



# An Examination of Research-Based Innovations in Physics Teacher Education at UBC

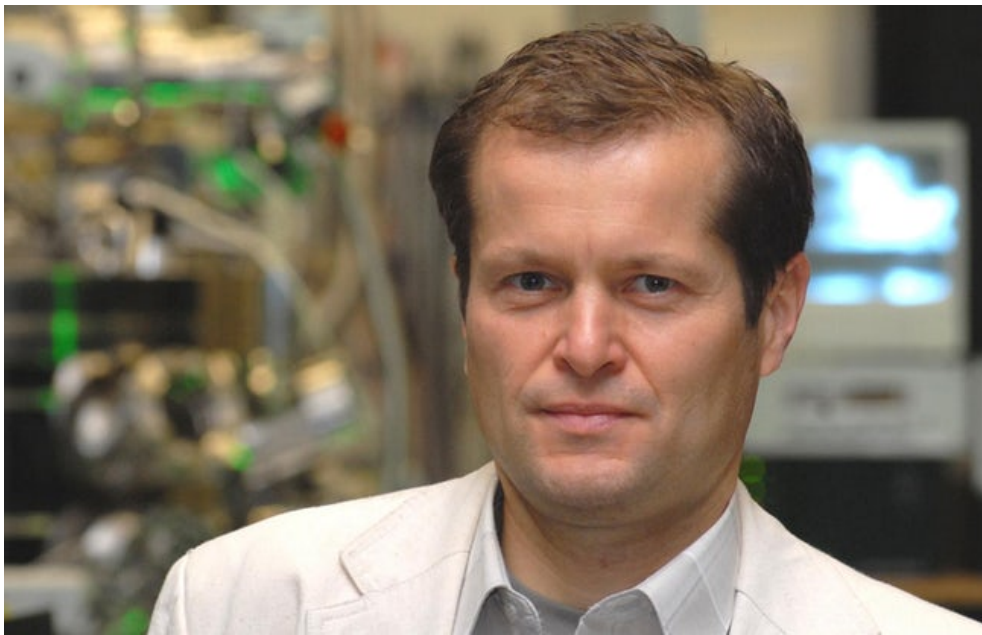
**Dr. Marina Milner-Bolotin**

Budapest, Hungary, September 25<sup>th</sup>, 2017

# Thank you for the invitation!



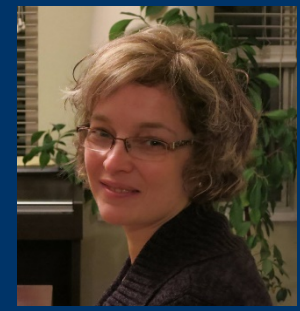
14th INTERNATIONAL CONFERENCE  
ON MULTIPHOTON PROCESSES  
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**Ferenc Krausz**  
generated and measured  
the first [attosecondlight  
pulse](#) and used it for  
capturing [electrons'](#) motion  
inside atoms, marking the  
birth of [attophysics](#).<sup>[1]</sup>

Graduate of Eotvos Lorand University

Atto =  $10^{-18}$  s



# Dr. Marina Milner-Bolotin

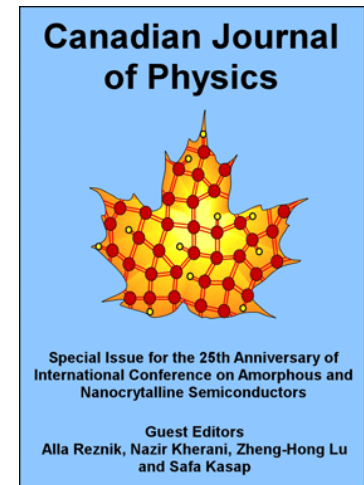
- **Associate Professor** in Science Education at the Department of Curriculum and Pedagogy, Faculty of Education, University of British Columbia, Vancouver, Canada
- **Teacher:** Taught secondary and post-secondary physics and math in Canada, US, and Israel
- **Researcher:** Physics education researcher, Associate Editor of the Canadian Journal of Physics
- **Info:** [marina.milner-bolotin@ubc.ca](mailto:marina.milner-bolotin@ubc.ca)  
<http://blogs.ubc.ca/mmilner/>

# Part 1: Physics Education Research in Canada



# Physics Education Research Publications

Canadian Journal of Physics (Physics  
Education Section)  
Physics in Canada  
Canadian Journal of Science, Mathematics  
and Technology Education



## PiC Archives (1955 - 2017)



Vol 73, No. 2a, 2017



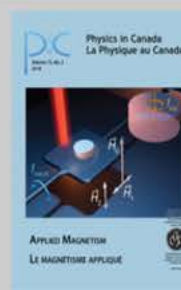
Vol 72, No. 4, 2016



Vol 72, No. 3, 2016



Vol 72, No. 2a, 2016



Vol 72, No. 2, 2016



Vol 72, No. 1, 2016



# Physics Education Research (PER) Groups

**Departments of Physics and Astronomy –  
Undergraduate and Graduate Focus**

**Faculties of Education – K-12 and Teacher Education**

**PER Centers in Canada:** UBC, Simon Fraser  
University, University of Calgary, University of  
Alberta, University of Toronto (OISE), Queens  
University, Concordia University in Montreal...

