



a place of mind

THE UNIVERSITY OF BRITISH COLUMBIA

TEACHING AND LEARNING
ENHANCEMENT FUND

21st Century Framework for Science Teacher Education: Using modern technologies to affect science education

Dr. Marina Milner-Bolotin

The University of British Columbia, Vancouver, Canada



STEM 2012 Beijing, China



a place of mind

THE UNIVERSITY OF BRITISH COLUMBIA

FACULTY OF EDUCATION

STEM 2014

The University of British Columbia, Vancouver, Canada

July 12-15, 2014



STEM

2014 | Science | Technology | Engineering | Mathematics | in Education Conference

Research Team

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

- * Dr. Marina Milner-Bolotin (PI, science education)
- * Dr. Cynthia Nicol (collaborator, mathematics education)
- * Heather Fisher and Alex McDonald (EDCP Grad Students)
- * Jeremy Ko and Kevin Yin (Faculty of Science undergrads)
- * Teacher-Candidates in 2012 EDCP 357 (Physics Methods)
- * Local Physics Teachers (testers, contributors of ideas)

UBC Teacher Education

<http://teach.educ.ubc.ca/>

Campuses + UBC Directories + UBC QuickLinks +

UBC
a place of mind
FACULTY OF EDUCATION

Teacher Education Office

INQUIRE
IMAGINE
INSPIRE

HOME | ABOUT | ADMISSIONS | CURRENT STUDENTS | PROGRAMS | RESOURCES | COMMUNITY | BLOG

Now Accepting Applications for the Bachelor of Education Program (BEEd) - September 2013 Start
Please visit Admissions for more information.

Featured News Events Twitter Links

**Teacher Education Student Awards Night
Tuesday, November 20**

Congratulations to all of our 2011/12 teacher education award recipients. For a full list of awards and winners, [please visit this page.](#)

Alumni Teacher Award

The UBC Faculty of Education [Alumni Teacher](#)

Breaking New Ground This Fall

A glimpse at what our revised Teacher Education program offers new teacher candidates this Fall

