

**Beijing Advanced Innovation Center for
Future Education (AICFE)**



2030未来学校第一次研讨会

Reimagining Technology-Enhanced STEM Teacher Education for 21st Century: From more technology to increased quality of teaching and learning



Dr. Marina Milner-Bolotin

Seminar 1 – October 29, 2016 Beijing Normal University



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October 25, 2010



TECHNOLOGY
IS A
GIVEN

NOT A
DEBATE

*Does technology
presence
guarantee
improved student
learning?*

Are We on the Same Page?

Educational technology **should not be used just because it is there**. It should be used because ...

1. It helps students engage with STEM fields
2. It helps address challenges we couldn't address before
3. It saves time, money, and other resources
4. It prepares students to become 21st century citizens
5. All of the above

Educational Technologies (ET) in STEM Teacher Education

- **Why** should we use ET?
- **How** can we use ET?
- **What new opportunities** does ET open?
- **Why** would STEM teachers adopt new ETs?
- **How** do we support them in this process?
- **How will ETs** encourage new pedagogies?

Philosophical Premises

- We can't predict what is coming, but we can prepare teachers for it.
- Teachers should experience the pedagogical benefits of new technologies.
- Teacher education should be informed by both practice and research
- **DELIBERATE PEDAGOGICAL THINKING with TECHNOLOGY** should begin in teacher education.

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

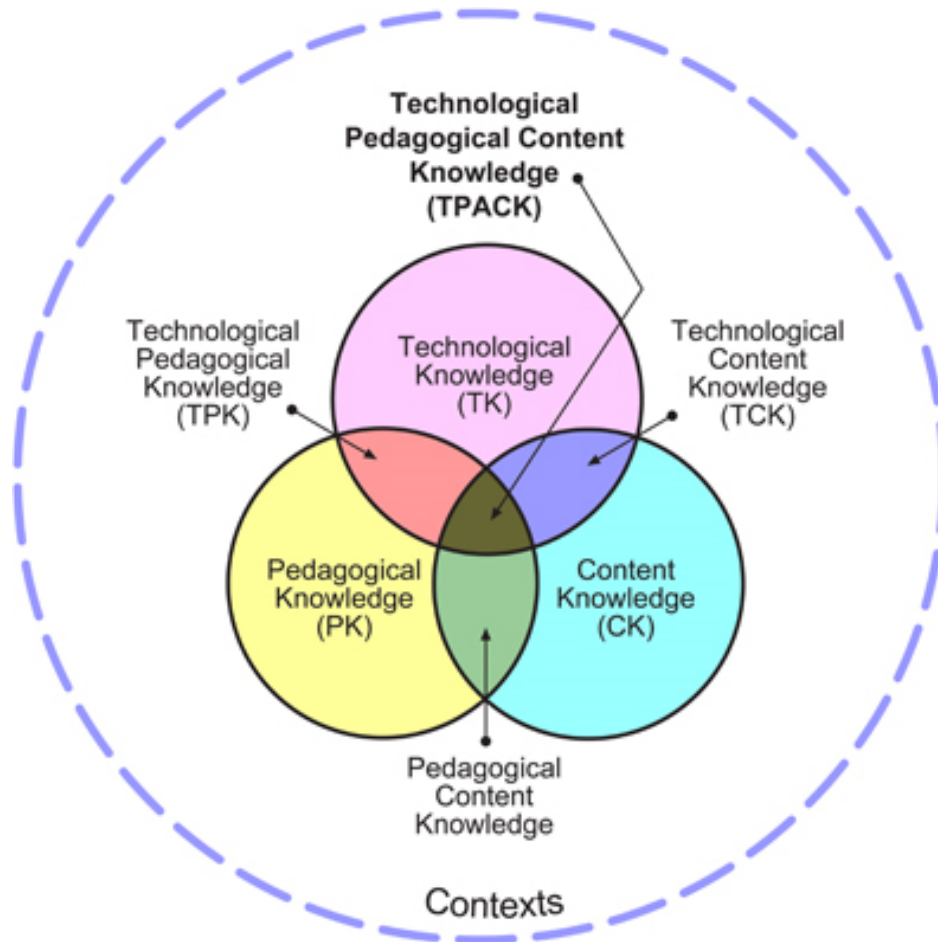
content-specific professional development, teacher education programs should emphasize the development of teacher-candidates’ PCK.