# Part 2: Physics Teacher Education @ UBC



# UBC Physics Teacher Education

- **Canada:** K-7 elementary; 8 -12 - secondary
- **British Columbia:**
  - Bachelor of Education: B.Sc. + 1 year Teacher Ed.  
60 credits of courses – 10% didactics courses
  - Small classes – 10 – 25 people
  - Teacher-Candidates from all over the world
  - 12 week school practicum
  - Variable teaching and educational experience
  - Most of the them want to teach in Canada



# Physics Teacher Education



PHYSICS AND 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 of the subject-matter that teacher-candidates were preparing to teach.

Teacher Education Programs have since tightened their entrance requirements. For example, to enter the Physics Teacher Education Program at the University of British Columbia (UBC), applicants must have a B.Sc. with a GPA of 65% or higher. At first glance, this should address the “missing” physics content knowledge problem and justify the reduced emphasis on the physics methods courses (courses dedicated to developing teacher-candidates’ PCK). At UBC, out of the 60 credits of the

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 physics Nobel Laureate, Prof. Carl Wieman:



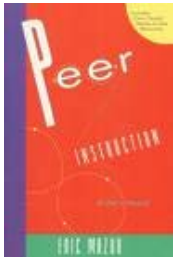
At the K-12 level, although there are notable exceptions, the typical teacher starts out with a very weak idea of what it means to think like a scientist or engineer. *Very few K-12 teachers, including many who were STEM majors, acquire sufficient domain expertise in their preparation.* Hence, the typical teacher begins with very little capability to properly design the requisite learning tasks. Furthermore, *... content mastery, combined with ... content knowledge ... evaluating ...* (It)

# Research-Based Innovations

**Innovations that according to research evidence promote physics learning inside and outside of the classroom both in K-12 and university settings.**

# Examples

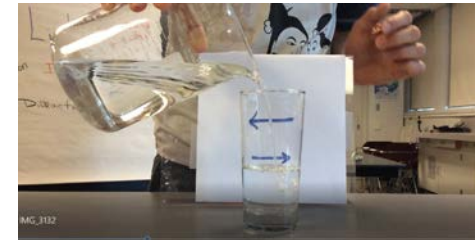
## 1) Peer Instruction and PeerWise



## 2) CLAS



## 3) Videos of Experiments



## 4) Live data collection and analysis



## 5) Computer Modeling and simulations



# 1

# Peer Instruction & PeerWise

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



# 1a

# Peer Instruction in Teacher Education

LUMAT 1(5), 2013 [LUMAT: Research and Practice in Math, Science & Technology Education, 2013. 1(5): p. 525-544.]

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

Marina Milner-Bolotin

Department of Curriculum and Pedagogy, Faculty of Education, The University of British Columbia • marina.milner-bolotin@ubc.ca

