Three Examples of Promoting Technology-Enhanced Collaboration in STEM Teacher Education: From theory to research-informed Practice

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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 Pernilla Wittgren, Laureate, Prof. Carl Wieman [5].

Theoretical Framework

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

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, 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 pedagogy on learning in small secondary or post-secondary contexts. The context of this study is a secondary physics course.

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

Peer Instruction and PeerWise integration
In near future smart phones, i-pads and other devices will replace clickers, **but the basic pedagogy will remain the same**…
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

Pre-Discussion Poll

Respondents: Physics Teacher-Candidates
Tips for Using a Peer Response System in a Large Introductory Physics Class

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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 their answers in a small group. The results are then compiled to determine the effectiveness of the learning process. The Peer Instruction (PI) method is one of the effective tools used in the classroom. However, implementing PI in a large introductory class can be difficult due to the sheer number of students. In this paper, the author presents a Peer Response System (PRS) that can be used in large introductory classes to enhance the teaching and learning process. The PRS method is a useful tool for improving student engagement and understanding.

Clickers beyond the First Year Science Classroom

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Abstract:

This case study’s primary objective is to describe the implementation of the electronic response-system (clickers) in a small (N=25) second-year engineering class. The results show that the use of clickers can significantly improve student engagement and understanding. The use of clickers in the classroom can be a useful tool for improving student learning in large introductory courses. The paper also discusses the challenges faced in implementing clickers in the classroom and provides suggestions for overcoming these challenges.


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

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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.

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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
2. 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 ... 

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

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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

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
Why CLAS: Collaborative Learning Annotation System?

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
Conclusions

In order to prepare our students for 21\textsuperscript{st} 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.