Lastly, there is a significant gap between the findings of Physics Education Research (PER)^[4] and current physics teaching practices. In the words of the 2007 Nobel Laureate, Prof. Carl Wieman,



[M. Milner-Bolotin, "Promoting research-based physics teacher education in Canada: Building bridges between theory and practice", *Physics in Canada*, **70**, 99-101 (2014).]

Theoretical Framework



Teachers should experience learning STEM with technology as learners and as future teachers.

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

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

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Alexandra MacDonald

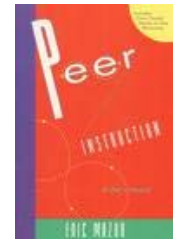
Department of Curriculum and Pedagogy, Faculty of Education, The University of British Columbia

Abstract One of the most commonly explored technologies in Science, Technology, Engineering, and Mathematics (STEM) education is Classroom Response Systems (clickers). Clickers help instructors generate in-class discussion by soliciting student responses to multiple-choice conceptual questions and sharing the distribution of these responses with the class. The potential benefits of clicker-enhanced pedagogy include: increased student engagement, reduced anxiety, continuous formative assessment, and enhanced conceptual understanding. Most studies, however, have focused on the effects of clicker-enhanced instruction in large undergraduate STEM courses. This study explores the effects of clicker-enhanced instruction on learning in small secondary or post-secondary physics courses. The context of this study is a secondary physics course.

[M. Milner-Bolotin, H. Fisher, & A. MacDonald, "Modeling active engagement pedagogy through classroom response systems in a physics teacher education course", *LUMAT: Research and Practice in Math, Science and Technology Education*, 1, 523-542 (2013).]

Promoting Deliberate Pedagogical Thinking with Technology in STEM Teacher Education

1. Peer collaboration (**Peer Instruction PeerWise**)



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



3. Computer Simulations (**PhET**)



4. Collaborative Learning Annotation Systems (**CLAS**)

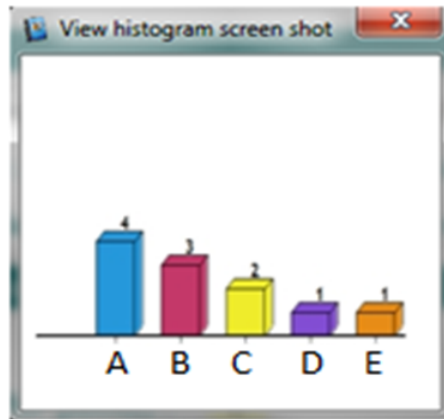
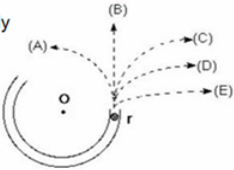


1. Technology-Supported Peer Collaboration

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?



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](#)

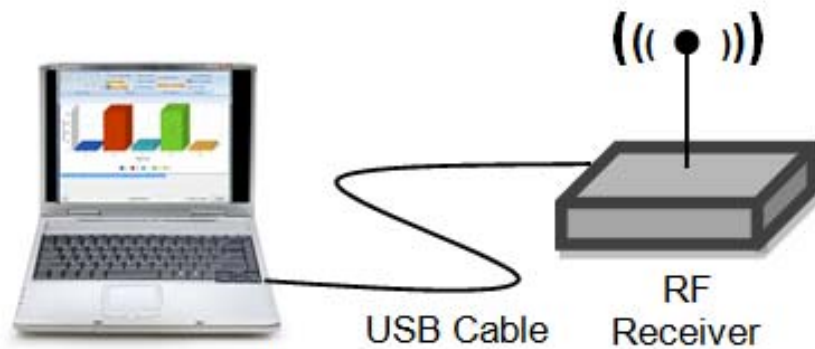
Showing new replies only

No comments to view

[Return to main menu](#)

Peer Instruction and PeerWise integration

Technology is There – Pedagogy is Often Missing



USB Cable

RF Receiver



Clickers used by the students

Software installed on the teacher's computer connected to a classroom projector



In near future smart phones, i-pads and other devices will replace clickers, **but the basic pedagogy will remain the same...**

PeerWise – Freely Available

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?