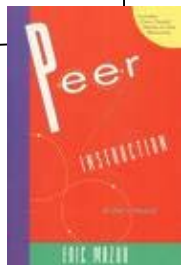
Heather Fisher

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

Alexandra MacDonald

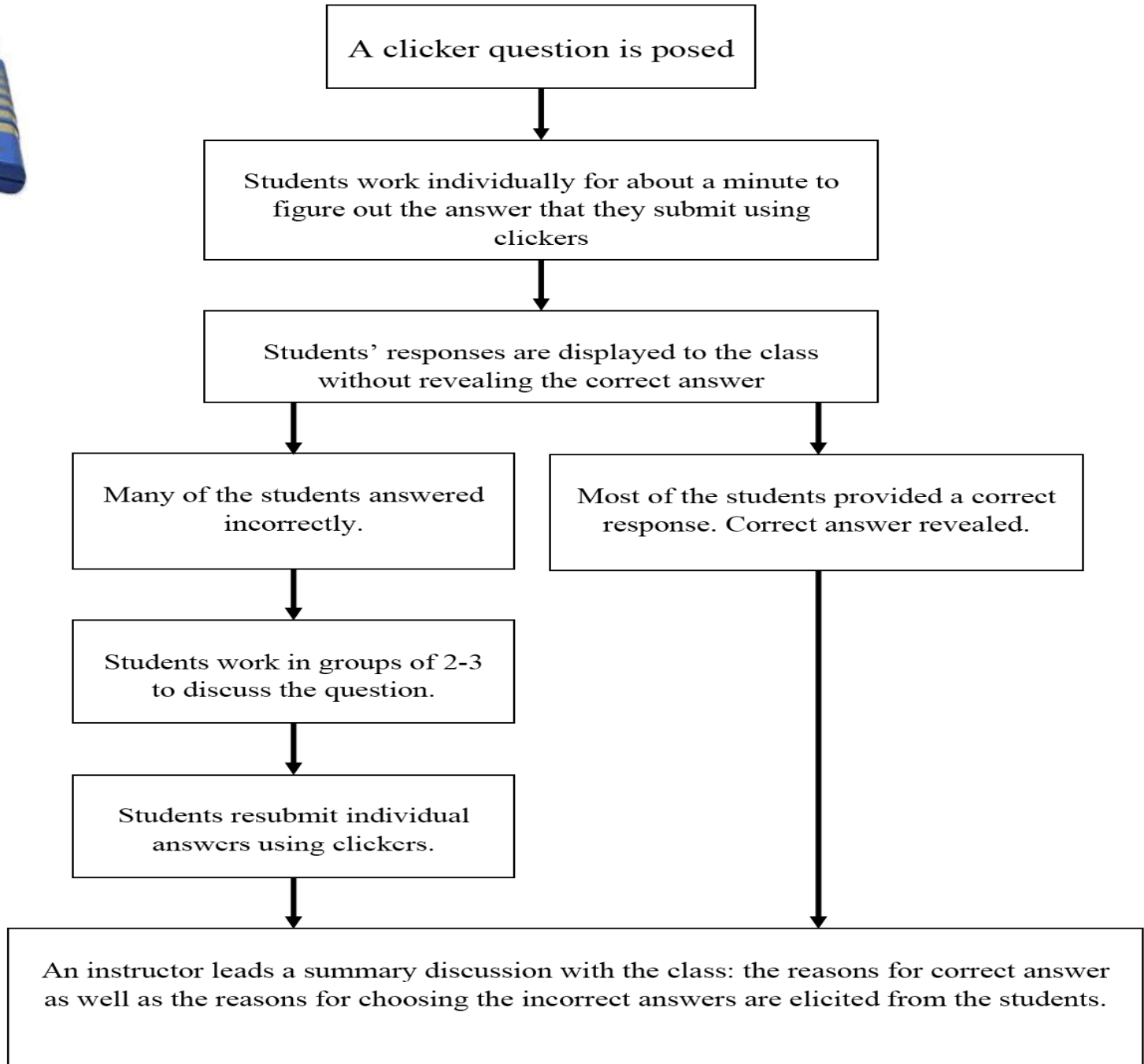
Department of Curriculum and Pedagogy, Faculty of Education, The University of British Columbia

**Abstract** One of the most commonly explored technologies in Science, Technology, and Mathematics (STEM) education is Classroom Response Systems (CRS). In this study, instructors generate in-class discussion by soliciting





