



## 2030未来学校第一次研讨会



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



**Dr. Marina Milner-Bolotin**



# Dr. Marina Milner-Bolotin



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RESEARCH

RECRUITMENT

COOPERATION & EXCHANGES

## Future Education

Collecting big data during learning process

Modeling knowledge and capability structures

Diagnosing and solving learning problems

Finding and strengthening subject advantages

### Discussion on the progress of developing discipline-based test tools

To further learn and follow up the progress of developing discipline-based test tools, a discussion meeting was held at 13.30 pm 10th, April in the room 208, Studio Building in order to ensure an on-time on-line application of technological platform. This meeting involved all discipline chiefs and assistants participating in.



#### NEWS

- |  |            |
|--|------------|
| Academic Lecture: The Fall and Rise of | 2016-05-09 |
| Call for Research Proposals - Future   | 2016-04-21 |
| Staff Training on Patent Knowledge     | 2016-04-13 |
| Discussion on the progress of          | 2016-04-11 |
| Call for papers : STEM—Connecting      | 2016-04-07 |

#### RECRUITMENT

- |  |            |
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| Recruitment--- Artificial Intelligence | 2016-03-22 |
| Recruitment--- Big Data Researchers    | 2016-03-22 |



21st 北京  
anniversary

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# CCCCCE

PROGRAMME

KEYNOTE

LOCATION

简体  
繁体

The 21st Global Chinese Conference on Computers in Education

## The Education Reform in the Era of “Internet Plus”

互联网+时代的教育变革



北京师范大学  
Beijing Normal University



### NEWS



Call for Paper



Beijing



Beijing Normal University



Preparation Stage ( meeting ) for

# Future School in 2030 Project

## Cooperative Research Projects - Future Schools in 2030

### Purposes:

To study the possibility and form of future education in the year of 2030;

To analyze the new form of education process reform from the perspective of a bi-directional integration of technology and education

### Expected outcome:

A White Paper on Future Schools will be published to the world after several symposiums with participants



Beijing Advanced Education Center for Future Education

### Call for Research Proposals

#### Backgrounds and Aims

The future has been used to various education and designed into diverse fields, which indicates the transformation of education owing to human-centered modern society characterized by information, knowledge and service. Considering this fact, a fair and thriving individualized education system is expected to satisfy the needs for tomorrow's schools in the modern society. In the Internet-based era, it is possible to break geographic, time and computer educational resources to build a personalized platform with high-quality services for learners.

Guided by the future, it is expected that schools may be reconstructed and re-designed in the 21st century. Schools may educate students according to their capabilities and qualities instead of age. Schools may flexibly design curriculum using students' individual needs instead of adopting uniformed contents and unified course sequences. With the integration of science into education, schools are aimed to provide more-sustainable, more-adaptable and more-positive education to students.

To study the possibility and form of future education in the 21st century, a project called Future Schools in 2030 has been recently established by the Advanced Education Center for Future Education (ACEFE), Beijing Normal University, P. R. China. This project aims to analyze the new form of education process actions from the perspective of a bi-directional integration of technology and education so as to look at the outlook of the upcoming actions of education.

This project will invite famous experts at home and abroad in education, computing education, environment, etc. to participate in. A White Paper on Future Schools will be published to the world to mark the completion of this project. It will be a valuable opportunity of international communication for experts in the field of education.

#### The Grants

Each grant provides up to US\$10,000,000 for applicants who are seriously working on or intend to do more research projects that are related to the project of Future Schools in 2030. The grant is used to cover any expenses for work in China and pay for the time and effort devoted to this project. Professors will be given the collaborating research that involves any combination of classroom practitioners.

# Prof. Yu Raised Many Interesting Points

- School will be reconstructed in the 21<sup>st</sup> century with the aid of internet and technology...
- Who will be leading the reconstruction?
- How do we see the final product?
- What is the role of technology in the process?
- What will be teachers role?
- How do we prepare teachers for the future?