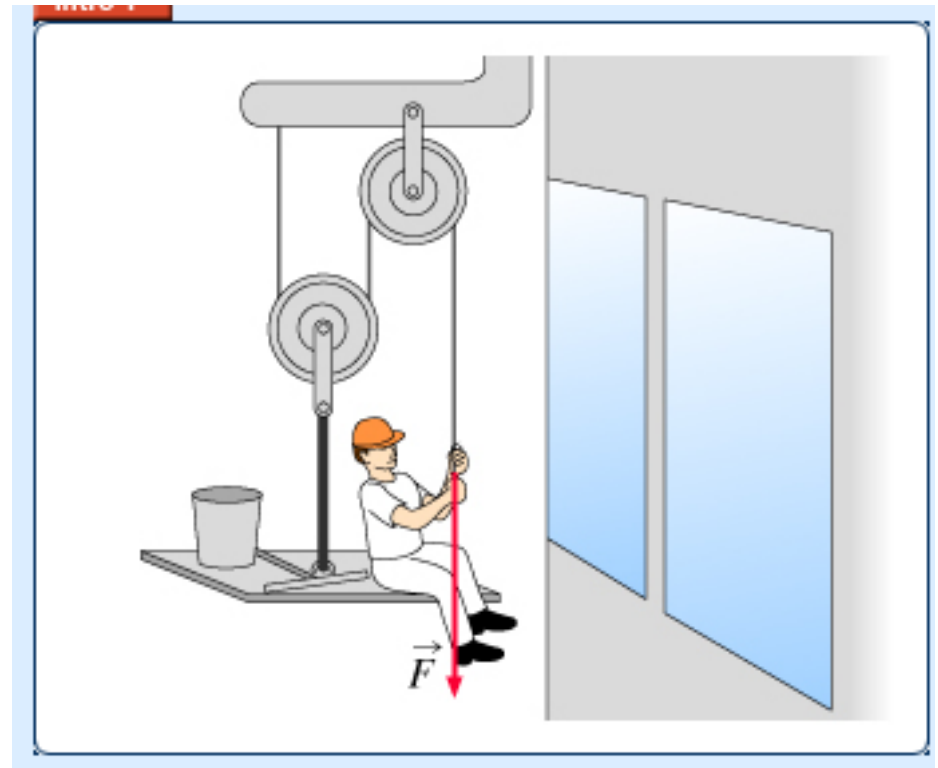
Students use PeerWise to create and to explain their understanding of course related assessment questions, and to answer and discuss questions created by their peers.

