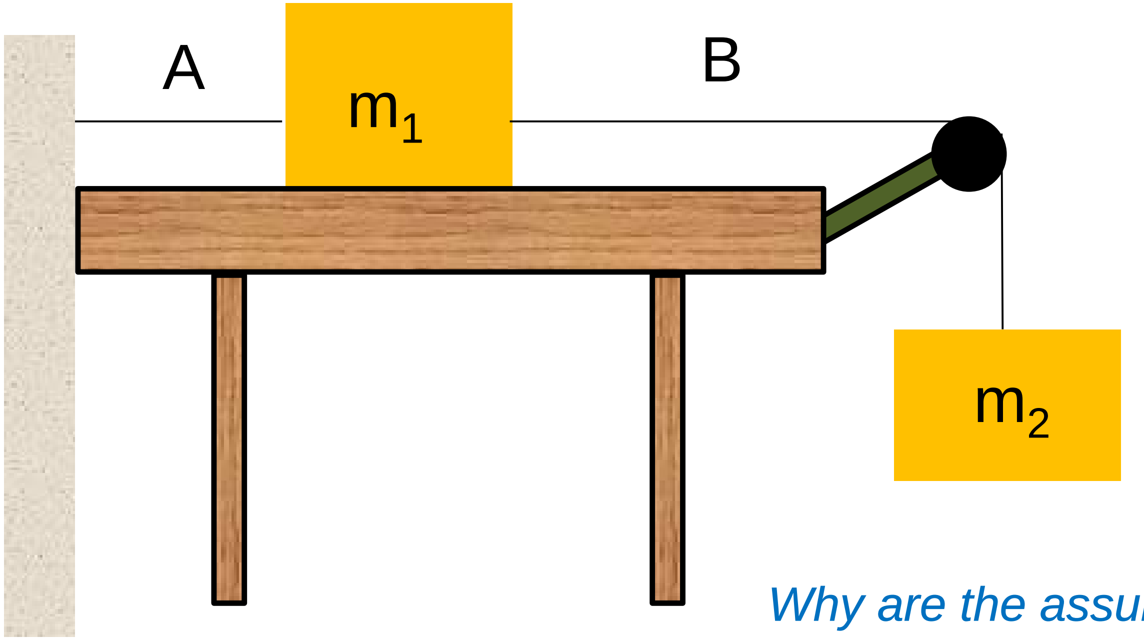
The following set of questions apply Newton's Second Law to scenarios with multiple blocks held together by the tension force from strings.

acceleration area centripetal force common ratio conservation of energy conservation of momentum Conversion Factors counting current displacement distance elastic collisions forces frames of reference free-body diagrams friction graphs gravitational acceleration gravitational potential energy inelastic collisions kinetic energy molar mass mole net force normal force numbers patterns percentages permutations power probability projectile motion ratios rectangles resistance sequences series tension triangles trigonometry unit circle vectors velocity voltage weight

http://scienceres-edcp-educ.sites.olt.ubc.ca/

Blocks and a Pulley

Two blocks are connected via a pulley. The blocks are initially at rest as block m_1 is attached to a wall. If string A breaks, what will the accelerations of the blocks be? (**Assume** friction is very small and strings don't stretch)



A. $a_1 = 0;\ a_2 = 0$

B. $a_1 = g;\ a_2 = g$

C. $a_1 = 0;\ a_2 = g$

D. $a_1 = g;\ a_2 = 0$

E. None of the above

Why are the assumptions above important?

Solution

Answer: E

Justification: None of the above answers is correct. Consider two blocks as one system: one can see that the system has a mass of (m_1+m_2), while the net force pulling the system down is m_1g. Therefore, applying Newton's second law, one can see that the acceleration of the system must be less than g:

$$a = \frac{m_2 g}{(m_1 + m_2)} = \frac{m_2}{(m_1 + m_2)} g < g$$

Some people think that the acceleration will be g. They forget that the system consists of two blocks (not just m_1) and the only pulling force is m_1g. Thus the system is NOT in a free fall. Compare this questions to the previous one to see the difference.

