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

Dr. Marina Milner-Bolotin

Budapest, Hungary, September 25th, 2017
Thank you for the invitation!

Ferenc Krausz generated and measured the first attosecond light pulse and used it for capturing electrons’ motion inside atoms, marking the birth of attophysics.\(^1\)

Graduate or Eotvos Lorand University

Atto = 10\(^{-18}\) s
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• **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

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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)

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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
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 them want to teach in Canada
More than 25 years ago, Lee S. Shulman, then president of the American Educational Research Association, 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) 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, the knowledge, combined with content mastery, combined with content knowledge, combined with evaluating knowledge, is often overlooked.
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
Peer Instruction & PeerWise

Electronic response systems (clickers) in K-12 classrooms...
Modeling Active Engagement Pedagogy through Classroom Response Systems in a Physics Teacher Education Course

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Abstract One of the most commonly explored technologies in Science, Technology, and Mathematics (STEM) education is Classroom Response Systems (CRS). CRS allows instructors to generate in-class discussion by soliciting student responses through electronic devices. This approach has been shown to increase student engagement and understanding. However, there is a need for further research on how CRS can be integrated into teacher education programs to enhance the preparation of future STEM educators. This paper explores the potential of CRS in a physics teacher education course and discusses the challenges and implications of implementing such technology in teacher training.
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.

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

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

Students resubmit individual answers using clickers.

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.
Example 1: Hook’s law

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

A. 5 J  
B. 10 J  
C. 20 J  
D. 30 J  
E. 40 J
Example 1: Results

Pre-Discussion Poll

<table>
<thead>
<tr>
<th>Option</th>
<th>Pre-Disc. Poll</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>0%</td>
</tr>
<tr>
<td>B</td>
<td>18%</td>
</tr>
<tr>
<td>C</td>
<td>36%</td>
</tr>
<tr>
<td>D</td>
<td>36%</td>
</tr>
<tr>
<td>E</td>
<td>9%</td>
</tr>
</tbody>
</table>

Respondents: Physics Teacher-Candidates

Post-Disc. Poll

<table>
<thead>
<tr>
<th>Option</th>
<th>Post-Disc. Poll</th>
</tr>
</thead>
<tbody>
<tr>
<td>D</td>
<td>100%</td>
</tr>
<tr>
<td>E</td>
<td>0%</td>
</tr>
</tbody>
</table>
Welcome to PeerWise

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

Just type the first few characters...

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

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

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 7904
Identifiers active 10 / 10
Questions 525
Answers 2055
Comments 1240
Last correct answer 11:00pm, 03 Dec

EDCP357_2014
Course ID 9453
Identifiers active 12 / 12
Questions 303
Answers 1476
Comments 914
Last correct answer 8:23pm, 30 Jul

ChaoyangSTEM_2015
Course ID 11156
Identifiers active 1 / 10
Questions 1
Answers 0
Comments 0
Last correct answer —

EDCP357_2015
Course ID 11423
Identifiers active 13 / 15
Questions 423
Answers 2123
Comments 1103
Last correct answer 10:08am, 14 Feb

EDCP357_2016

Manage access | Administration
Designing, Answering, Commenting, Reflecting & Improving
Effect of Peer Instruction on Teacher-Candidates’ Content Knowledge

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

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Peer-reviewed research article. Submitted

Education Corner

Using PeerWise to Promote Student Collaboration on Design of Conceptual Multiple-Choice Physics Questions

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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(1), but are not yet as common in K-12 physics textbooks. For the past three years, a team has been working on designing such questions and contributing them to the PeerWise database. This database is already being used by teachers, contributing to its growing reputation which is helping it to attract more users.
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 a rubric developed for the study.

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Math & Science Teaching and Learning through Technology

Mathematics and Science Teaching
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Graduate Student, EDC
Undergraduate Student, EDC

Background

Centred Pedagogies

Engagement (E) in Mathematics & Science Classrooms
regards to promote conceptual understanding of fundamental
deriving and hands-on (integrative) activities which yield
effective through discussion with peers and in reported
Exams of E (Peer Instruction) using Electronic Response
Systems (Clickers), Interactive Improvements
Incorporating blended Learning in Science Education

The Resource

• Available online
• Downloadable PPT slides
• Sequence of questions
• Pascal’s Triangle
• Topics in geometry
• Topics based on ICERPs

The Pilot Project

• Pilot in the Mathematics Methods course for B. Ed students
• Developing the Resource

TELF Showcase Presentation
Our team had an opportunity to present our TELF project to the
larger UBC community during the 2012 TELF Showcase that took
Read More
- Upload & manage videos
- Annotate them
- Collaborate
- Share
- Learn from each other
- Improve
Science & Math Education Videos for All

This channel is created to support future and practicing mathematics, science and technology educators who want to have more engaging lessons... Show more
Thinking like a scientist means being able to analyze real life situations using real life data.
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


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 Cen H. Kim


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

\[ T = 2\pi \sqrt{\frac{l}{g}} \]
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

September 28, 2017