a place of mind

THE UNIVERSITY OF BRITISH COLUMBIA

TEACHING AND LEARNING ENHANCEMENT FUND

Closing the Research-Practice Gap through Innovative Technology Use in STEM Teacher Education

Dr. Marina Milner-Bolotin

The University of British Columbia, Vancouver, Canada

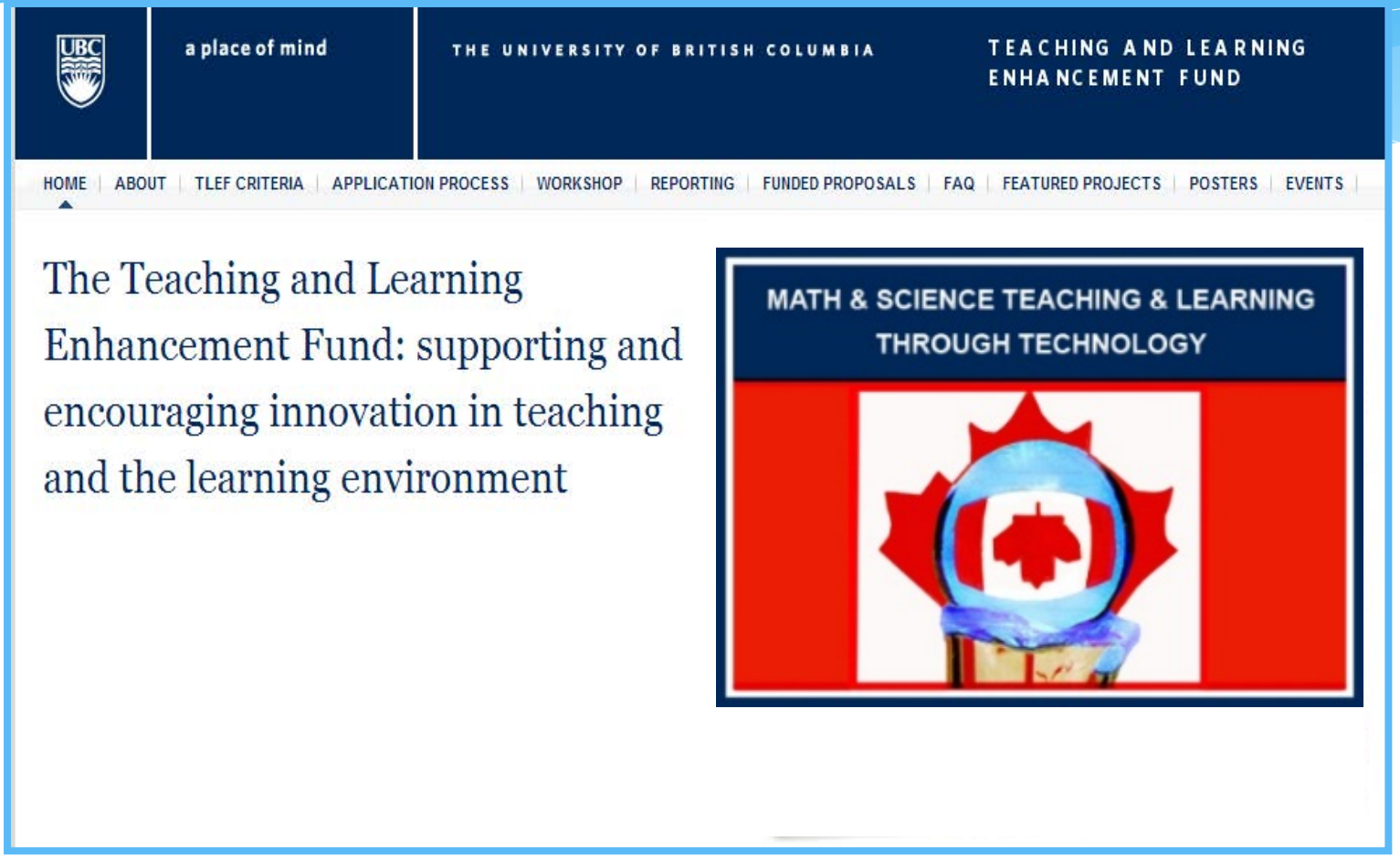
5th North American GeoGebra Conference: Explorative Learning with Technology

Words of Wisdom from my Son

Mom, don't worry about me. Get ready for your talk. Remember that what you are doing is very important for teachers; you have to inspire them so they can further realize change.