II. PeerWise Online System

PeerWise

EDCP357 (Winter 1, 2013)

Home | Main menu > Comments written by you

Comments written by you

Comments written by you, about questions you have answered, are shown below.

Select an order:

New replies Most recent first Show agreements only Show disagreements only

Showing new replies only

No comments to view

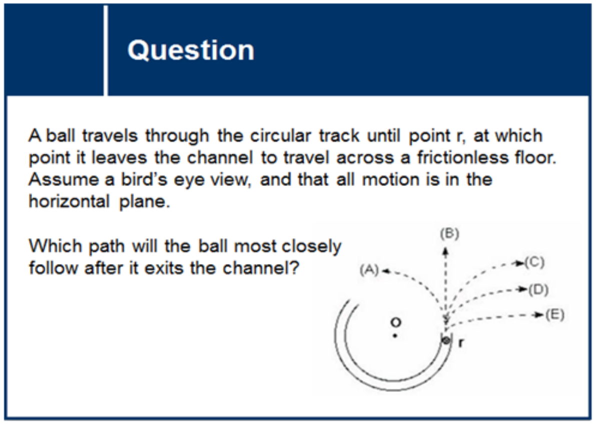
Return to main menu

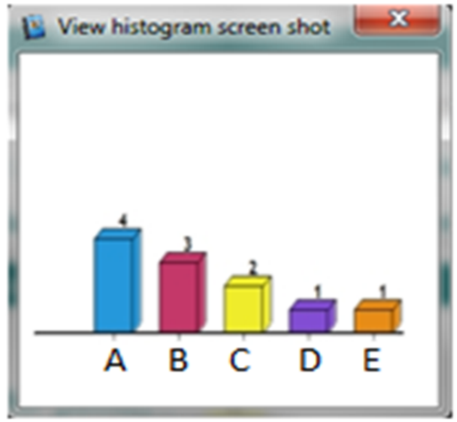
What is PeerWise?

Students use PeerWise to create and to explain their understanding of course related assessment questions, and to answer and discuss questions created by their peers.

http://peerwise.cs.auckland.ac.nz/

Technology-Enhanced Active Engagement Integration





Peer Instruction modeled in every class

PeerWise used to design, critique, respond to Conceptual Questions as a community of future teachers

PeerWise Pedagogy

[Res. & Pract. in Math, Sci. & Techn. Ed., 2013. 1(5): p. 525-544.]

LUMAT 1(5), 2013

Modeling Active Engagement Pedagogy through Classroom Response Systems in a Physics Teacher Education Course

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Heather Fisher
Department of Curriculum and Ped

Alexandra MacDonald
Department of Curriculum and Ped

Abstract One of the most comm
and Mathematics (STEM) educat
instructors generate in-class discus

USING PEERWISE TO PROMOTE STUDENT COLLABORATION ON DESIGN OF CONCEPTUAL MULTIPLE-CHOICE PHYSICS QUESTIONS

BY MARINA MILNER-BOLOTIN*
DEPARTMENT OF CURRICULUM AND PEDAGOGY
UNIVERSITY OF BRITISH COLUMBIA

Every physics instructor who ever used clicker-enhanced pedagogy knows that coming up with pedagogically effective conceptual questions i

contributed to PeerWise d
Table 1.

[Physics in Canada., 2014, 70(3): p. 149-150]

III: Live Data Collection & Analysis

2007, Journal of College Science Teaching, 36(4), 45-49.

Can Students Learn from Lecture Demonstrations?

The Role and Place of Interactive Lecture Experiments in Large Introductory Science Courses

By Marina Milner-Bolotin, Andrzej Kotlicki, and

2008, The Physics Teacher, 46(8), 494-500.