*If we teach today as we taught  
yesterday, then we rob our students of  
tomorrow.*

*John Dewey*



*My prediction:*

*In the school of the future, the  
TEACHERS will play a different role. We  
have to understand how to prepare  
teachers to be the teachers of the  
future.*

*Marina Milner-Bolotin*



# 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<sup>[1]</sup>, 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

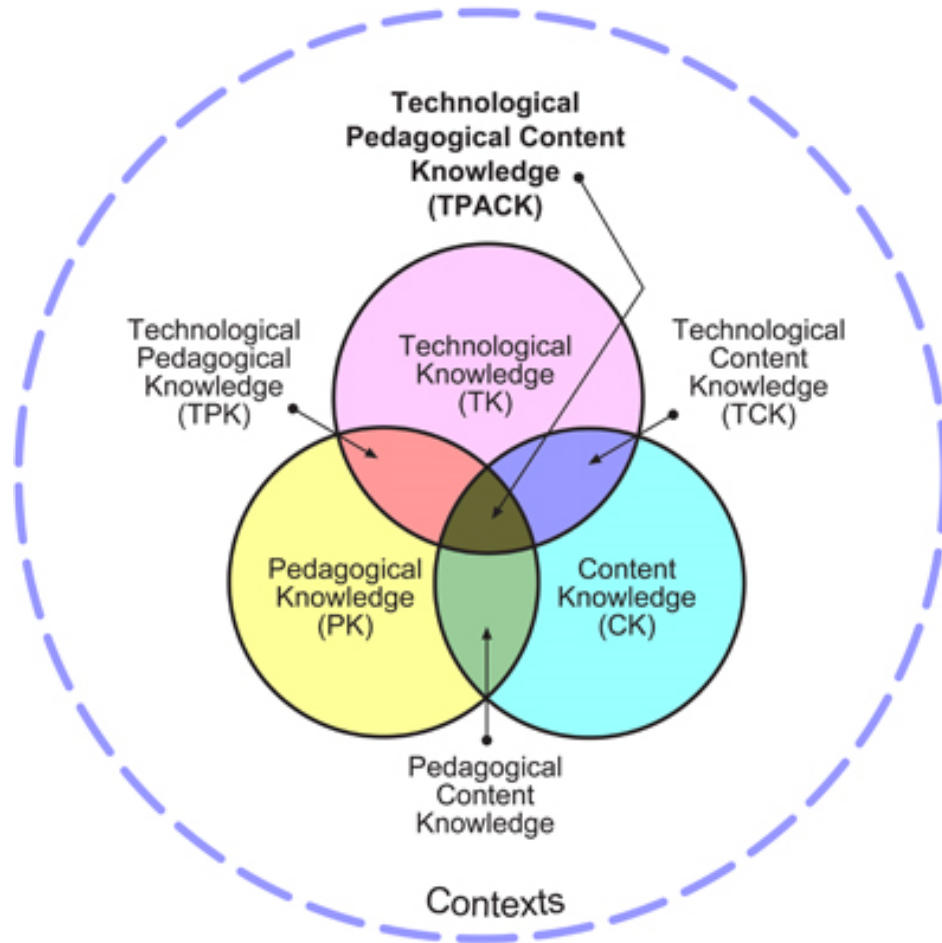
content-specific professional development, teacher education programs should emphasize the development of teacher-candidates’ PCK.

Lastly, there is a significant gap between the findings of Physics Education Research (PER)<sup>[4]</sup> and current physics teaching practices. In the words of the 2007 PER 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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Heather Fisher

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

Alexandra MacDonald

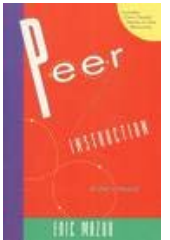
Department of Curriculum and Pedagogy, Faculty of Education, The University of British Columbia

**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, investigate the effects of clicker-enhanced instruction in large undergraduate STEM courses. The context of this study is a secondary physics teacher education 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**)

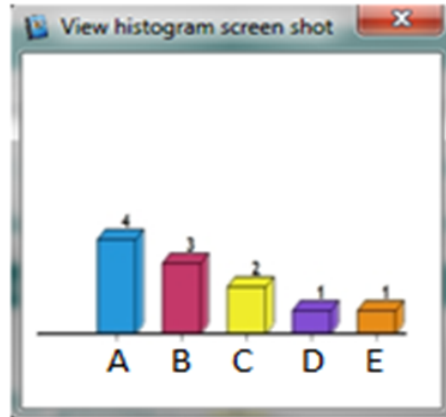
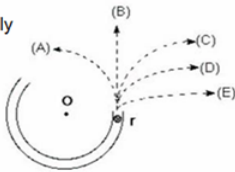