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

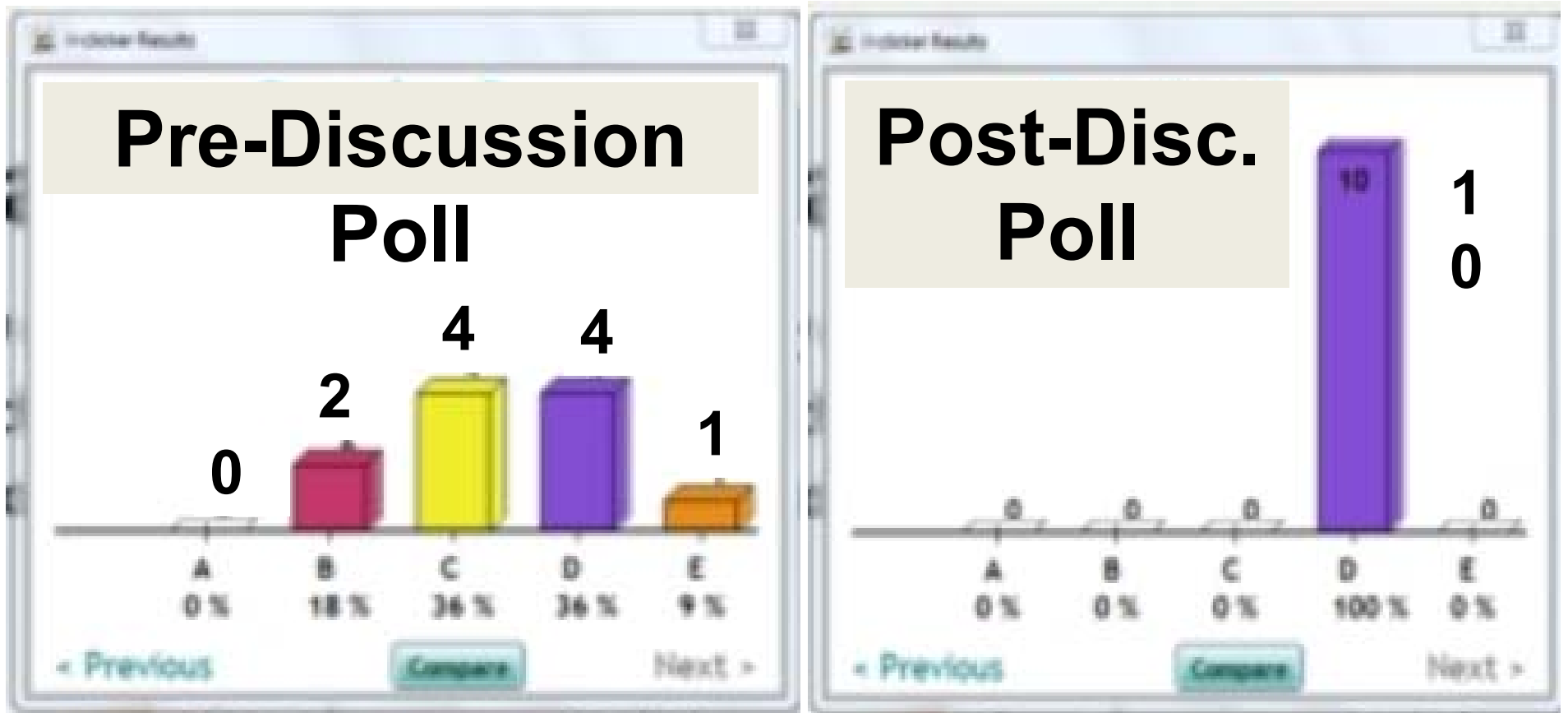
Physics Teacher Education Example

Find the magnitude of the force a person has to pull the rope with in order to pull himself upwards with a **constant speed**. He and the platform “weigh” 60 kg.

- A. 600 N
- B. 450 N
- C. 300 N
- D. 200 N
- E. 150 N



Peer Instruction in Action



Respondents: Physics Teacher-Candidates

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

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

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Piscataway, NJ 08854-8019; milnerm@physics.rutgers.edu

Teaching a large introductory physics course can be a challenge for a young physics instructor. To do so, an instructor poses the lecture by asking multiple-choice questions. The students discuss about the effective use of the PRS in an introductory physics class.

Clickers beyond the First Year Science Classroom

Marina Milner-Bolotin

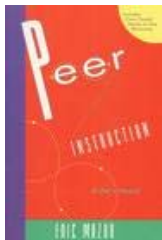
Tetyana Antimirova

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



Investigating the effect of question-driven pedagogy on the development of physics teacher candidates' pedagogical content knowledge

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(Received 29 April 2016; published 7 September 2016)

This paper describes the second year of a multi-year study on the implementation of Peer Instruction and PeerWise-inspired pedagogies in a physics methods course in a teacher education program at a large research university in Western Canada. In the first year of this study, Peer Instruction was implemented consistently in the physics methods course and teacher candidates were asked to submit five conceptual multiple-choice questions as a final assignment. In the second year of the study we incorporated PeerWise online tool to facilitate teacher candidates' design of conceptual questions by allowing them to provide and receive feedback from their peers, and consequently improve their questions. We have found that as a result of this collaboration teacher candidates improved their pedagogical content knowledge as measured by the rubric developed for the study.

DOI: [10.1103/PhysRevPhysEducRes.12.020128](https://doi.org/10.1103/PhysRevPhysEducRes.12.020128)

I. INTRODUCTION: ADDRESSING THE CHALLENGES OF PHYSICS TEACHER EDUCATION

often question driven, it is not surprising that a key element of PCK is teacher's ability to ask questions that elicit student conceptual difficulties and promote meaningful