5 / 5

Physics Methods Course

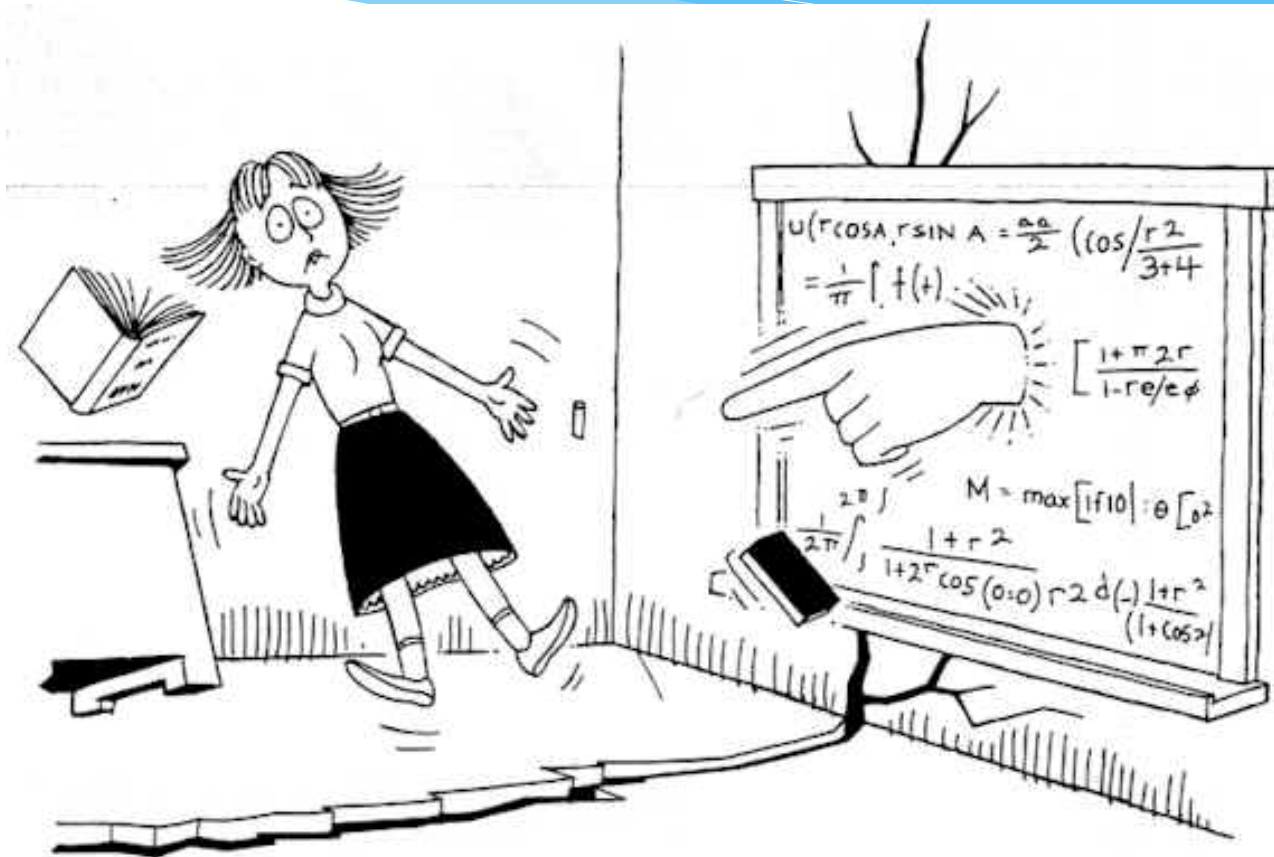
Part of B.Ed. Program

- * Enrolled: 14 teacher-candidates
- * From 22-32 years old
- * All of them have at least a B.Sc. in Physics
- * Meet for 3 hours a week for 13 weeks
- * Have various but limited teaching experiences
- * Very motivated and interested in physics education

Inquiry in STEM Education

- 1. How do you define inquiry in the STEM context?**
- 2. How do you engage future teachers in inquiry-based STEM education?**

What Was Your STEM Experience as a Student?



"NO, NO, NO WRONG AGAIN!"

WORKSHOP'S AIM

**TO THINK ABOUT WHAT CAN BE DONE TO IMPROVE
MATHEMATICS AND SCIENCE K-12 TEACHER
EDUCATION THROUGH INNOVATIVE USE OF
EDUCATIONAL TECHNOLOGIES...**

Technology as Means to an End...

Educational technology in STEM teacher education has a potential to **help future teachers** to:

1. Acquire pedagogical-content knowledge
2. Generate creative approaches to teaching
3. Get ready to teach in the 21st century

Technology in Teacher Education



Future teachers should experience SMET technology-enhanced learning as students and as teachers

[Koehler, M. J., & Mishra, P. (2009). What is technological pedagogical content knowledge? *Contemporary Issues in Technology and Teacher Education*, 9(1), 60-70.]

Three Examples of Technologies in SMET

1. Electronic Response Systems (**clickers**)



2. Live Data Collection and Analysis (**Logger Pro**)



3. Computer Simulations (**PhET**)



I. Electronic Response Systems

Electronic response systems (clickers) in K-12 classrooms...



Research-Informed Teacher Education

2004, *The Physics Teacher*, 42(8), 47-48.

Tips for Using a Peer Response System in a Large Introductory Physics Class

Marina Milner-Bolotin, Physics and Astronomy Department, Rutgers, The State University of New Jersey
Piscataway, NJ 08854-8019; milnerm@physics.rutgers.edu

Clickers beyond the First Year Science Classroom

Marina Milner-Bolotin

Tetyana Antimirova

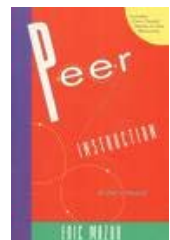
Anna Petrov

2010, *Journal of College Science Teaching*,
40(2), 18-22.

Abstract:

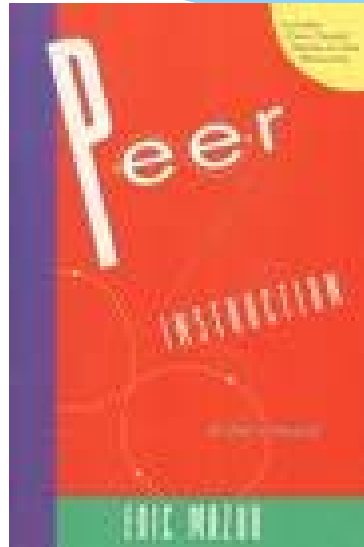
This case study's primary objective is to describe the implementation of the electronic response-system (clickers) in a small (N=25) second

Teaching
physics
challenge for



Have You Ever Heard of Peer Instruction (PI) & Eric Mazur?

- A. Yes
- B. No

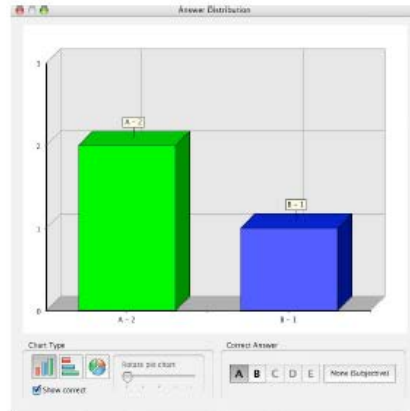
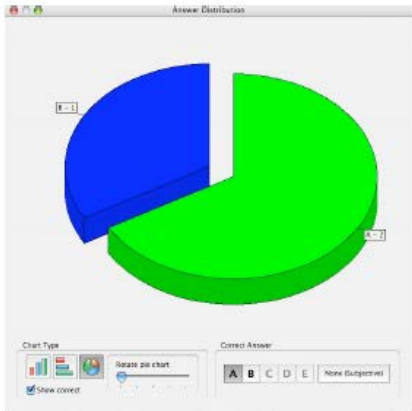