# 1. Technology-Supported Peer Collaboration

## 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](#)

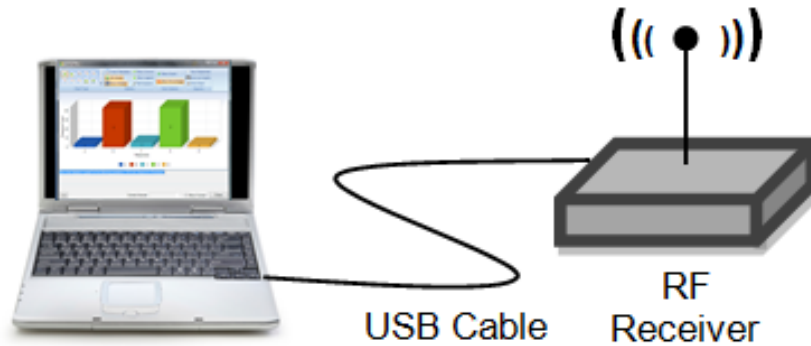
Showing new replies only

No comments to view

[Return to main menu](#)

## Peer Instruction and PeerWise integration

# Technology is There – Pedagogy is Often Missing



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



Clickers used by the students



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

# PeerWise – Freely Available



*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.

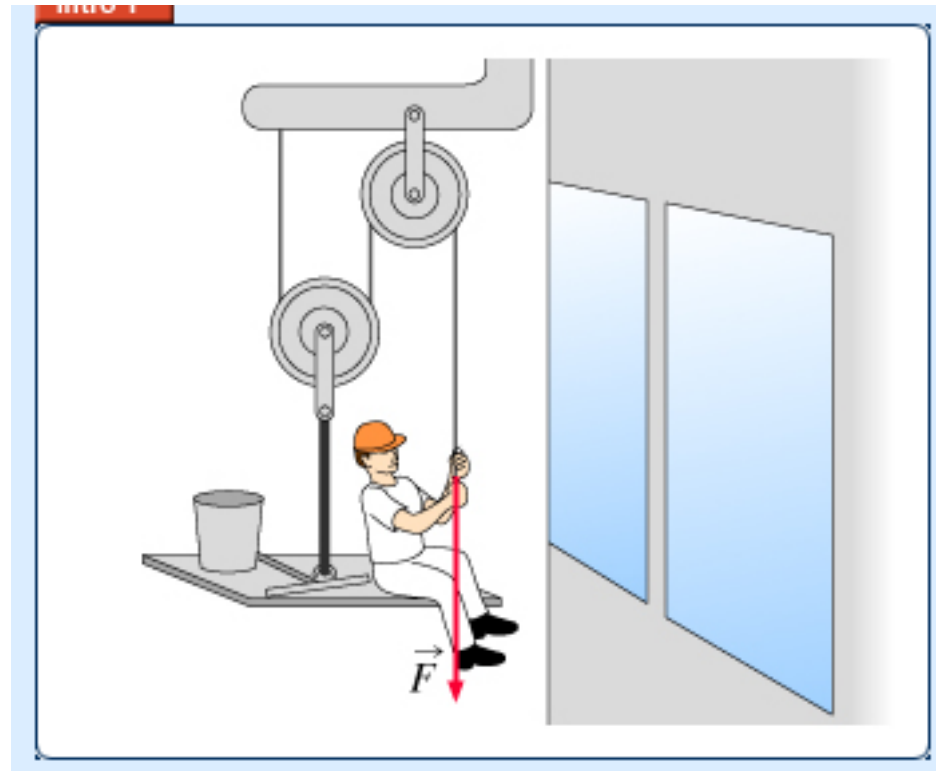
<http://peerwise.cs.auckland.ac.nz/>



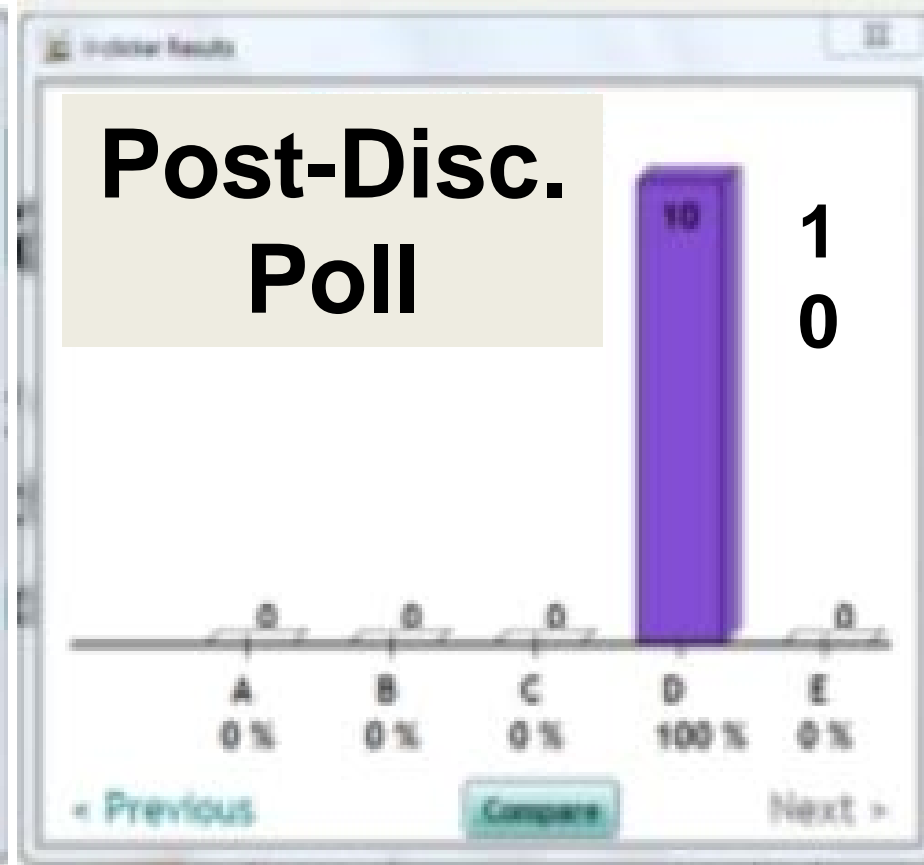
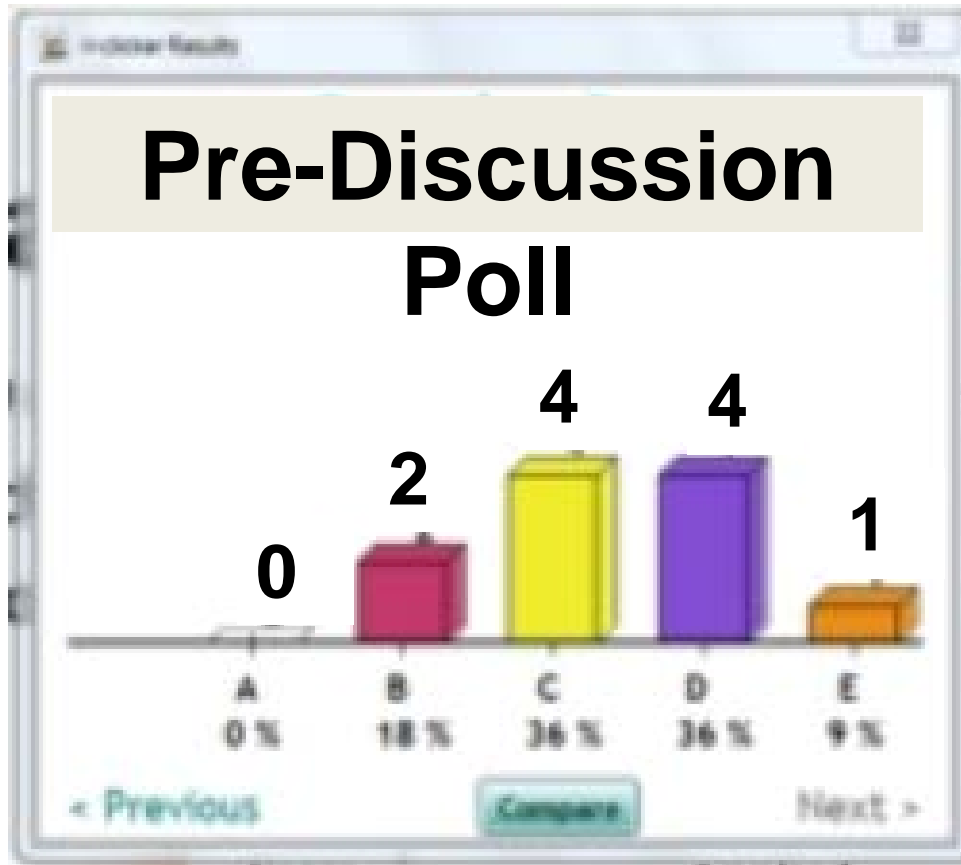
# Physics Teacher Education Example