Love, Aviv

Acknowledgements



UBC TLEF support 2012-2015

Research Team Members

* Davor Egersdorfer (Grad student)
* Murugan Vinayagam (Grad student)
* Alexandra MacDonald (graduated, MA summer 2014)
* Heather Fisher (graduated, MA summer 2014)
* Teacher-Candidates, Physics Methods courses
* BC Physics and Mathematics teachers

Explorative Learning with Technology

Fifth North American GeoGebra Conference

Conference Theme: Explorative Learning with Technology

November 21-22, 2014

Ontario Institute for Studies in Education,
University of Toronto,
252 Bloor Street West, Toronto,
Ontario M5S 1V6 CANADA

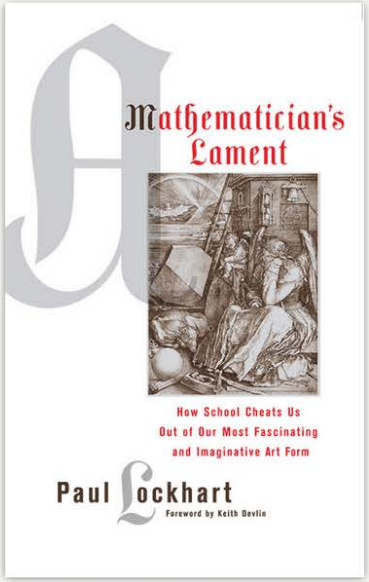
Deliberate Pedagogical Thinking

Using Technology to Promote Teacher-Candidates' capacity and positive attitudes for Deliberate Pedagogical Thinking: Thinking driven by improving student learning and inspiring them in meaningful STEM learning

Paul Lockart on Mathematics Education

A Mathematician's Lament

How School Cheats Us Out of Our Most Fascinating and Imaginative Art Form



144 pages
Trade Paper

"Provides a fresh way of thinking about math, and education in general, that should inspire practical applications in the classroom and at home."

— *Publishers Weekly* (link) on A Mathematician's Lament

see more reviews

Buy Now

Paul Lockhart

SYNOPSIS EXCERPT

A brilliant research mathematician who has devoted his career to teaching kids reveals math to be creative and beautiful and rejects standard anxiety-producing teaching methods. Witty and accessible, Paul Lockhart's controversial approach will provoke spirited debate among educators and parents alike and it will alter the way we think about math forever.