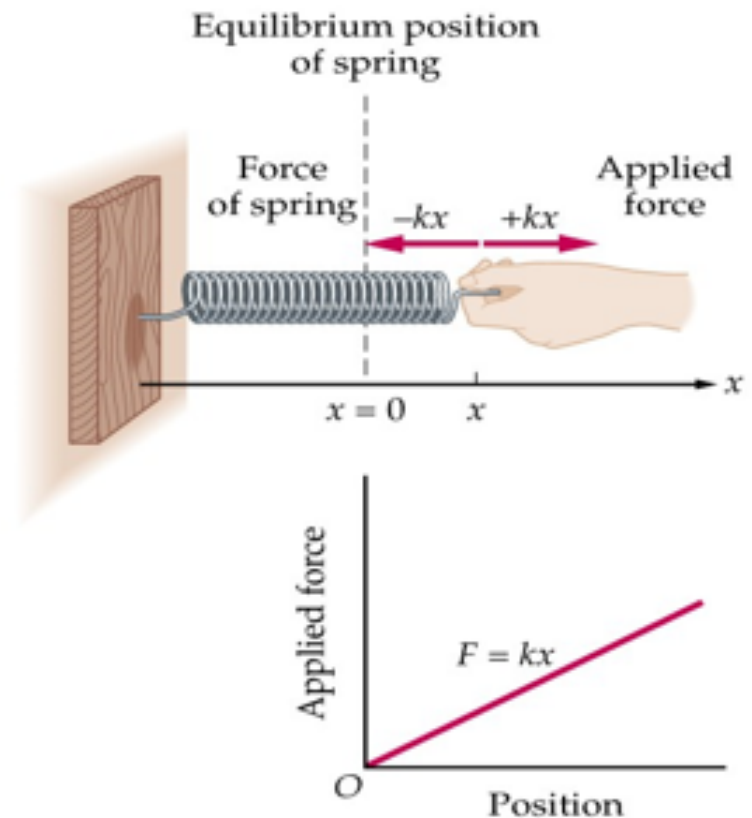
# Peer Instruction



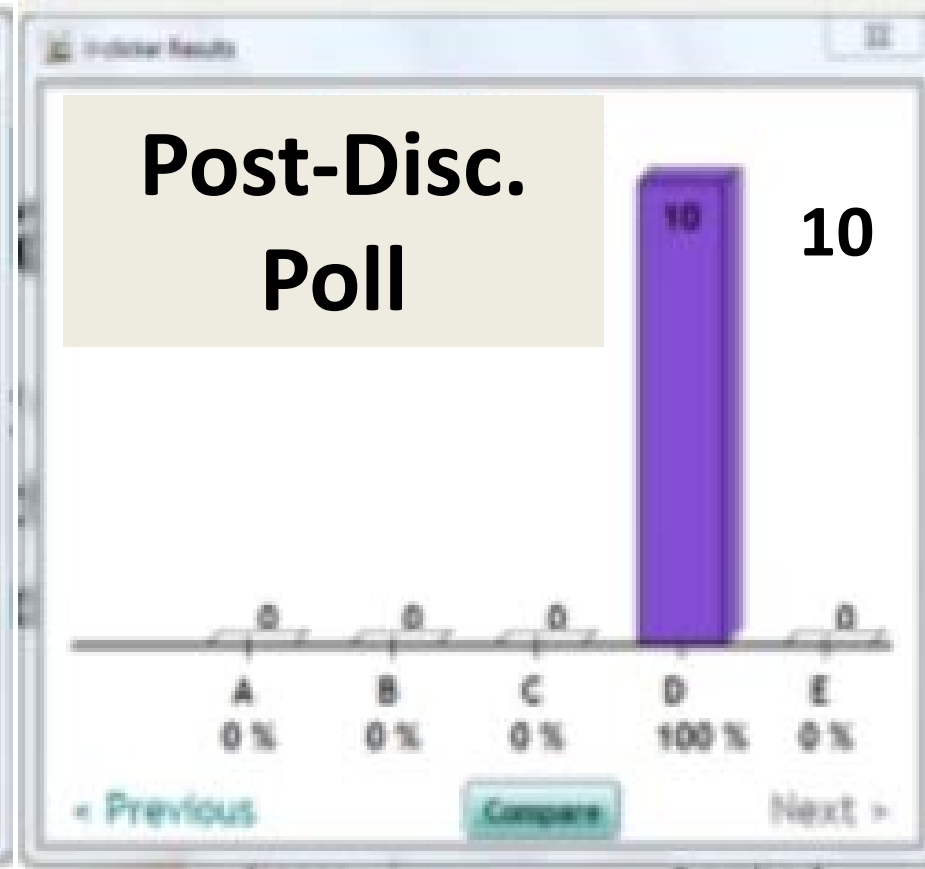
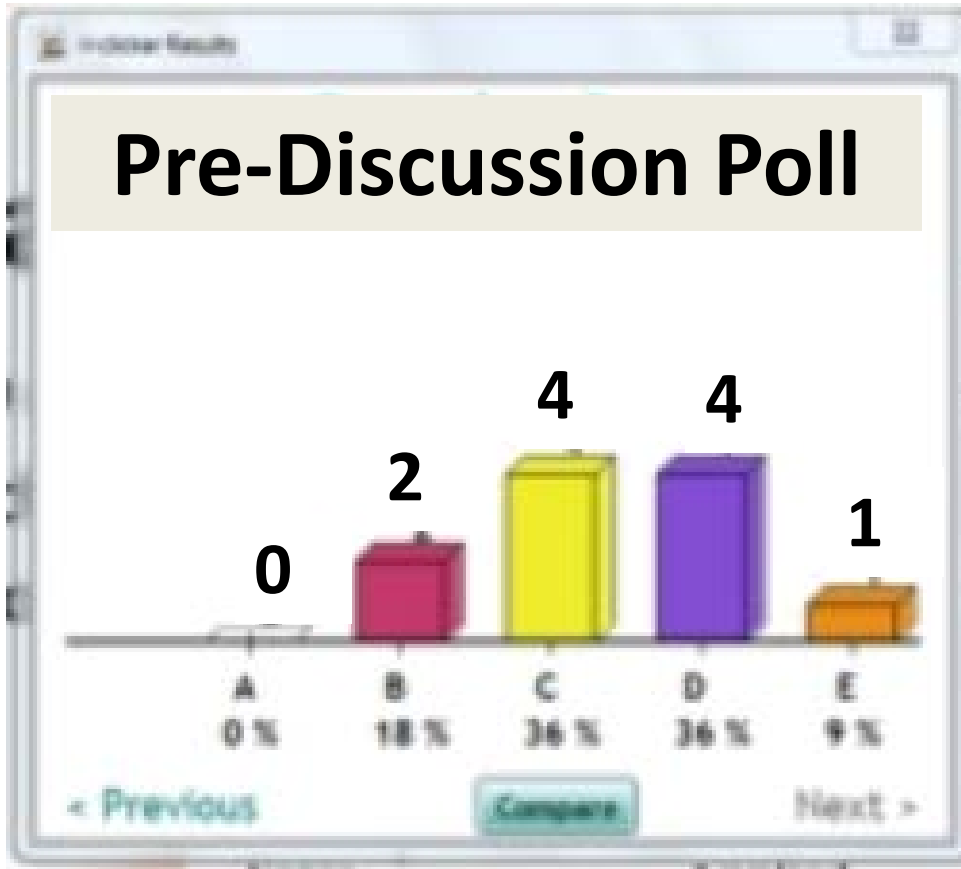
# Example 1: Hook's law