INTERACTIVE TEACHING

Promoting Better Learning Using *Peer Instruction* and *Just-in-Time Teaching*

FEATURING the award-winning documentary
FROM QUESTIONS TO CONCEPTS
with Harvard Physics Professor Eric Mazur

Silver Remi Award, 2005 WorldFest-Houston International Film Festival
Bronze Plaque, 2004 Columbus International Film Festival
Award of Distinction, 2004 Communicator Awards





First International Asia-Pacific Conference on Peer Instruction (COPI 2012)



Beijing, China 14-16 Dec, 2012

[Home](#)

[Registration](#)

[Organization](#)

[Invited Speakers](#)

[Programme](#)

[Contact Us](#)

[login](#) [Chinese](#)

[Important Dates](#)

[Abstract
Submission](#)

[Pre - Workshop](#)

[Payment of the
Registration Fee](#)

[Visa Application](#)

[Accommodation](#)

[Travel Guide](#)

Welcome Message

Welcome to the First International Asia-Pacific Conference on Peer Instruction which will be held in Beijing Normal University on December 15 and 16, 2012. This conference will bring together educators and Peer Instruction practitioners from Asia and the Pacific to contribute experiences implementing Peer Instruction in a range of disciplines, and to share knowledge and resources about its practice. You will connect with a global network of educators who are working on improving education and developing innovative teaching strategies.

Share.Showcase your experience in the implementation of Peer Instruction.

Connect.Connect with practitioners and educators around the world who are improving education.

Create.Develop new strategies to strengthen your teaching practice.

The conference will include plenary sessions, discussion panels, and a poster session discussing the implementation of Peer Instruction in Science, Technology, Engineering and Mathematics, in the Social Sciences and Humanities, and in Medical Education. The program will also include sessions about the implementation of Peer Instruction in secondary school education.

A separate, pre-workshop conference on Peer Instruction and ConcepTest development will be offered on December 14.

Who should attend?

<http://physics.bnu.edu.cn/copi/module/en/index.php>

A Key to Clicker-Pedagogy...

*Effective use of clicker pedagogy is based on using pedagogically effective questions... The technology itself will change, yet the **ability to come up with pedagogically sound** questions will remain with future teachers forever!*

Socrates Didn't Use Technology, Yet He Knew How to Ask Questions



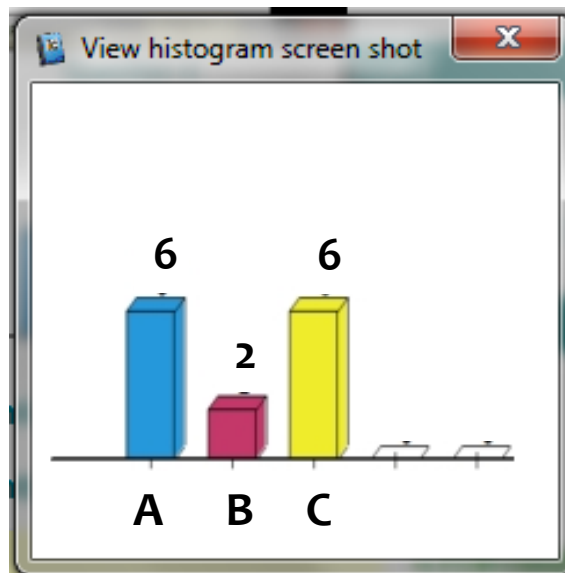
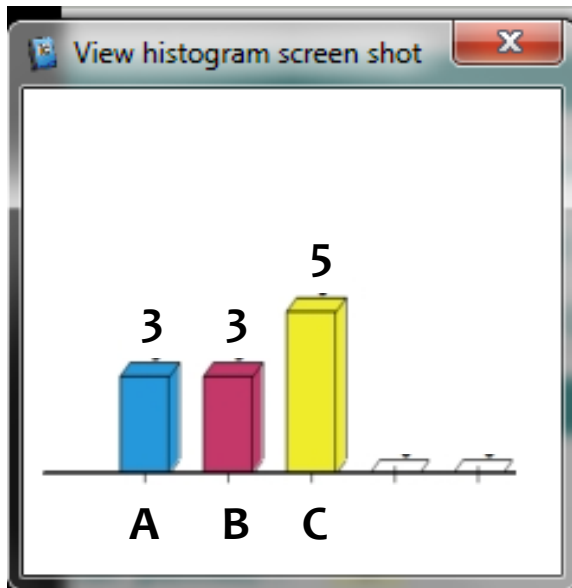
Q1: The Monty Hall Problem: Let Us Make a Deal