Research-Based Resource for Teachers

The screenshot displays the UBC Faculty of Education website. The top navigation bar includes the UBC logo, the motto "a place of mind", and the department name "FACULTY OF EDUCATION" and "DEPARTMENT OF CURRICULUM AND PEDAGOGY". The main header area features "Math & Science Teaching & Learning through Technology". A secondary navigation bar contains links for HOME, ABOUT, RESEARCH, ELEMENTARY, SECONDARY, ADD YOUR PRESENTATION, and NEWS. A dropdown menu for "SECONDARY" lists subjects: MATHEMATICS, PHYSICS, CHEMISTRY, and BIOLOGY. A further dropdown for "PHYSICS" lists topics: VECTORS, KINEMATICS, DYNAMICS, MOMENTUM, WORK, ENERGY, POWER, THERMODYNAMICS, CIRCULAR MOTION, GRAVITATION, WAVE MOTION AND OPTICS, PARTICLE AND NUCLEAR PHYSICS, EQUILIBRIUM, and ELECTROSTATISTICS. The main content area features a "Teacher Education" banner and a "CREATE" section titled "Community to Reimagine Educational Alternatives for Teacher Education". A sidebar on the right contains links for Mission, Contact, and Our sponsors. A bottom section highlights a "Presentation about MSTLT Project" with a "Read More" button.

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

2. 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*

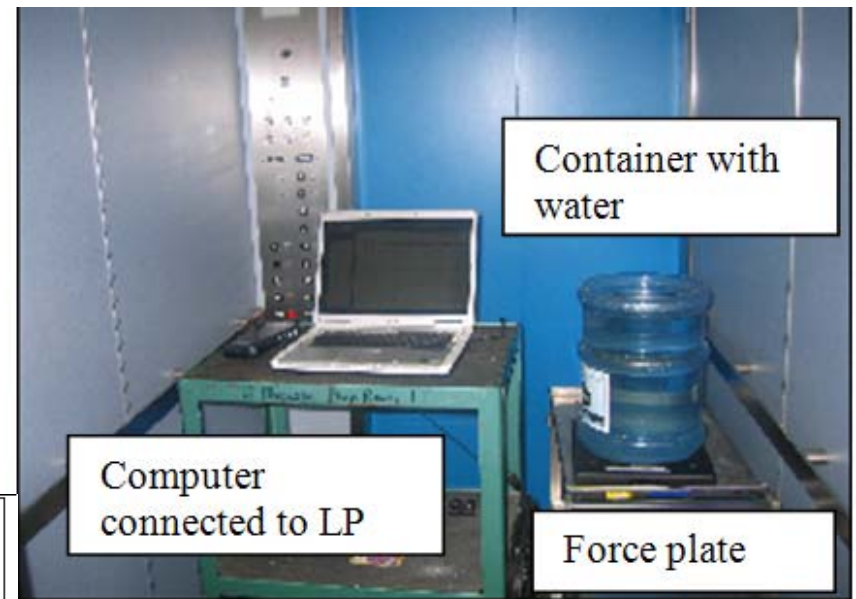
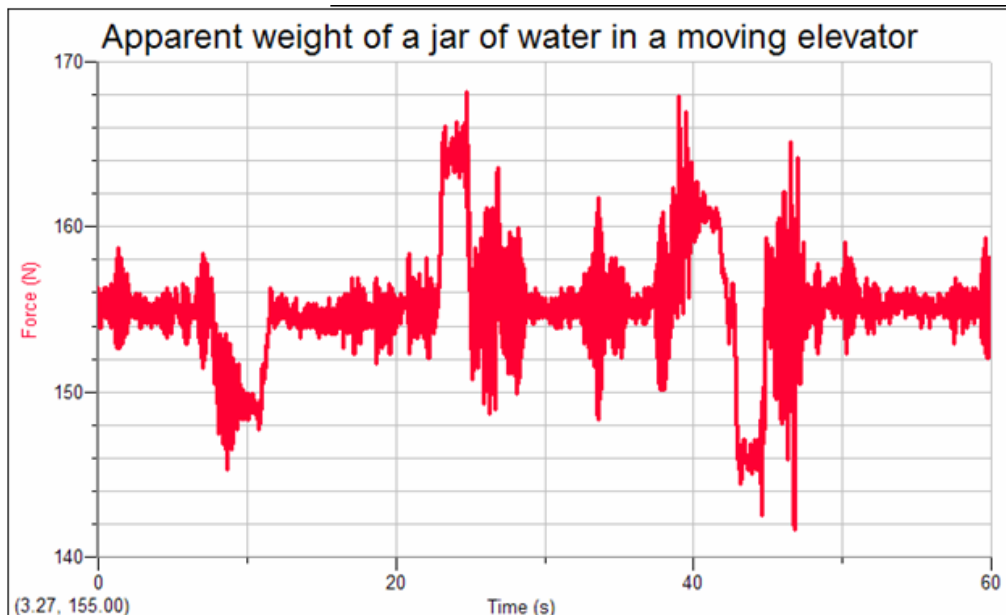
Marina Milner-Bolotin, Ryerson University, Toronto, ON