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

**Marina Milner-Bolotin**, Physics and Astronomy Department, Rutgers, The State University of New Jersey  
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 instant.

## 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**

Marina Milner-Bolotin, Davor Egersdorfer, and Murugan Vinayagam

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2329 West Mall, Vancouver, British Columbia V6T 1Z4, Canada*

(Received 29 April 2016; published 7 September 2016)

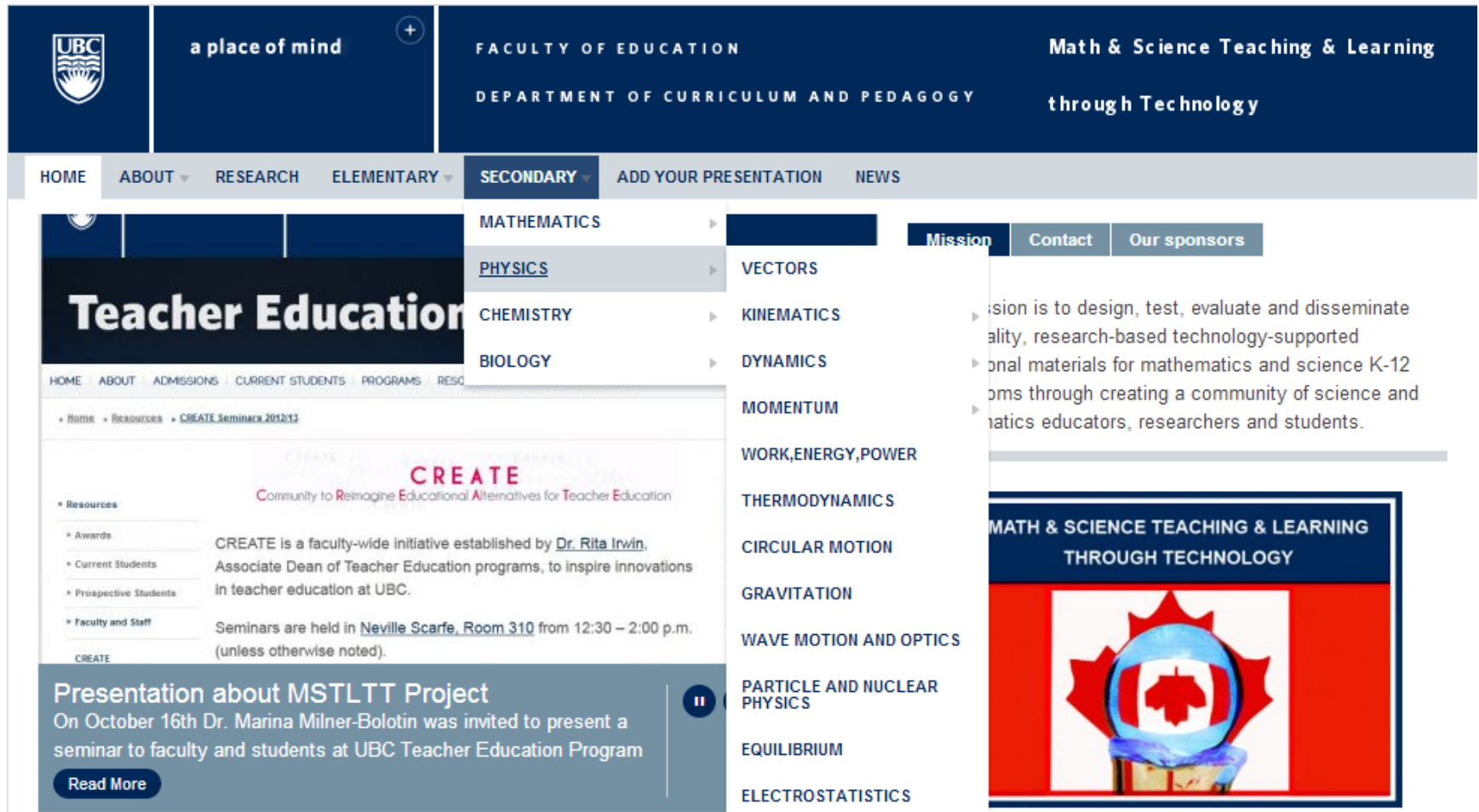
This paper describes the second year of a multi-year study on the implementation of Peer Instruction and PeerWise-inspired pedagogies in a physics methods course in a teacher education program at a large research university in Western Canada. In the first year of this study, Peer Instruction was implemented 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 website for the Faculty of Education, Department of Curriculum and Pedagogy, specifically the Math & Science Teaching & Learning through Technology section. The header features the UBC logo, the tagline "a place of mind", and navigation links for HOME, ABOUT, RESEARCH, ELEMENTARY, SECONDARY, ADD YOUR PRESENTATION, and NEWS. A dropdown menu for SECONDARY is open, showing categories like MATHEMATICS, PHYSICS, CHEMISTRY, and BIOLOGY, with a sub-menu for PHYSICS listing topics such as 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 includes a "Teacher Education" banner, a "CREATE" section (Community to Reimagine Educational Alternatives for Teacher Education) with resources, awards, current students, prospective students, and faculty/staff information. A "Presentation about MSTLT Project" is also featured, mentioning Dr. Marina Milner-Bolotin. A sidebar on the right contains links for Mission, Contact, and Our sponsors. The footer shows the UBC logo and the text "MATH & SCIENCE TEACHING & LEARNING THROUGH TECHNOLOGY" above a graphic of a globe with a Canadian flag motif.