- A. Stick with the original choice
- B. Swap doors
- C. It doesn't matter



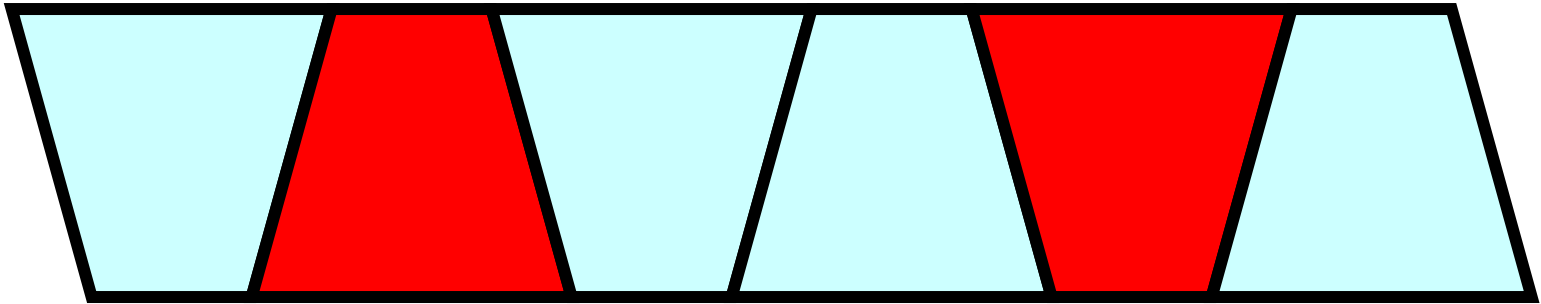
Results: Future Physics Teachers

- A. Stick with the original choice
- B. Swap doors
- C. It doesn't matter



Q2: Engaging With Fractions

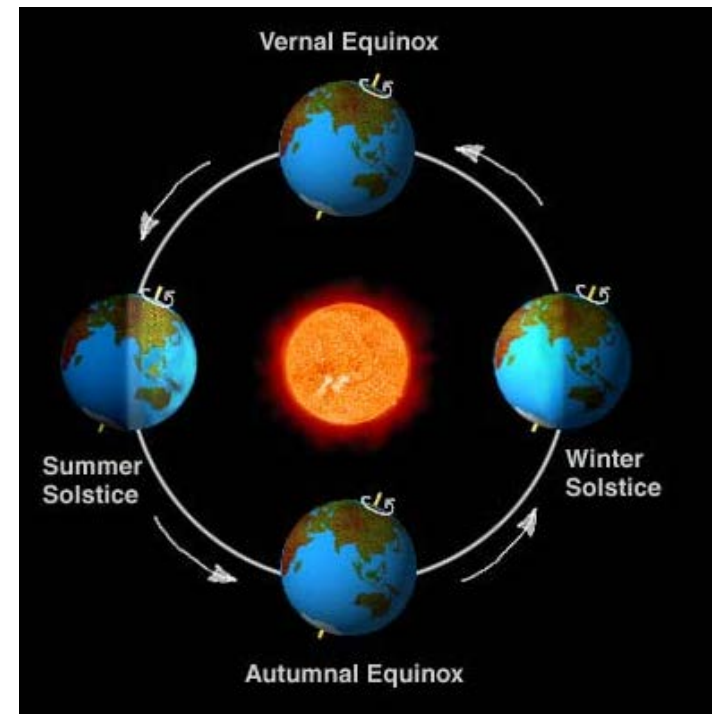
* What fraction of this shape is red?



- A. $\frac{1}{2}$ B. $\frac{1}{3}$ C. $\frac{2}{3}$ D. $\frac{2}{6}$ E. $\frac{4}{6}$

Q3: What Causes Seasons?

- A. The tilt of the Earth
- B. The Earth-Sun distance
- C. The weather patterns
- D. The position of Sun spots
- E. All of the above



Q4: Why Does the Tilt Cause Seasons?

- A. Because one part of the Earth gets closer to the Sun
- B. Because the tilt changes the amount of direct light
- C. Because the tilt and the clouds produce cooler weather
- D. Because the tilt makes another of the Earth to be farther away from the Sun
- E. Because the tilt prevents the Earth from absorbing Sun's Energy

What Constitutes a Powerful Clicker Question?



CLICKER QUESTIONS' DATABASE: <http://scienceres-edcp-educ.sites.olt.ubc.ca/>

Campuses +

UBC Directories +

UBC QuickLinks +



a place of mind



FACULTY OF EDUCATION

DEPARTMENT OF CURRICULUM AND PEDAGOGY

Math & Science Teaching & Learning

through Technology

HOME

ABOUT ▾

RESEARCH

ELEMENTARY ▾

SECONDARY ▾

ADD YOUR PRESENTATION

NEWS

Analysis: Phil's 2c



Mission

Contact

Our sponsors

Our mission is to design, test, evaluate and disseminate high quality, research-based technology-supported educational materials for mathematics and science K-12 classrooms through creating a community of science and mathematics educators, researchers and students.

MATH & SCIENCE TEACHING & LEARNING
THROUGH TECHNOLOGY



Factors Influencing College Science Success

If you are a science or mathematics teacher, you probably wondered, what your students take out of your classes beyond a

[Read More](#)

11 1 / 9

Feedback from UBC Teacher-Candidates

I feel that the use of clickers in the classroom can keep a student remain anonymous. It reduces stress among students due to embarrassment of failure, and at the same time it helps instructor assess the success of the teaching strategies. Whereas, if they are simply asked if they have any questions or understood the concept, they might just nod without any understanding. It can give false expression of their understanding, mitigating their learning potential. Deep Kaur (EDCP 357)

Feedback from UBC Teacher-Candidates

I have found the conceptual clicker questions from your classroom to be probably the most useful and illuminating part of my classes. This format provides an environment in which the class feels comfortable investigating and exposing their prior knowledge about physics. (Adam Quiring).