Physics Exam Problems Reconsidered: *Using Logger Pro to Evaluate Student Understanding of Physics*

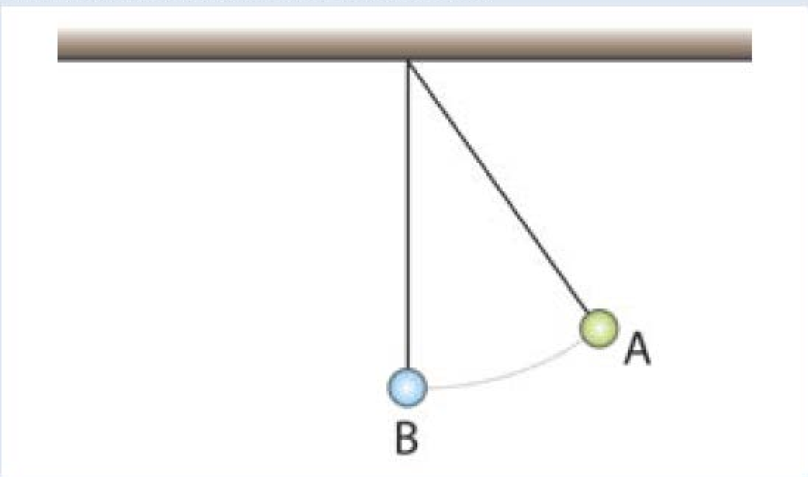
Marina Milner-Bolotin, Ryerson University, Toronto, ON
Rachel Moll, The University of British Columbia, Vancouver, BC

Example: Demos vs. Interactive Lecture Experim's

A 0.2-kg pendulum bob is attached to a string 1.2 m long. The bob is released at the point A as shown in the picture. The tension in the string as the bob passes its lowest position is about (use g = 10 m/s2):

(A) 0.00 N (B) 0.70 N (C) 1.30 N (D) 2.00 N (E) 2.70 N

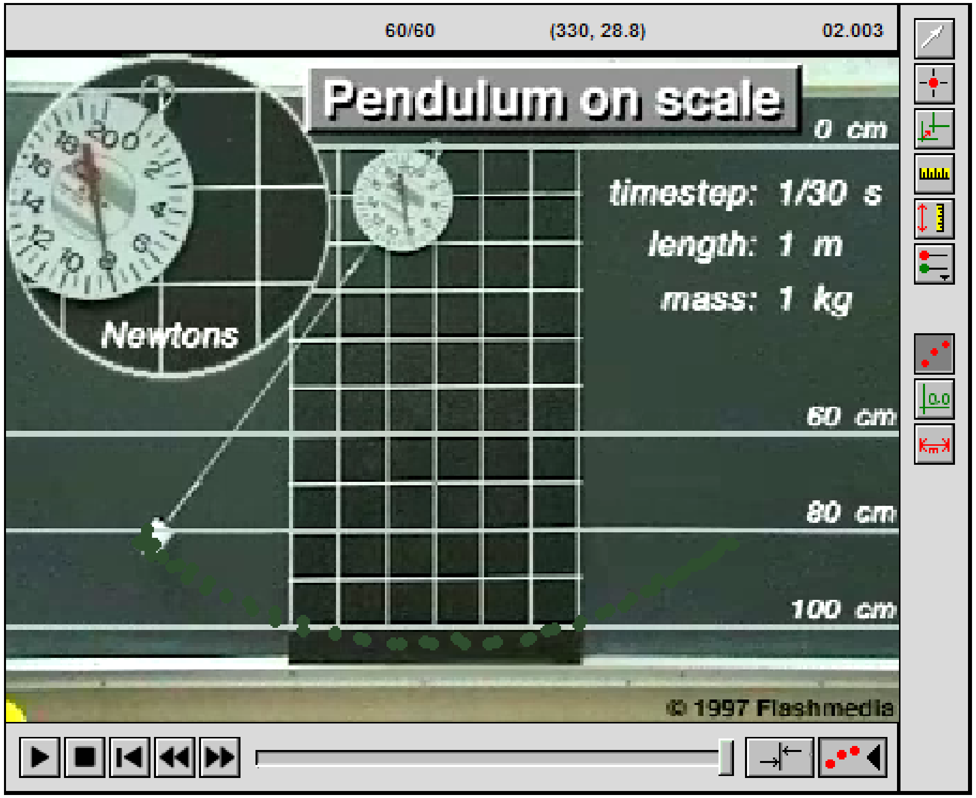
Tension in a pendulum's string exam problem.