UBC 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

Teacher Education

HOME ABOUT ADMISSIONS CURRENT STUDENTS PROGRAMS RESOURCES

Home Resources CREATE Seminars 2012/13

CREATE  
Community to Reimagine Educational Alternatives for Teacher Education

Resources

- Awards
- Current Students
- Prospective Students
- Faculty and Staff

CREATE

CREATE is a faculty-wide initiative established by [Dr. Rita Irwin](#), Associate Dean of Teacher Education programs, to inspire innovations in teacher education at UBC.

Seminars are held in [Neville Scarfe, Room 310](#) from 12:30 – 2:00 p.m. (unless otherwise noted).

Presentation about MSTLT Project

On October 16th Dr. Marina Milner-Bolotin was invited to present a seminar to faculty and students at UBC Teacher Education Program

[Read More](#)

MATHEMATICS

PHYSICS

CHEMISTRY

BIOLOGY

VECTORS

KINEMATICS

DYNAMICS

MOMENTUM

WORK, ENERGY, POWER

THERMODYNAMICS

CIRCULAR MOTION

GRAVITATION

WAVE MOTION AND OPTICS

PARTICLE AND NUCLEAR PHYSICS

EQUILIBRIUM

ELECTROSTATISTICS

Mission

Contact

Our sponsors

MATH & SCIENCE TEACHING & LEARNING  
THROUGH TECHNOLOGY

<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. St.