Rachel Moll, The University of British Columbia, Vancouver, BC



Real Life HW & Exam Problems

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

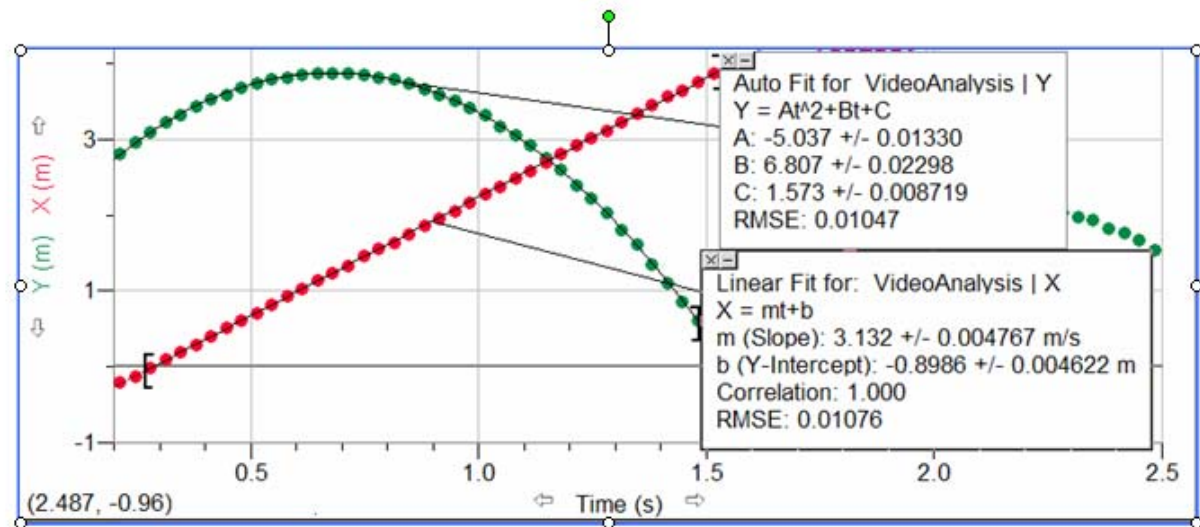


A water jar was placed on a force plate inside a moving elevator: weight and apparent weight problem

Reconsidering Assessment

Your friend analyzed a video clip of a basketball shot using a Logger *Pro* Video Analysis feature. However she was not certain how to find the acceleration of free fall from his analysis and turned to you for advice. What is the reasonable experimental value of the **magnitude** of the acceleration of free fall your friend should report during the next class?

- a) 5.037 m/s²
- b) 6.807 m/s²
- c) 9.823 m/s²
- d) 10.074 m/s²
- e) 10.10 m/s²



3. Computer Simulations



The screenshot shows the PhET website header with the PhET logo, the text "Over 200 million simulations delivered", and the University of Colorado Boulder logo. Below the header is a search bar and a "Donate Today" button. The main content area features a "Play with Simulations" button and a preview of the "Faraday's Law" simulation, which shows a circuit with a light bulb and two coils of wire. To the right of the simulation preview is a vertical stack of social media icons for HTML5, YouTube, Facebook, Twitter, and Pinterest. Below the simulation preview is a navigation menu with four columns: "How to Run Simulations", "For Teachers", "About", and "PhET is supported by...".

PhET INTERACTIVE SIMULATIONS Over 200 million simulations delivered University of Colorado Boulder

Support PhET's Annual Campaign: [Donate Today](#) [HTML5 Sims](#)

INTERACTIVE SIMULATIONS FOR SCIENCE AND MATH

[Play with Simulations](#)

The Tech Awards

Faraday's Law

How to Run Simulations

- On Line
- Full Installation
- One at a Time
- Troubleshooting
- FAQs

For Teachers

- Tips for Using PhET
- Browse Activities
- Share your Activities
- Workshops
- Translate simulations
- Translate the website

About

- What's New?
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- Research on PhET
- Contact Us
- Donate

PhET is supported by...

PANCO Pan America Construction Corp.

and our [other sponsors](#), including educators like you.