The use of conceptual questions and clickers is very engaging and intellectually stimulating. The clickers create a safe learning environment where students do not have to fear giving an incorrect response to the teacher. I look forward to using this in my future classroom (Clement Law).

Activity: Asking Effective Clicker Questions (10 min)

Group activity: You plan a 45 min lesson on **a topic of your choice**. You have a class of 30 students and you want to use clickers.

Come up with three clicker questions at different levels in your discipline.

Why do you want to use them?

What are expected students' answers/difficulties?

What are you planning to do next?



II. 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 G. ...

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

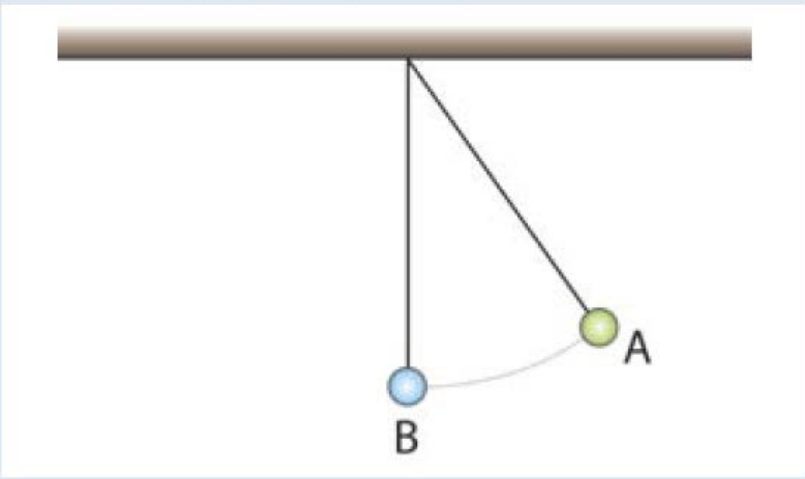


Using Live Data Collection

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 $g = 10 \text{ m/s}^2$):

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

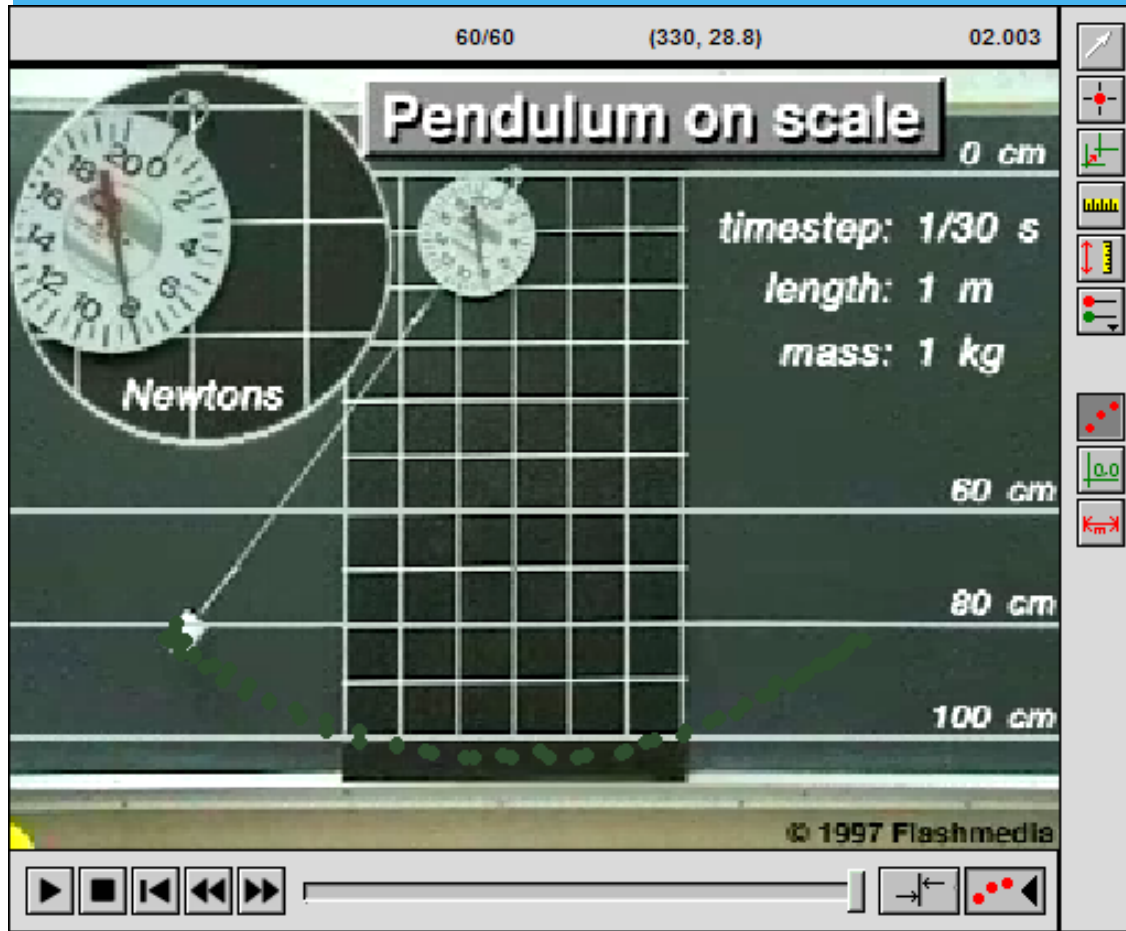
Tension in a pendulum's string exam problem.