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



# Example 1: Results



**Respondents:** Physics Teacher-Candidates



# 1b

# PeerWise

## PeerWise

Ask | Share | Learn

## Welcome to PeerWise

To log in, select your school / institution from the list below

Go »

*Just type the first few characters...*



Get started!

Follow @peerwise

PeerWise supports students in the creation, sharing, evaluation and discussion of assessment questions.



### 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.



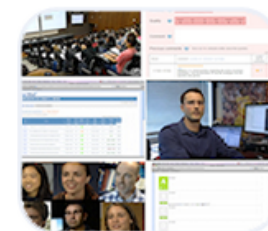
### Any subject

PeerWise is used in a wide range of subjects, including Anthropology, Biology, Chemistry, Computer Science, Physics, Population Health, Pharmacology, Medicine, and many more...



### Free and easy to use

PeerWise is free and very easy to use. Students are presented with a simple, intuitive interface and instructors can easily view student content and monitor participation.



### Find out more

Want to get started? View student and instructor guides, watch screencasts of PeerWise in action, and hear what students and instructors think in the [Information about PeerWise](#) section.

# PeerWise: Online Collaboration on Multiple-Choice Questions



The University of British Columbia

You are logged in as **marinamb** [Logout](#)

Home

Email: [marina.milner-bolotin@ubc.ca](mailto:marina.milner-bolotin@ubc.ca) [update](#)  
Password for "marinamb": [update](#)

## Welcome home

Welcome to PeerWise. Simply choose one of your courses or you might like to activate the pending course below. If you like, you can also create a new course or join an existing course.

## Pending courses

The following courses are not yet active. To activate a course, simply upload the identifiers that your students will use to access the course by clicking on the "Upload student identifiers to activate this course" link. Each student will be asked to provide their identifier to join the course (either when they register a new account or join the course with their existing account).

### EDCP357\_2017

Course ID  
14628

[➔ Upload student identifiers to activate this course ➔](#)

[Manage access](#) | [Administration](#)

## Your courses

You are currently a member of the following courses. Simply click on the course name to begin.

### EDCP357 (Winter 1, 2013)

Course ID	Identifiers active	Questions	Answers	Comments	Last correct answer
7904	10 / 10	525	2055	1246	11:00pm, 03 Dec

[Manage access](#) | [Administration](#)

### EDCP357\_2014

Course ID	Identifiers active	Questions	Answers	Comments	Last correct answer
9453	12 / 12	303	1476	914	8:35pm, 30 Jul

[Manage access](#) | [Administration](#)

### ChaoyangSTEM\_2015

Course ID	Identifiers active	Questions	Answers	Comments	Last correct answer
11156	1 / 70	1	0	0	---

[Manage access](#) | [Administration](#)

### EDCP357\_2015

Course ID	Identifiers active	Questions	Answers	Comments	Last correct answer
11423	13 / 15	423	2123	1103	10:08am, 14 Feb

[Manage access](#) | [Administration](#)

### EDCP357\_2016

[Manage access](#) | [Administration](#)

# Designing, Answering, Commenting, Reflecting & Improving

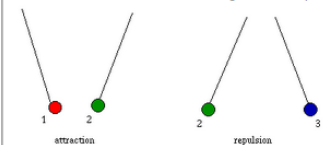
... **DO NOT AGREE WITH AUTHOR**

... **DO NOT AGREE WITH AUTHOR** Your answer does not agree with the answer suggested by the author, but more responses are needed

### Question:

This question has been answered by 3 people and has an average rating of 4.00 (based on 1 rating)

Each of the three balls shown have been given either a positive charge, a negative charge or no charge. By looking at the diagram below we can conclude that...



### Alternatives

You selected A when answering this question. The contributor suggested E is the correct option.

OPTION	ALTERNATIVE	FIRST ANSWERS	CONFIRM ANSWERS
<b>A</b>	...balls 1 and 3 carry charges of opposite sign.	3 (100.00%)	0
B	...balls 1 and 3 carry charges of the same sign.	0 (0.00%)	0
C	...balls 2 and 3 carry negative charges and ball 1 carries a positive charge.	0 (0.00%)	0
D	...balls 2 and 3 carry negative charges and ball 1 carries no charge.	0 (0.00%)	0
E	None of the above.	0 (0.00%)	0

After looking at the information on this page, do you believe your answer is correct?