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

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

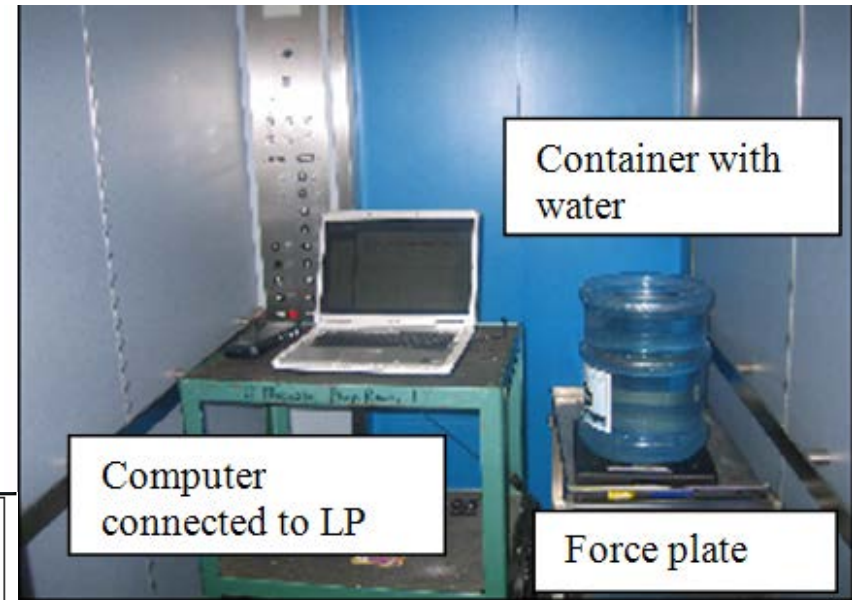
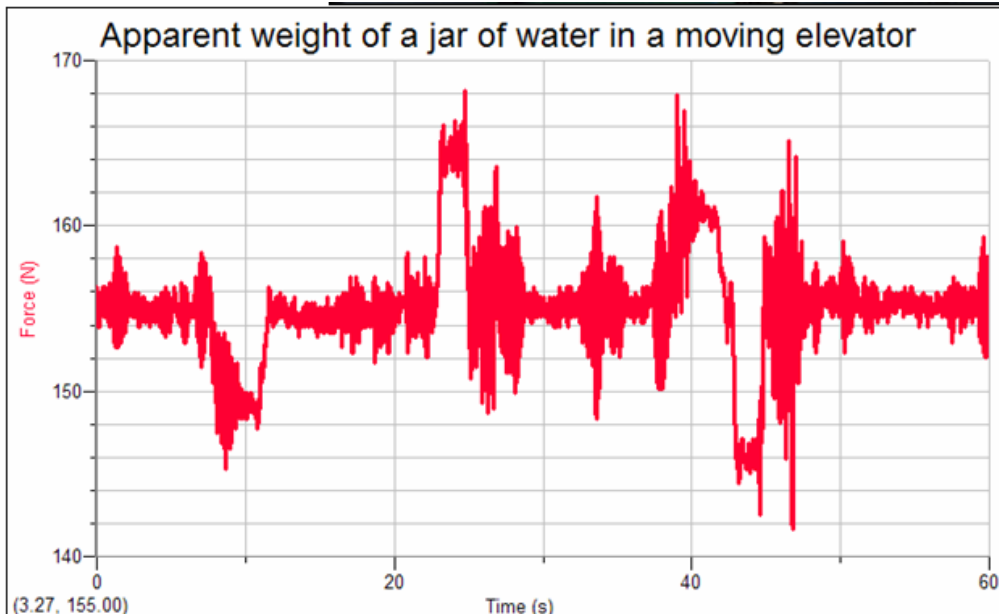
**Marina Milner-Bolotin**, Ryerson University, Toronto, ON