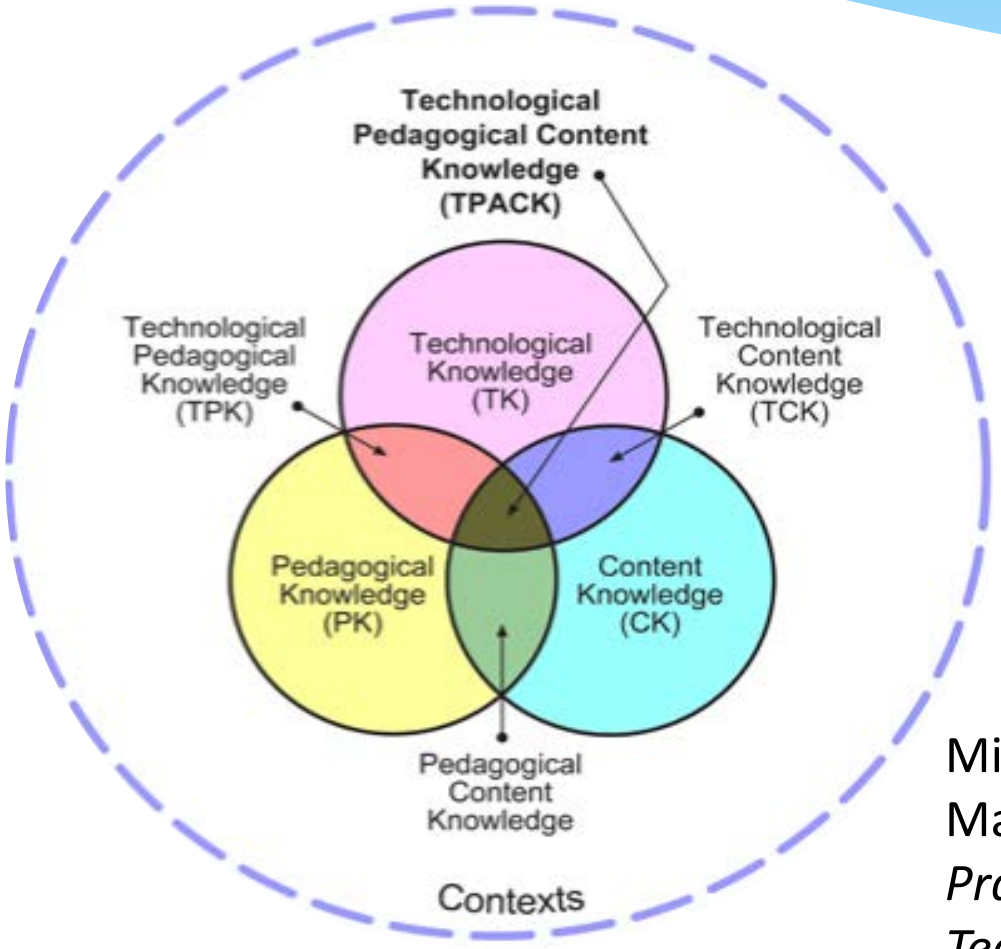
Research Goals: Promoting Deliberate Pedagogical Thinking via technology

(a) Pedagogical Content Knowledge

(b) Positive attitudes about technology in STEM

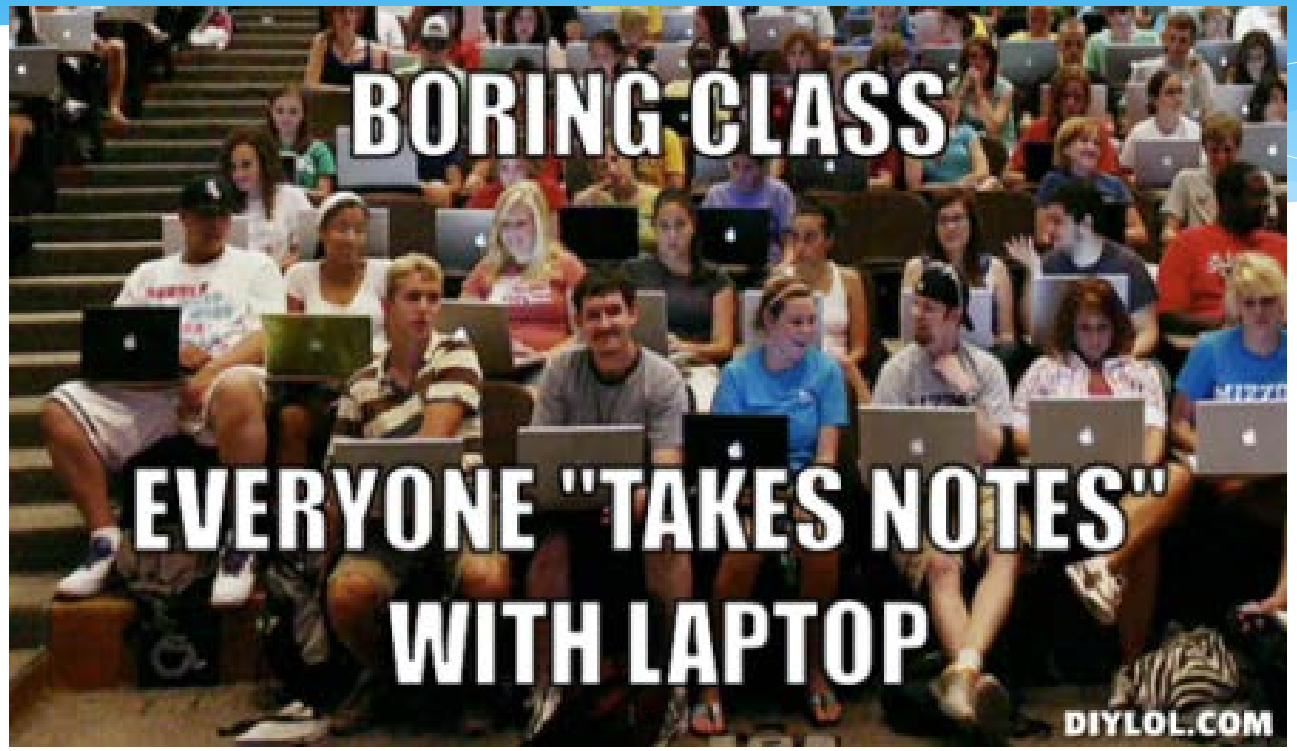
(c) Capacity for deliberate technology use.