Only 25% of the students chose the correct response. 59% chose the incorrect response (D).

[M. Milner-Bolotin et al, Journal of College Science Teaching, January-February 2007, pp.45-49.]

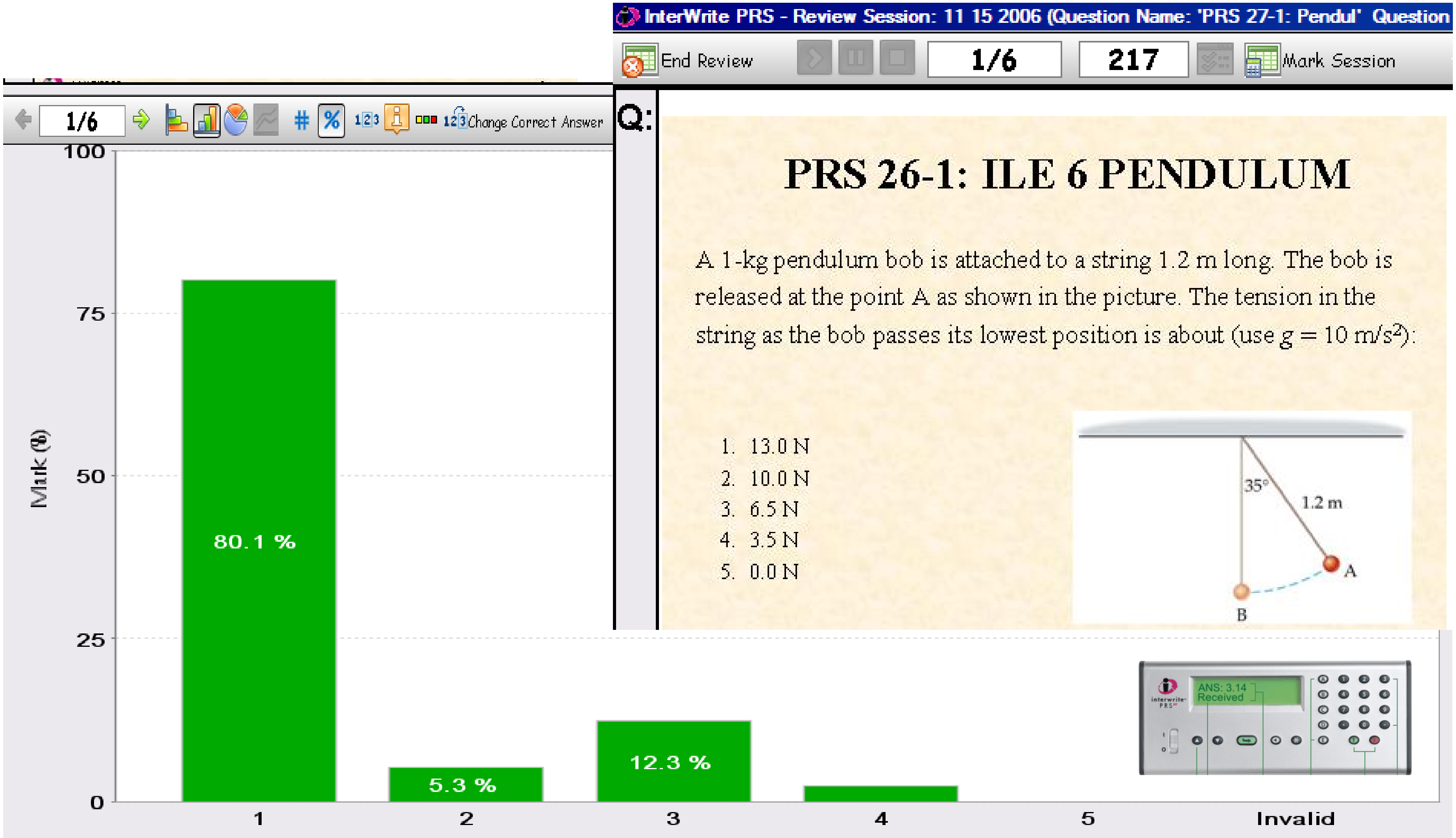
Pedagogy: Interactive Lecture Experiment