**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.

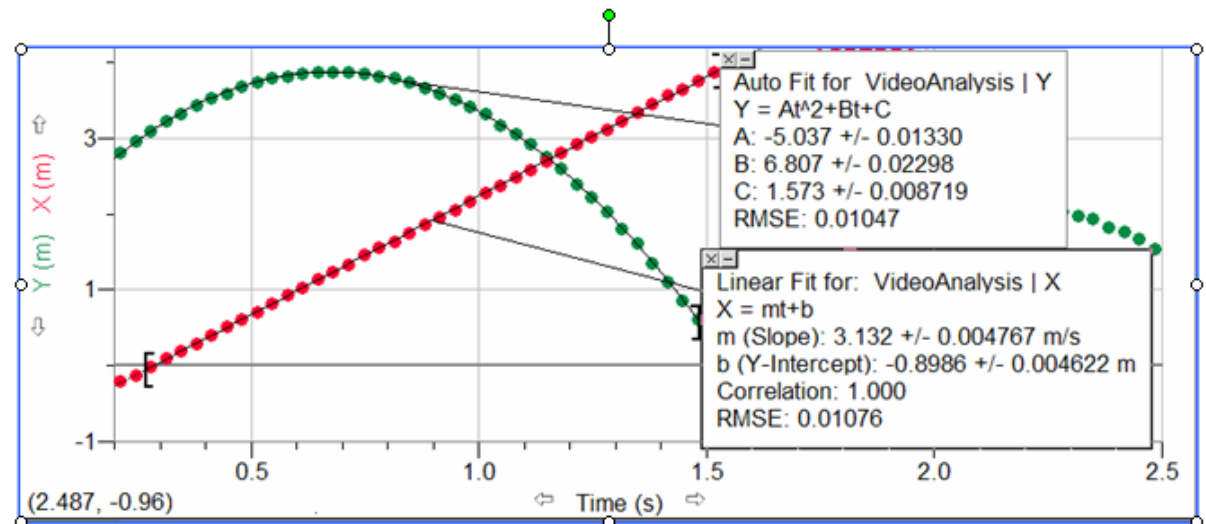


*A water jar was placed on a force plate inside a moving elevator: weight and apparent weight problem*

# 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)  $5.037 \text{ m/s}^2$
- b)  $6.807 \text{ m/s}^2$
- c)  $9.823 \text{ m/s}^2$
- d)  $10.074 \text{ m/s}^2$
- e)  $10.10 \text{ m/s}^2$



# 3. Computer Simulations

FREE  
RESOURCES

The screenshot shows the PhET Interactive Simulations website. At the top, the PhET logo is on the left, followed by the text "Over 200 million simulations delivered". On the right is the University of Colorado Boulder logo. Below the logo is a search bar. A blue banner across the top contains the text "Support PhET's Annual Campaign: Donate Today" and "HTML5 Sims" with a logo. Below the banner, the text "INTERACTIVE SIMULATIONS FOR SCIENCE AND MATH" is on the left, and a blue button says "Play with Simulations". In the center is a simulation titled "Faraday's Law" showing a coil and a magnet. To the right of the simulation are social media icons for YouTube, Facebook, Twitter, and Pinterest. At the bottom, there is a navigation menu with four sections: "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

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- One at a Time
- Troubleshooting
- FAQs

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PhET is supported by...

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

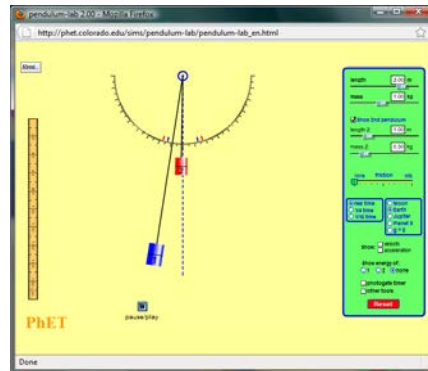
PhET Computer simulations from the University of Colorado, Boulder

*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

The screenshot displays the CLAS interface. At the top, there are links for "Instructions for this course" and "upload & manage videos". The main video player shows a woman standing in front of a chalkboard titled "FREE BODY DIAGRAMS". The chalkboard contains handwritten notes: "gravity", "friction", "normal", and "free fall", along with a diagram of a block on a table with forces labeled  $F_g$  and  $F_N$ . The video player has a progress bar at 0:00/4:01. To the right of the video player, the course information is shown: "Course: EDCP357 301 2015W" and "Playlist: everyone in this course (42 items)". Below this, there are options to "Autoplay entire playlist" and "Loop this video or playlist". A list of videos is displayed, including "Caitlin - Terminal Velocity 2", "Caitlin - Terminal Velocity 1", "Nadereh - Lesson 1", "Irit Teaching FBD - new version", and "Irit Teaching FBD - part 2". Below the video player, there is a "Time-specific comments" section with a text input field and buttons for "Post", "Record video as response", "Use existing audio / video", "Book mark", and "Hide my identity". A filter bar shows "Filter: mine / all" and "Private Unread Anonymous Mine Instructor or TA's Student's". A progress bar for comments is shown with markers at 25% (01:00), 50% (02:00), and 75% (03:00). Below the progress bar, there are options to "Follow along with video" and "Highlight tagged posts". A search bar for "search comments & annotations" is present, with filters for "by content", "author", "tag", and "hover on words to search". At the bottom, there is a "General comments to the whole video" section with an "Add general comment" button. The text "There is no comment for this video yet." is displayed.

# 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



## Canadian Journal of Science, Mathematics and Technology Education

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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/10.1080/14926156.2015.1038441>

[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 21<sup>st</sup> 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**



TECHNOLOGY  
IS A  
GIVEN

NOT A  
DEBATE

*Does technology  
presence  
guarantee  
improved student  
learning?*