Theoretical Framework: TPCK



Milner-Bolotin, M., Fisher, H., & MacDonald, A. (2013). *Research and Practice in Math, Science and Technology Education, 1*(5), 525-544.

Research and Practice Gap



STEM teachers lack TPCK needed for producing CHANGE. Teacher-Candidates need to begin acquiring this TPCK during their teacher-education years.

Context

* Secondary Teacher Education Program (~80 STEM teacher-candidates)
* Physics methods and inquiry courses
* ~20 teacher-candidates per course
* Action research study

Intervention – Action Research in a Physics Methods Course

* **Instructor models:**
  * Deliberate Technology-Enhanced Pedagogical Thinking
  * Technology-Enhanced Pedagogies
* **Teacher-Candidates practice Technology-Enhanced Pedagogies:**
  * In the methods course
  * During Physics Methods courses
* **Teacher-Candidates reflect on Technology-Enhanced Pedagogies**

Research Study: 2013-2014

Timeline

Secondary Physics Methods Course **(Deliberate Technology-Enhanced Pedagogical Thinking)** (+ 2-week short practicum)

13 students and 13 weeks

Extended Practicum

10 weeks

Enhanced Practicum

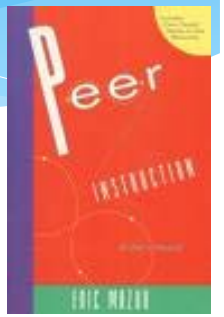
3 weeks

Pre-Practicum Interviews (8)

Post-Practicum Interviews (7)

Focus Group (1)

Four Examples of Deliberate Technology-Enhanced Pedagogical Thinking



1. Electronic Response Systems **(clickers)** and **PeerWise**

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

3. Computer Simulations **(PhET)**

4. GeoGebra

I. Peer Instruction and PeerWise:
Active Learning

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

Research-Informed Teacher Education

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

Teac
phy
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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

Peer Instruction

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.

A Key to Question-Driven Pedagogy

Effective use of Peer Instruction is based on using pedagogically effective questions… The technology (clickers) will evolve, yet the ability to come up with pedagogically sound questions will remain with teacher-candidates forever!

Example of a Conceptual Question

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) ?