Students work in small groups, collect necessary data, come up with the analysis and solution and then check if their answer is meaningful using in-class live experiment (data collection).

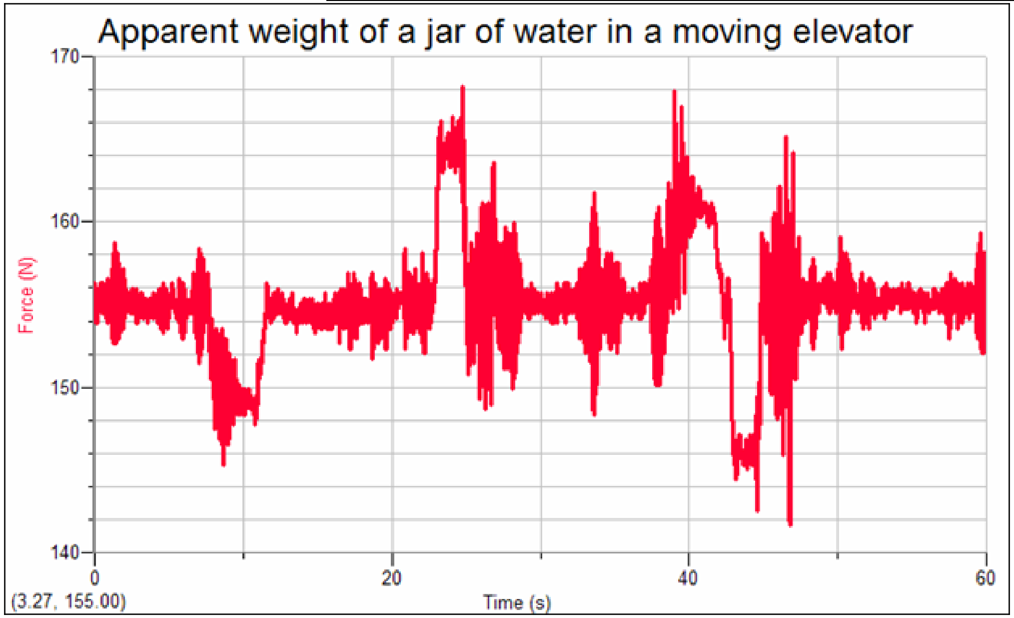
Traditional lecture demonstrations are replaced by Interactive Lecture Experiments