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: Logger Pro Video Analysis



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

Results

InterWrite PRS - Review Session: 11 15 2006 (Question Name: 'PRS 27-1: Pendul' Question

End Review

1/6

217

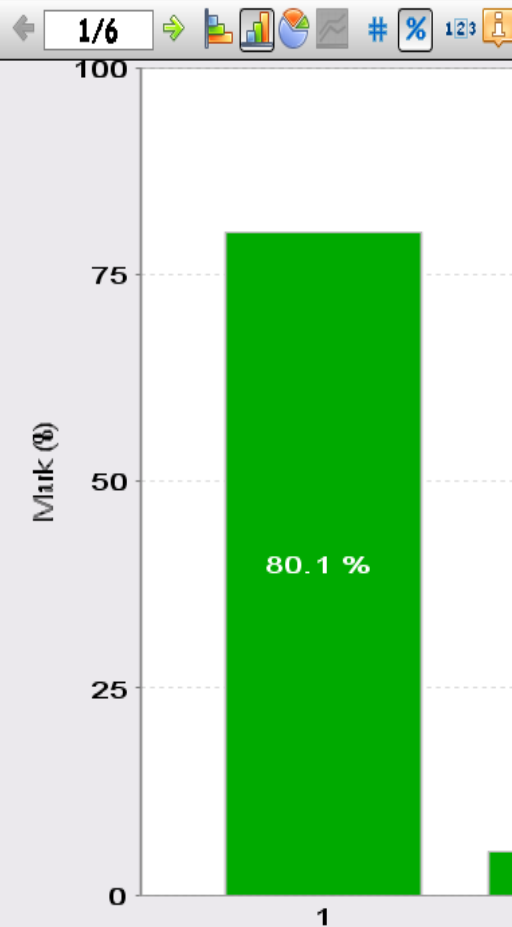
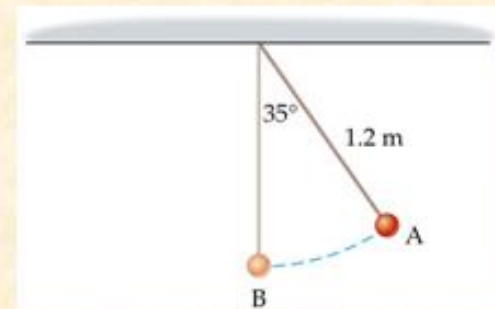
Mark Session

Q:

PRS 26-1: ILE 6 PENDULUM

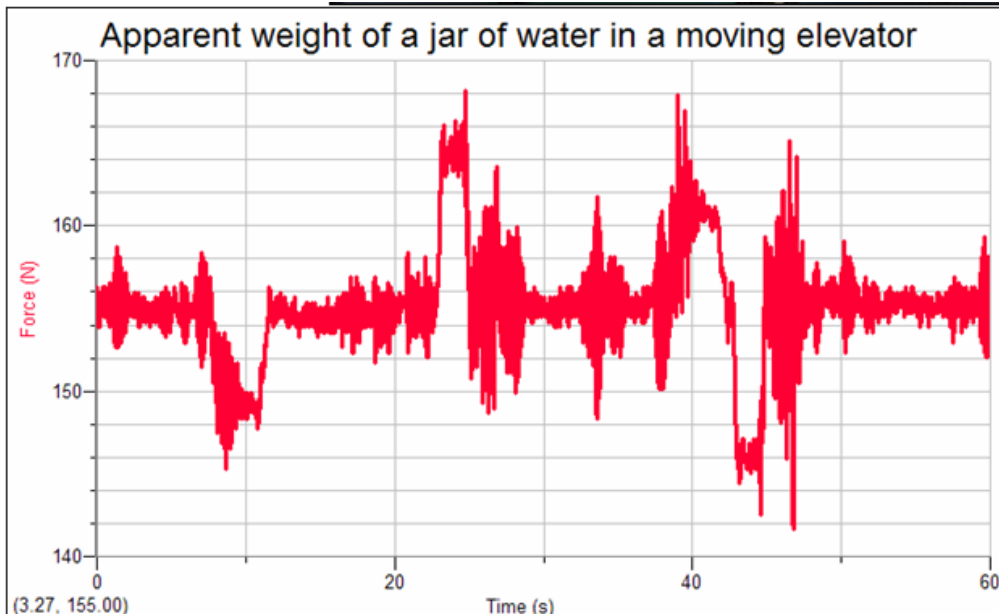
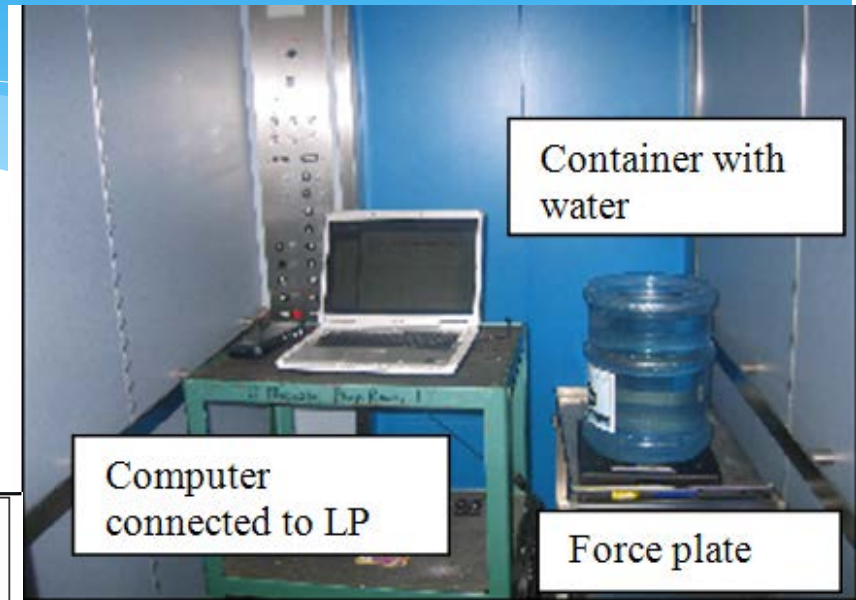
A 1-kg pendulum bob is attached to a string 1.2 m long. The bob is released at the point A as shown in the picture. The tension in the string as the bob passes its lowest position is about (use $g = 10 \text{ m/s}^2$):

1. 13.0 N
2. 10.0 N
3. 6.5 N
4. 3.5 N
5. 0.0 N



Real Life HW & Exam Problems

Thinking like a scientist means being able to analyze real life situation using real data.