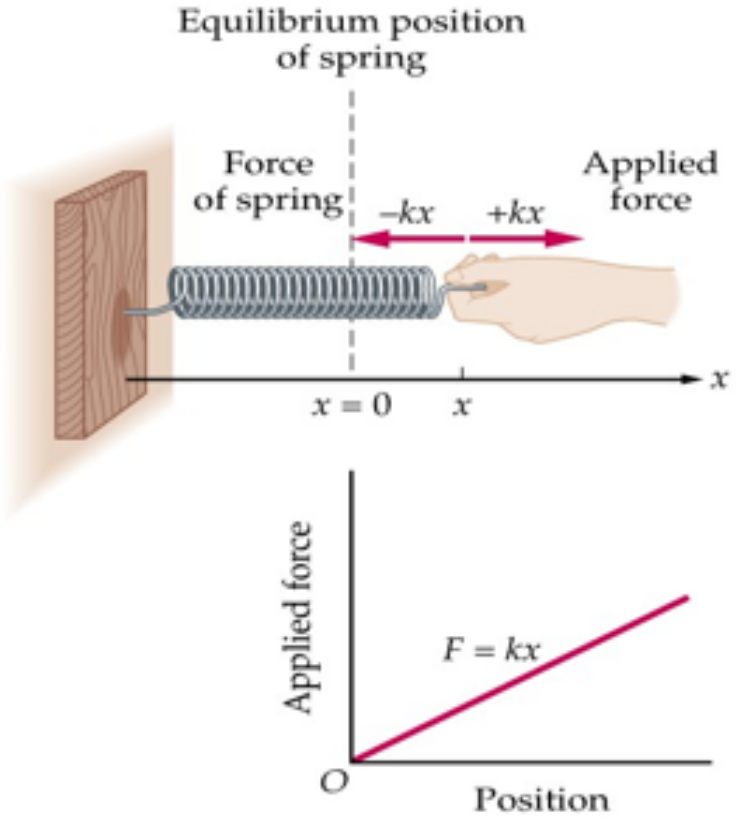
A. 5 J

B. 10 J

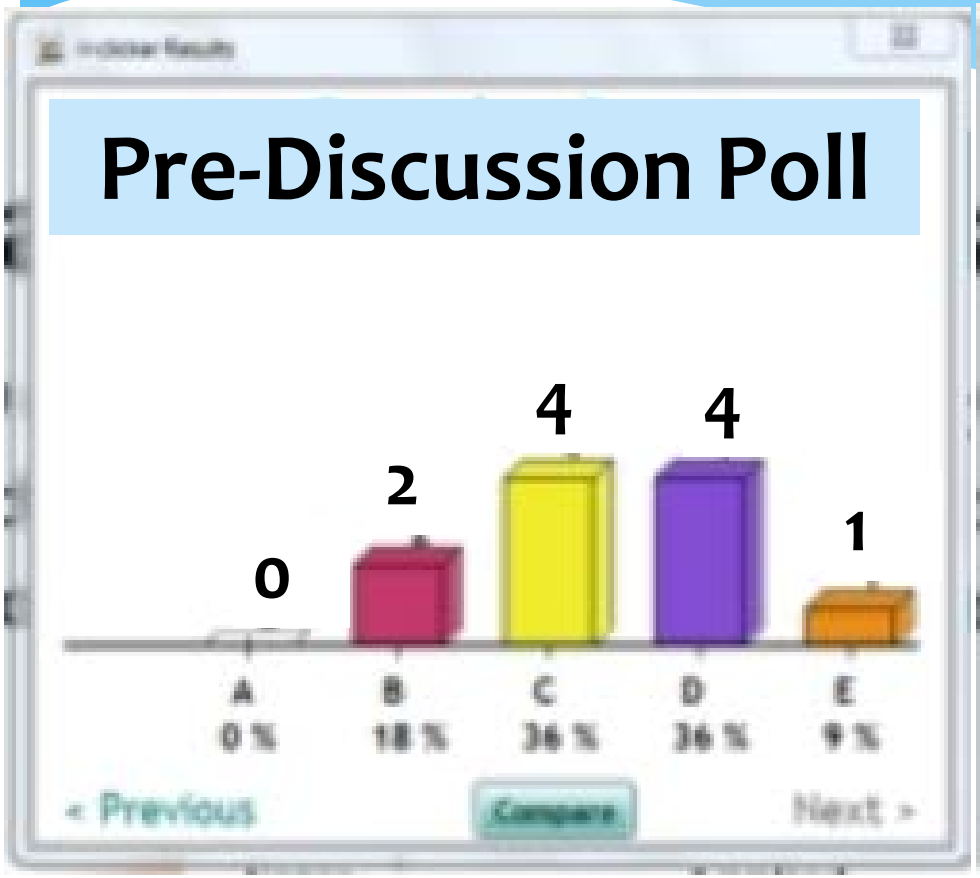
C. 20 J

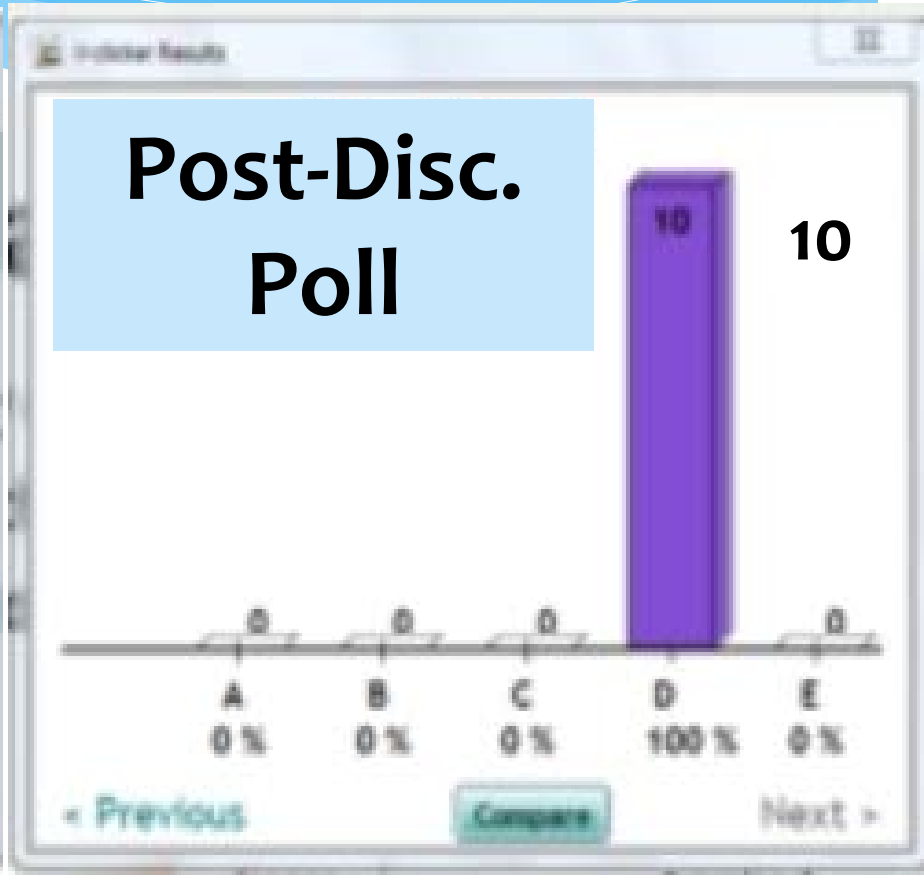
D. 30 J

E. 40 J



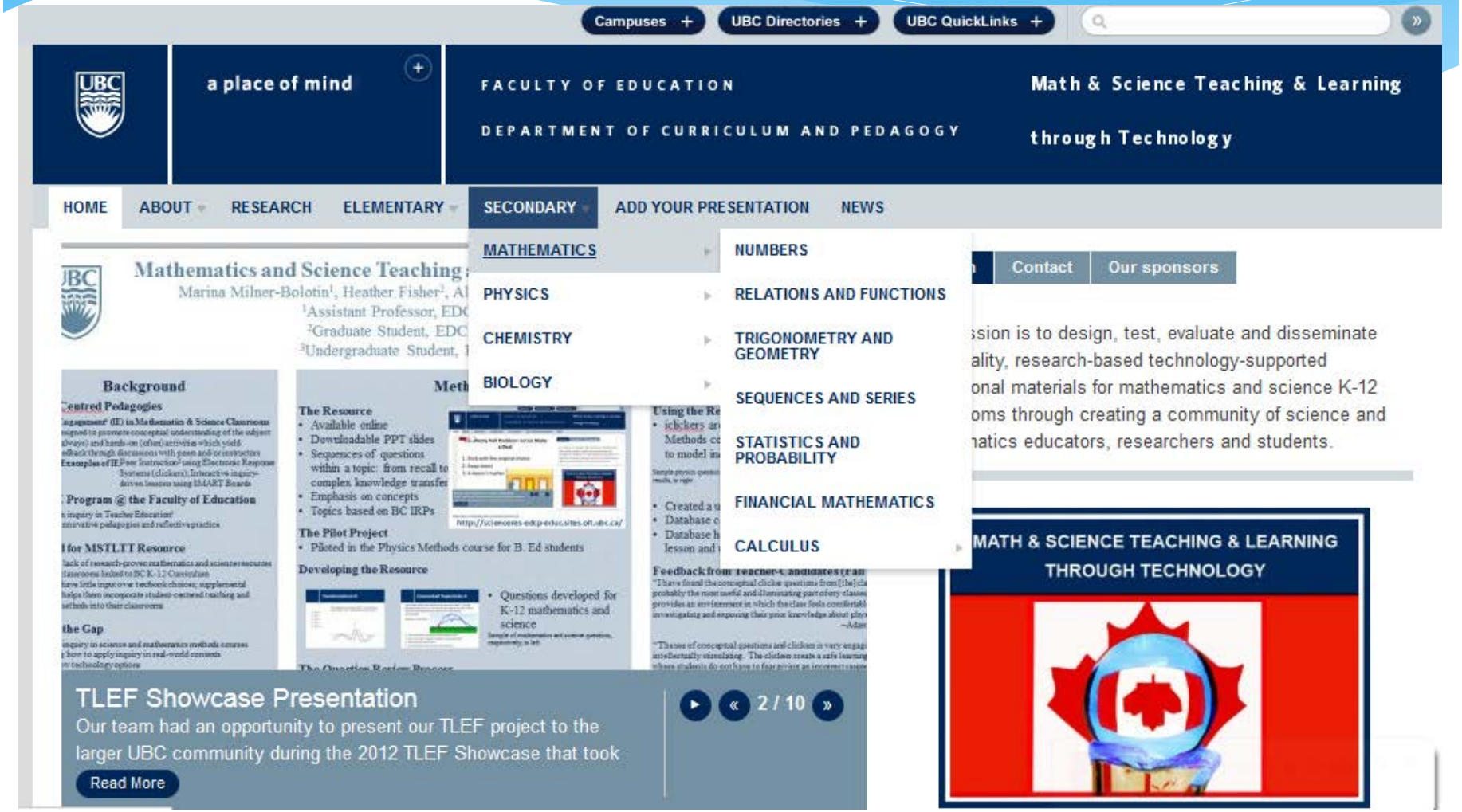
Example of a Conceptual Question





Respondents: Physics Teacher-Candidates

Math & Science Teaching and Learning through Technology



Feedback from UBC Teacher-Candidates

I have found the conceptual clicker questions from your classroom to be probably the most useful and illuminating part of my classes. This format provides an environment in which the class feels comfortable investigating and exposing their prior knowledge about physics. (Adam Quiring).

The use of conceptual questions and clickers is very engaging and intellectually stimulating. The clickers create a safe learning environment where students do not have to fear giving an incorrect response to the teacher. I look forward to using this in my future classroom (Clement Law).

PeerWise: Pedagogically Inspired Online Collaboration

Designing, Answering, Commenting, Reflecting & Improving

PeerWise

EDCP357_2014

You are logged in as marinamb. Logo

Home | Main menu > Unanswered questions > Rate question

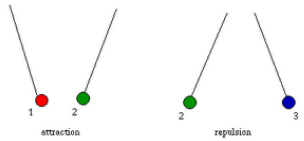
... × DO NOT AGREE WITH AUTHOR

... × Your answer does not agree with the answer suggested by the author, but more responses are needed -1

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 suggests E is the correct option

OPTION	ALTERNATIVE	FIRST ANSWERS	CONFIRMED ANSWERS
A	...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 TCs' Pedagogical 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

EDUCATION CORNER

SPACE ÉDUC

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[1], but are not yet as common in K-12 physics textbooks. For the past three years [illegible] has been working on designing [illegible]

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

In addition, PeerWise coll[illegible] reputation which [illegible] they [illegible]