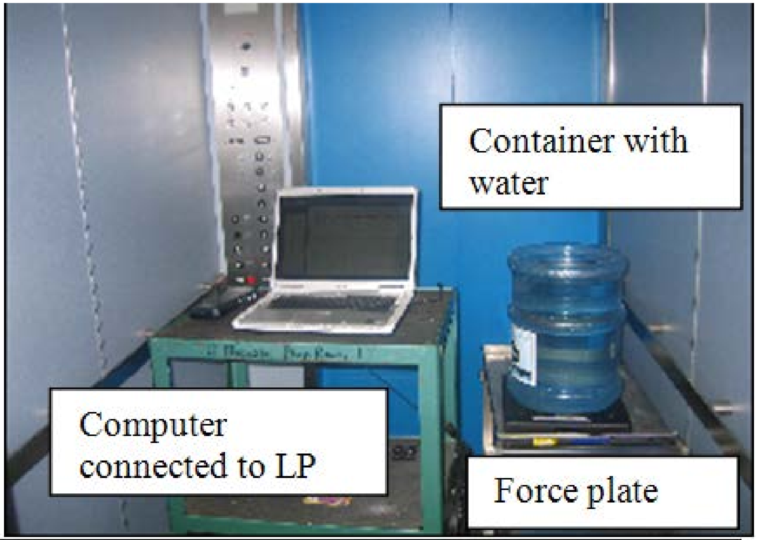
Post-Instruction Results



Making Science Relevant

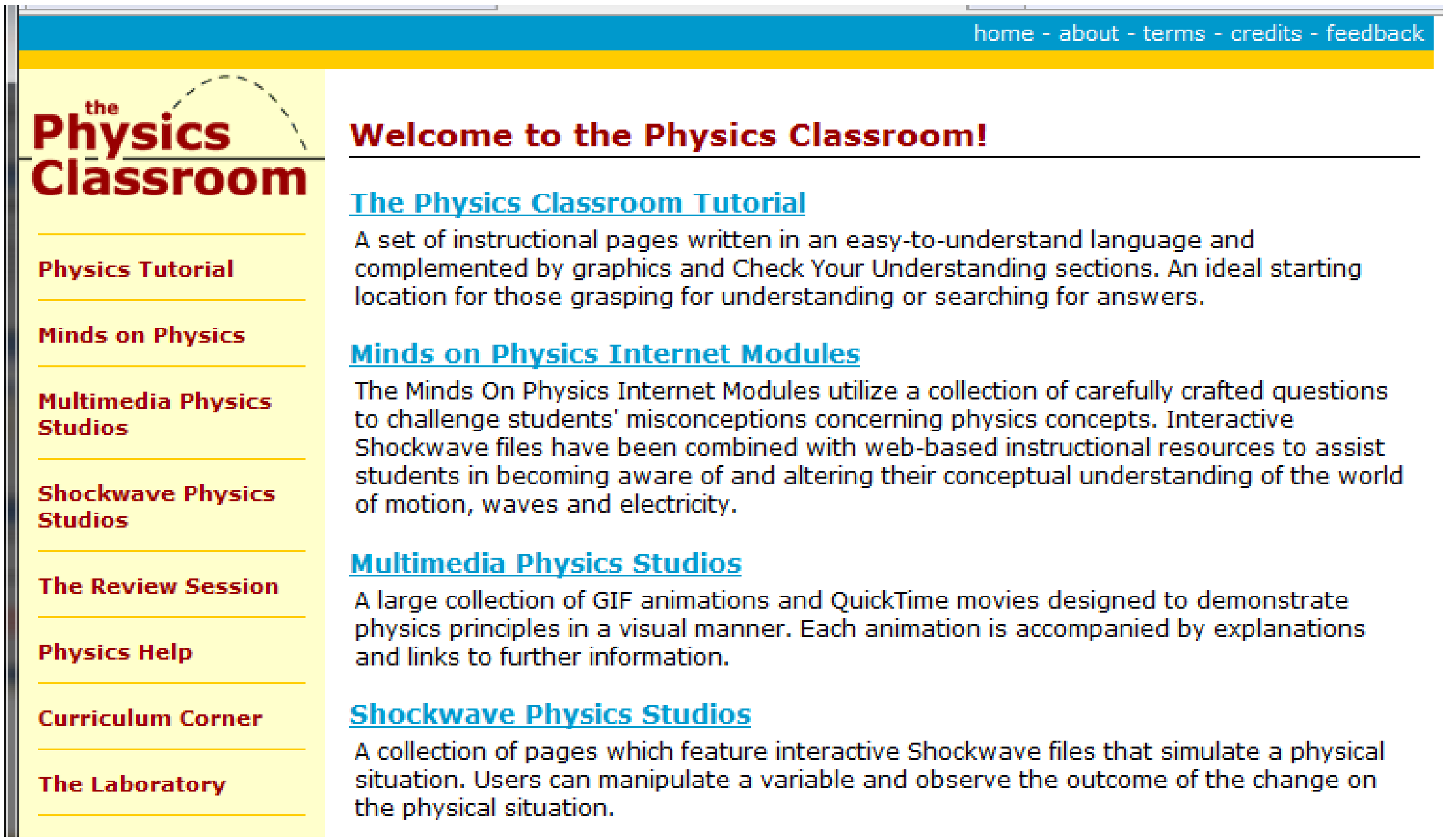
Why do you sometimes feel lighter and sometimes heavier in an elevator?