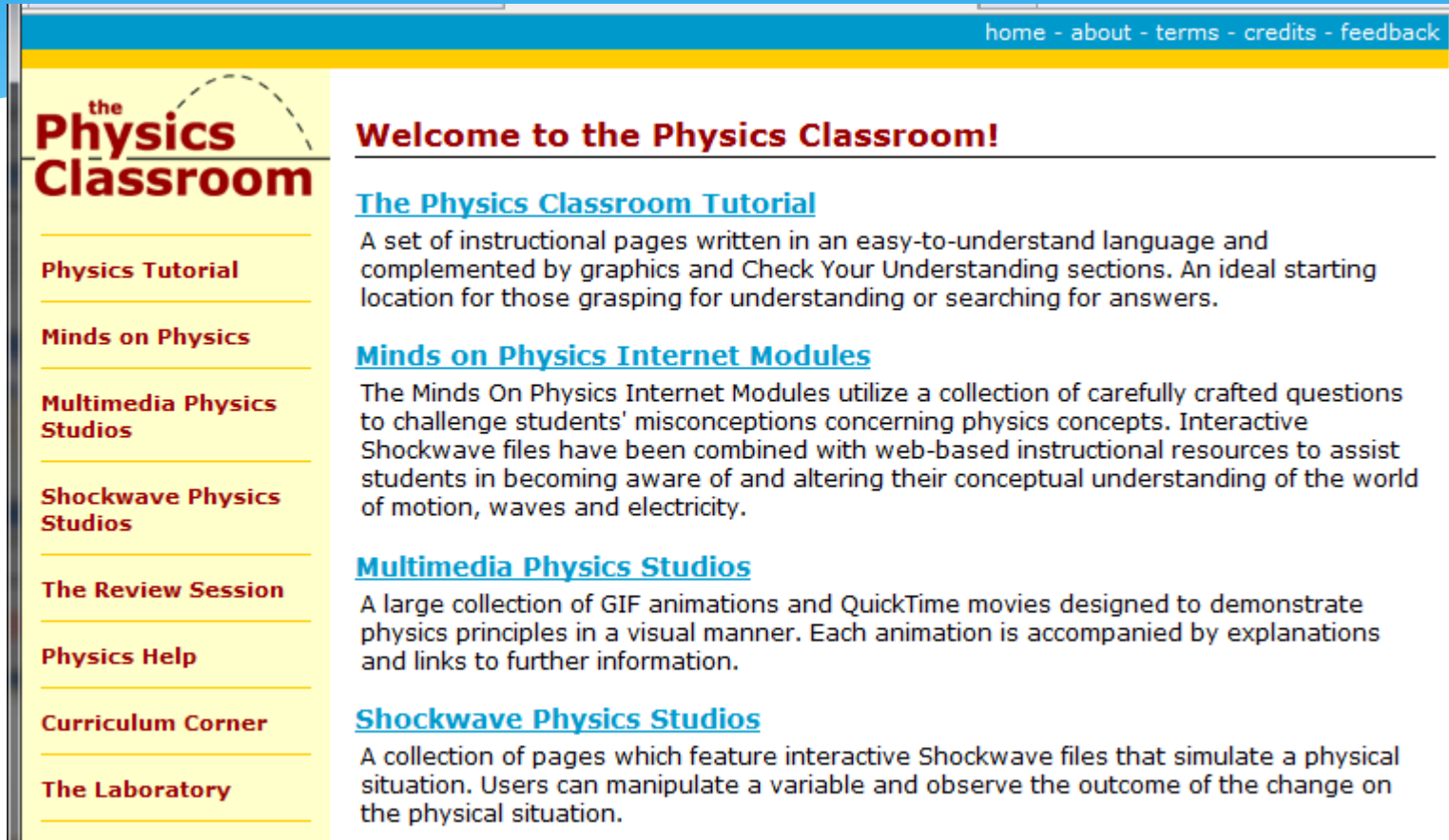


A water jar was placed on a force plate inside a moving elevator: weight and apparent weight problem

What Constitutes a Powerful Live Data Activity?



III. Using Computer Simulations

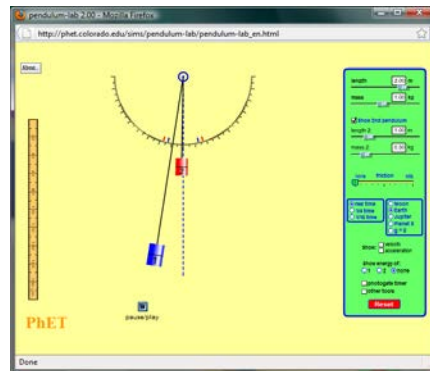


The screenshot shows the Physics Classroom website. At the top right, there is a navigation bar with links: [home](#) - [about](#) - [terms](#) - [credits](#) - [feedback](#). On the left is a yellow sidebar with a dashed arc above the text "the Physics Classroom". The sidebar contains the following menu items: [Physics Tutorial](#), [Minds on Physics](#), [Multimedia Physics Studios](#), [Shockwave Physics Studios](#), [The Review Session](#), [Physics Help](#), [Curriculum Corner](#), and [The Laboratory](#). The main content area has a white background with a red header "Welcome to the Physics Classroom!". Below this is a section titled "The Physics Classroom Tutorial" with a description: "A set of instructional pages written in an easy-to-understand language and complemented by graphics and Check Your Understanding sections. An ideal starting location for those grasping for understanding or searching for answers." This is followed by "Minds on Physics Internet Modules" with a description: "The Minds On Physics Internet Modules utilize a collection of carefully crafted questions to challenge students' misconceptions concerning physics concepts. Interactive Shockwave files have been combined with web-based instructional resources to assist students in becoming aware of and altering their conceptual understanding of the world of motion, waves and electricity." Next is "Multimedia Physics Studios" with a description: "A large collection of GIF animations and QuickTime movies designed to demonstrate physics principles in a visual manner. Each animation is accompanied by explanations and links to further information." Finally, "Shockwave Physics Studios" with a description: "A collection of pages which feature interactive Shockwave files that simulate a physical situation. Users can manipulate a variable and observe the outcome of the change on the physical situation."

Developing Intuition & Visualization Skills

Developing intuition about physical phenomena via testing experimentally different scenarios which cannot be tested in the lab – WHAT IF...? For this to take place a teacher must **be able to design meaningful assignments.**

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



35

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

December 4, 2012

Computer Simulations as a Pedagogical Tool

Protoplasma (2012) 249 (Suppl 1):S25–S30
DOI 10.1007/s00709-011-0346-6

REVIEW ARTICLE

The essence of student visual–spatial literacy and higher order thinking skills in undergraduate biology

Marina Milner-Bolotin · Samson Madera Nashon

Received: 11 June 2011 / Accepted: 17 October 2011 / Published online: 3 November 2011
© Springer-Verlag 2011

Abstract Science, engineering and mathematics-related disciplines have relied heavily on a researcher’s ability to visualize phenomena under study and being able to link and superimpose various abstract and concrete representations including visual, spatial, and temporal. The spatial representations are especially important in all branches of biology (in developmental biology time becomes an important dimension), where 3D and often 4D representations are crucial for

representations of scientific phenomena. This has been underscored by Richardson and Richardson (2002) who emphasize the increased importance of understanding 3D structure/function relationships to modern biochemistry and molecular biology. In highlighting this importance, Richardson and Richardson observe, “Not only are the overall “folds” that illuminate evolutionary relationships uncompromisingly three-dimensional but so, too, are the

What Constitutes a Powerful Simulation-Based Activity?



Inquiry in SMET Education

**How do we engage future teachers
in inquiry-based SMET Education?**

**By using inquiry in their methods
courses...**