Yes - my answer is correct [confirm answer](#)

No - let me change my answer [change answer](#)

Or, you may answer this question again later

# Effect of Peer Instruction on Teacher-Candidates' Content Knowledge

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

Marina Milner-Bolotin

Department of Curriculum and Pedagogy, Faculty of Education, The University of British Columbia •  
marina.milner-bolotin@ubc.ca

Heather Fisher

Department of Curriculum and Pedagogy,

Alexandra MacDonald

Department of Curriculum and Pedagogy,

*Peer-reviewed research article. Submitted*

[Full text](#)

## EDUCATION CORNER

S  
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### 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 is challenging. These questions are often provided by the undergraduate textbook authors<sup>[1]</sup>, but are not yet as common in K-12 physics textbooks. For the past three years, our team has been working on designing our

contributed to PeerWise database has the fields displayed in Table 1.

In addition, PeerWise collects data on its reputation which is used to rank questions. They also

# Effect of PeerWise on Teacher-Candidates' Content Knowledge

PHYSICAL REVIEW PHYSICS EDUCATION RESEARCH **12**, 020128 (2016)

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

Marina Milner-Bolotin, Davor Eggersdorfer, and Murugan Vinayagam

*Department of Curriculum and Pedagogy, Faculty of Education, The University of British Columbia,  
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 a rubric developed for the study.

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

# Math & Science Teaching and Learning through Technology

Campuses + UBC Directories + UBC QuickLinks +

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

**MATHEMATICS**

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**CHEMISTRY**

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mission is to design, test, evaluate and disseminate 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.

**Background**

**Centred Pedagogies**

Engagement (E) in Mathematics & Science Classrooms designed to promote conceptual understanding of the subject through hands-on (often) activities which yield feedback through discussions with peers and/or instructors

Examples of EIPs are: Instruction using Electronic Response Systems (clickers), Interactive inquiry-driven lessons using IMART Boards

**Program @ the Faculty of Education**

An inquiry in Teacher Education! innovative pedagogies and reflective practices

**Help for MSTLIT Resource**

Lack of research-proven mathematics and science resources (resources linked to BC K-12 Curriculum) have led to input over textbook choices; supplemental helps then incorporate student-centred teaching and stretch into their classrooms

**the Gap**

Equity in science and mathematics methods courses + how to apply inquiry in real-world contexts in technology options

**The Resource**

- Available online
- Downloadable PPT slides
- Sequences of questions within a topic: from recall to complex knowledge transfer
- Emphasis on concepts
- Topics based on BC IRPs

**The Pilot Project**

- Piloted in the Physics Methods course for B. Ed students

**Developing the Resource**

- Questions developed for K-12 mathematics and science

**Using the Resource**

- Created a user-friendly database of lesson and

**Feedback from teacher-educators (EIPs)**

"I have found the conceptual clicker questions from [the] site probably the most useful and illuminating part of my classes provides an environment in which the class feels comfortable investigating and exposing their prior knowledge about physics."  
-Adam

"These sets of conceptual questions and clickers is very engaging and intellectually stimulating. The clickers create a safe learning where students do not have to fear giving an incorrect answer."

**TLEF Showcase Presentation**

Our team had an opportunity to present our TLEF project to the larger UBC community during the 2012 TLEF Showcase that took

Read More

2 / 10

MATH & SCIENCE TEACHING & LEARNING THROUGH TECHNOLOGY

# 2

# CLAS



Instructions for this course

upload & manage videos

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



# 3

# Collection of Video STEM Experiments

The screenshot shows a YouTube channel page. At the top left is the YouTube logo with 'CA' next to it. A search bar is located to the right of the logo. Below the search bar, the channel name 'Science & Math Education Videos for All' is displayed, along with '14 subscribers', '464 views', and a 'Video Manager' icon. A large banner image shows a mountain valley with a rainbow. Below the banner, there is a 'Subscribe' button with '14' subscribers. A description below the banner reads: 'This channel is created to support future and practicing mathematics, science and technology educators who want to have more engaging les... Show more'. Under the 'Uploads Public' section, there are four video thumbnails: a woman in a classroom, a man in a lab coat, a person pouring liquid into a jar, and a diagram of light refraction.