A water jar was placed on a force plate inside a moving elevator: weight and apparent weight problem

IV: Computer Simulations



AAPT PHYSICS EDUCATION American Association of Physics Teachers

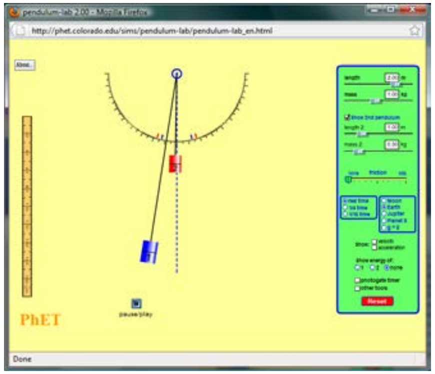
comPADRE Physics and Astronomy Education Communities

NSF

Developing Science Intuition

Simulations help develop physics intuition via testing experimentally different scenarios – WHAT IF…? (Think critical thinking).

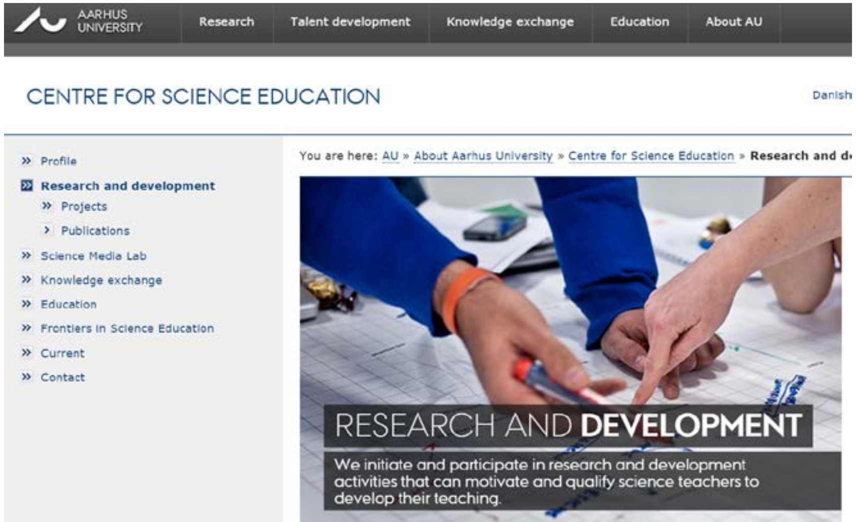
$$T = 2\pi\sqrt{\frac{l}{g}}$$



We can place the pendulum on Moon, Earth, Jupiter or even Planet X…

Conclusions: Deliberate Pedagogical Thinking with Technology

Technology opens unprecedented opportunities for educators, but we have just scratched the surface. We have to explore how to use it to promote meaningful science education. Teacher education both at K-12 and post-secondary levels should model effective research-based uses of technology.



UBC Science Teacher Education

the COPENHAGEN post

National

PISA results show dropping maths abilities

Danish students still produce second-best PISA results in Nordics despite dropping performance in mathematics