PhET Computer simulations from the University of Colorado, Boulder

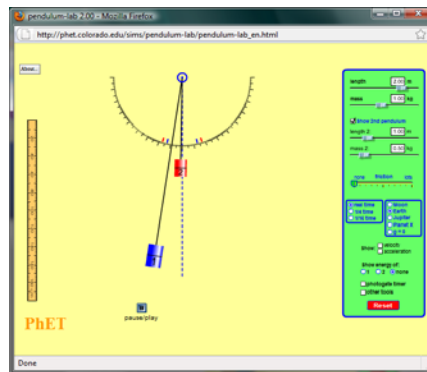
You can download the simulations.

You can also use them in Chinese!

Developing STEM **Intuition**

Simulations can help develop intuition about physical phenomena via testing experimentally different scenarios which or cannot be tested in the lab – WHAT IF...? (Think critical thinking). However, for this to take place the teacher must **be creative in designing meaningful assignments.**

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



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

4. CLAS – Collaboration on Improving Teaching Skills

- Upload & manage videos
- Annotate them
- Collaborate
- Share
- Learn from each other
- Improve

Instructions for this course

upload & manage videos

Course: EDCP357 301 2015W

Playlist: everyone in this course (42 items)

Autoplay entire playlist | Loop this video or playlist

Caitlin - Terminal Velocity 2

Caitlin - Terminal Velocity 1
Better late than never! Due to technical difficulties we had to switch phones at the beginning so there are 2 different parts. I tried to put them together but I'm technologically useless.

There's some overlap in the videos sorry!

Nadereh - Lesson 1

Irit Teaching FBD - new version
This is an edited version - I have attempted to correct the quality issue.

Irit Teaching FBD - part 2

search videos across collections

save video

share & embed

import URL

back channel

usage data

0:00/4:01

Time-specific comments

Video will pause as you type.

Post | Record video as response | Use existing audio / video | Book mark | Hide my identity

Filter: mine / all

Private | Unread | Anonymous | Mine | Instructor or TA's | Students

25% 01:00 | 50% 02:00 | 75% 03:00

Follow along with video | Highlight tagged posts

search comments & annotations by content | author | tag | hover on words to search

General comments to the whole video

Add general comment

There is no comment for this video yet.

UBC a place of mind THE UNIVERSITY OF BRITISH COLUMBIA



Why CLAS: Collaborative Learning Annotation System?

CLAS - Collaborative Learning Annotation System

ARTS

About CLAS

Ideas & Strategies

Help & Support

Workshops

Quick Guide

Best Practices

FAQ

SIGN-IN TO CLAS

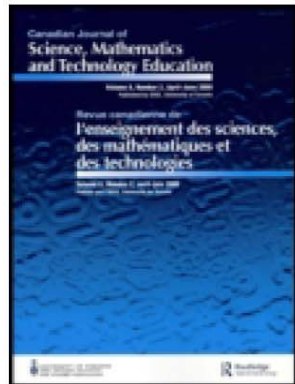
Home / Marina Milner-Bolotin in Curriculum and Pedagogy uses CLAS for mini-teaching by Teacher-Candidates

Marina Milner-Bolotin in Curriculum and Pedagogy uses CLAS for mini-teaching by Teacher-Candidates



“ CLAS allows you to have a discussion which is very purposeful and to the point. I find that it not only saves time, but also makes it much more meaningful.

—Marina Milner-Bolotin, Assistant Professor of Faculty of Education



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Taylor & Francis Group

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Rethinking Technology-Enhanced Physics Teacher Education: From Theory to Practice

Marina Milner-Bolotin

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To link to this article: <http://dx.doi.org/10.1080/14926156.2015.1080411>

[M. Milner-Bolotin, "Rethinking technology-enhanced physics teacher education: From theory to practice", *Canadian Journal of Science, Mathematics and Technology Education*, **16**, 284-295 (2016).]

Conclusions

In order to prepare our students for 21st century challenges, we have to reimagine how we use technology in STEM teacher-education.

Instead of focusing on new gadgets and new innovations we should focus on new technology-enhanced pedagogies.

Let us move from more technology to increased quality of STEM teaching and learning.

Acknowledgements

Many thanks to Beijing Advanced Innovation Center for Future Education (AICFE) for providing this exciting opportunity to reimagine the future of STEM education together.



Beijing Advanced Innovation Center for Future Education