YouTube CA

Search

14 subscribers 464 views Video Manager

Science & Math Education Videos for All

Subscribe 14

This channel is created to support future and practicing mathematics, science and technology educators who want to have more engaging les... Show more

Uploads Public

Electrostatics

Life Science

Law of Refraction (Snell's Law)

Refracted Rays

Normal

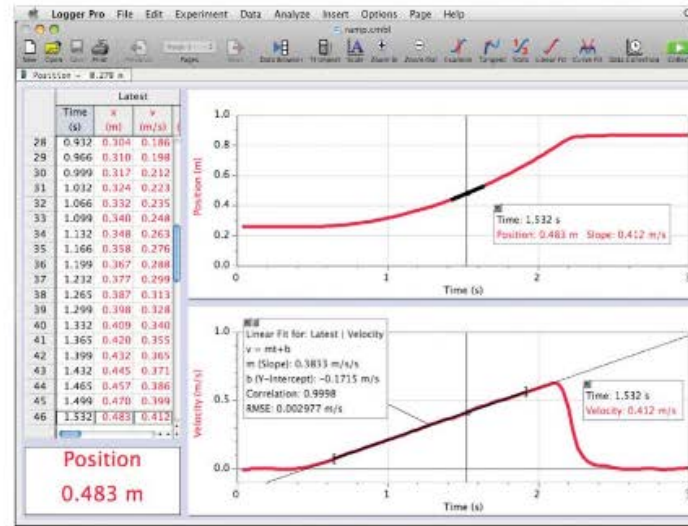
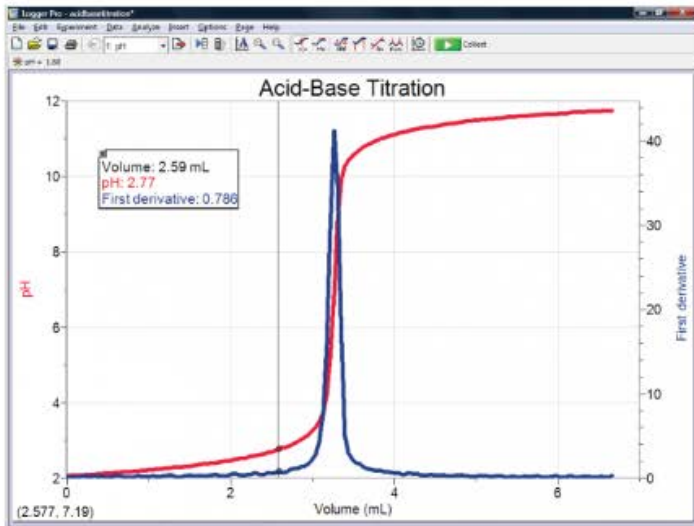
$\sin \theta_1 = \frac{v_1}{c}$   $\sin \theta_2 = \frac{v_2}{c}$



# 4

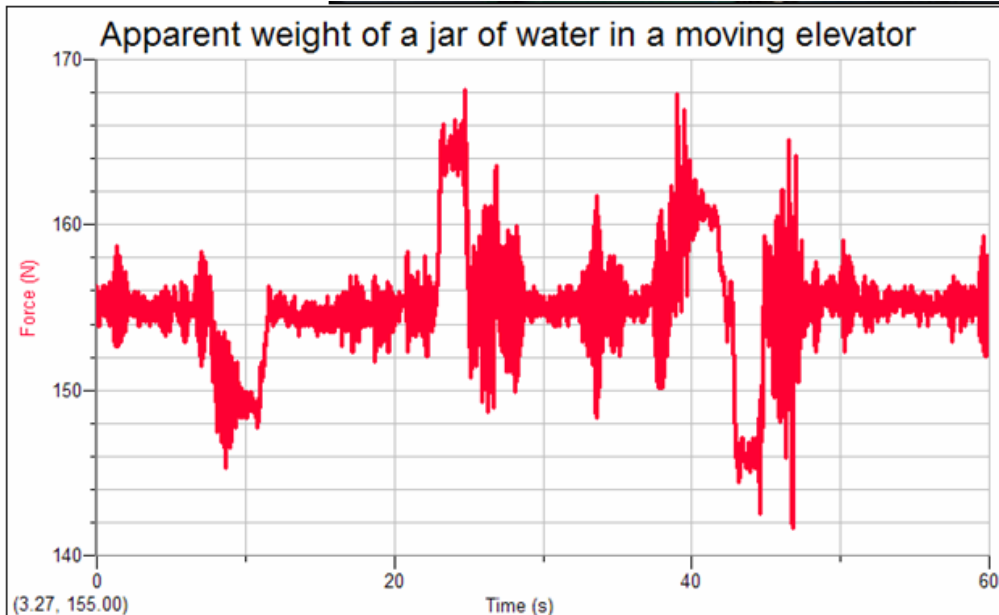
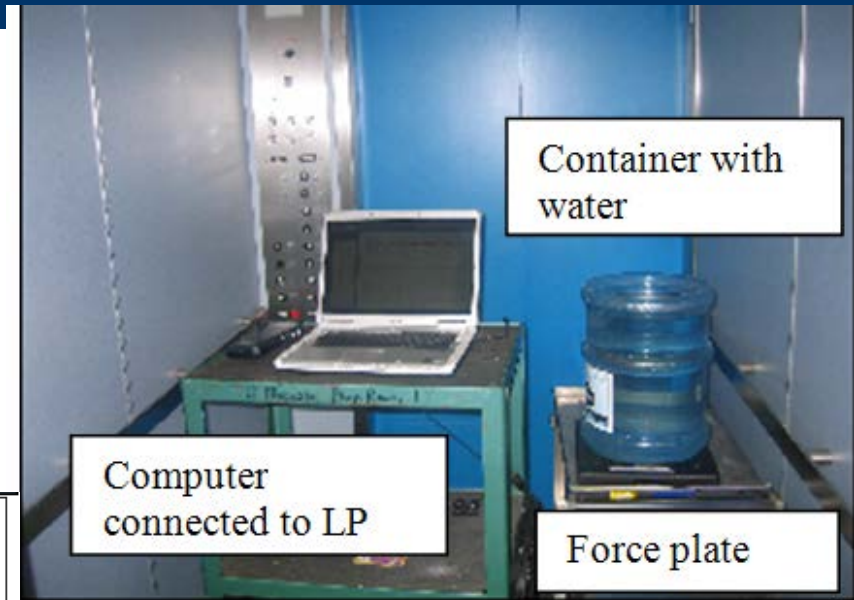
# Live Data Collection & Analysis

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



# Logger Pro Example

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*

# 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.

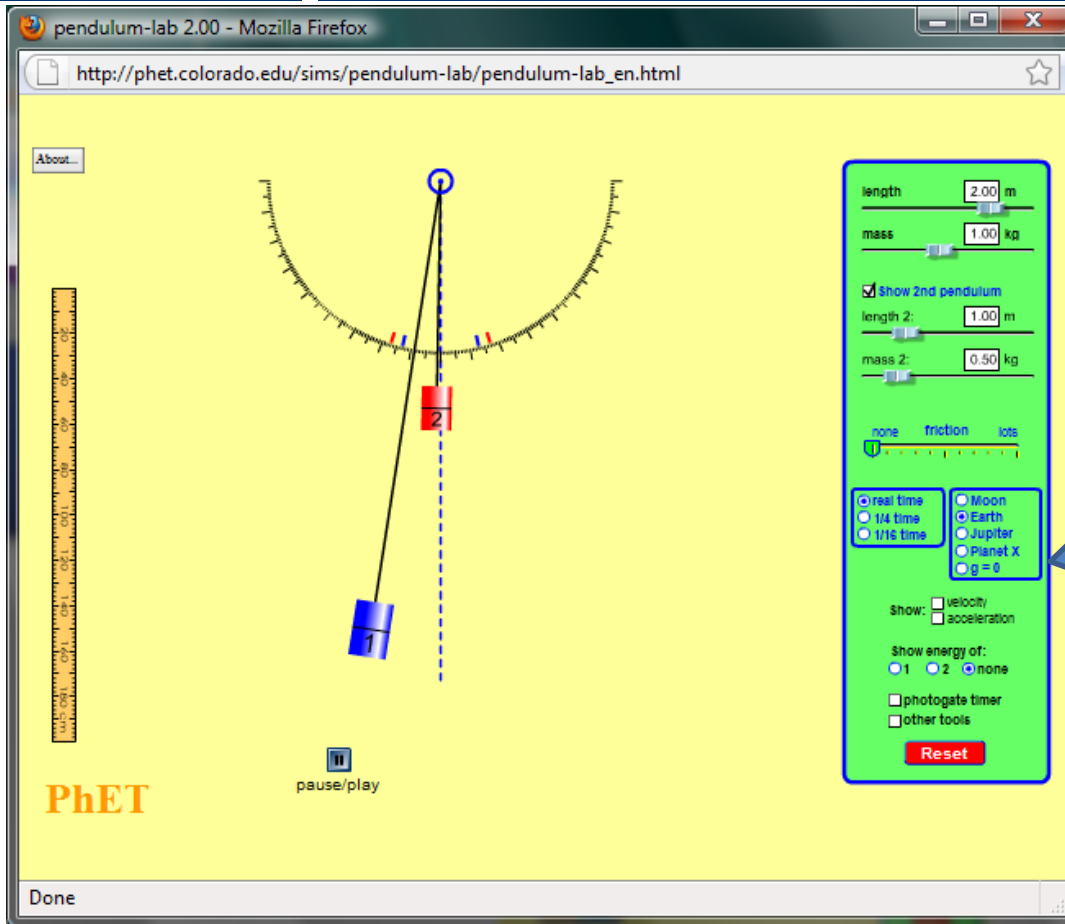
## Physics Exam Problems Reconsidered: *Using Logger Pro to Evaluate Student Understanding of Physics*

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

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



# 5 Simulations & Modeling



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

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



# Part 3: PER – Examining Innovations

Many pedagogical innovations in physics courses remain unexamined and often unshared. We keep reinventing the wheel and rarely learn from each other. **More research is needed in our countries and internationally.**

PER can help bridge what we know about learning to how we teach physics both in K-12 and at university.

# Conclusions



Eötvös Loránd  
University



September 28, 2017