II. 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

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

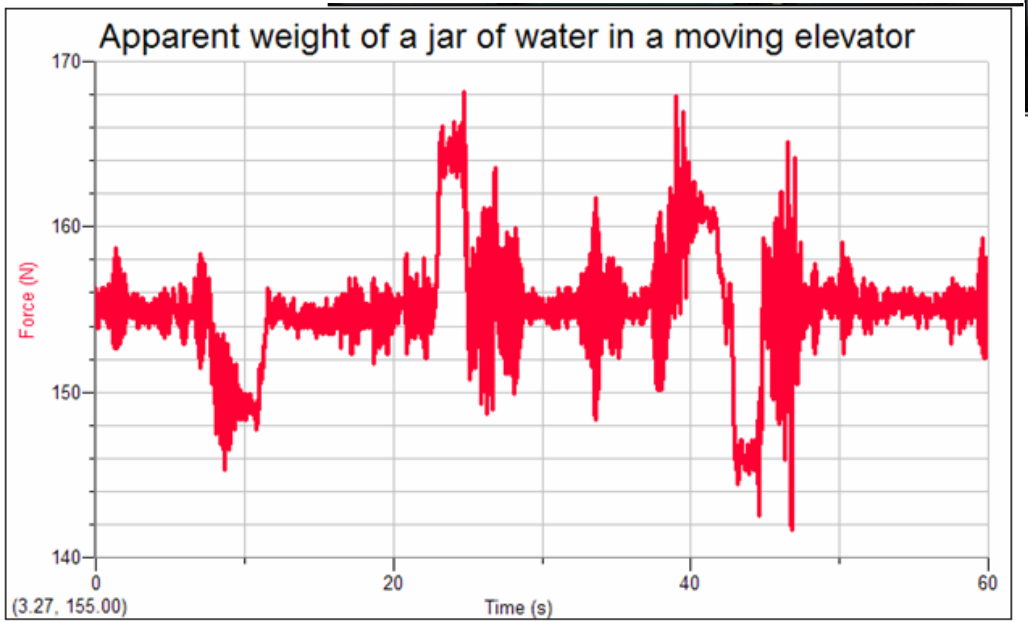
Physics Exam Problems Reconsidered: *Using Logger Pro to Evaluate Student Understanding of Physics*

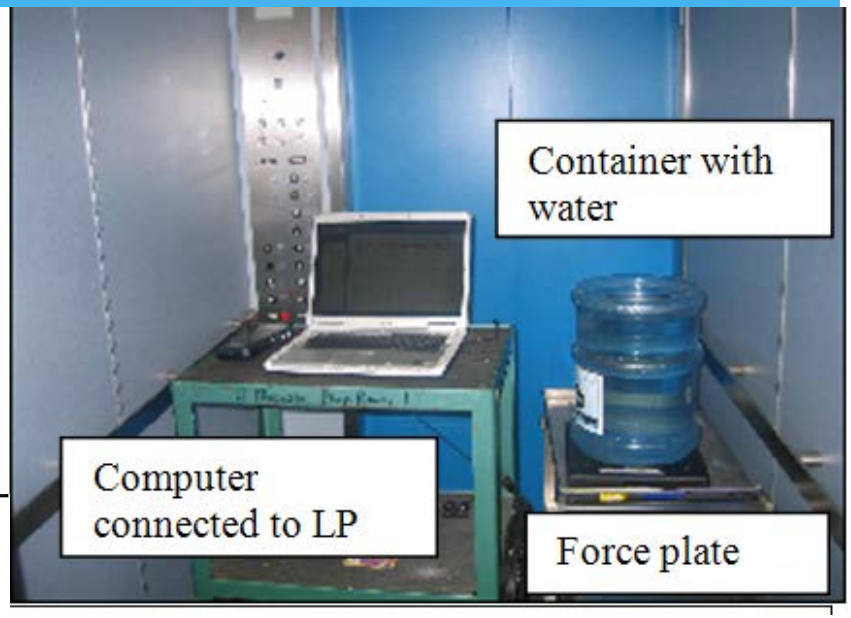
Marina Milner-Bolotin, Ryerson University, Toronto, ON

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

Developing Scientific Thinking

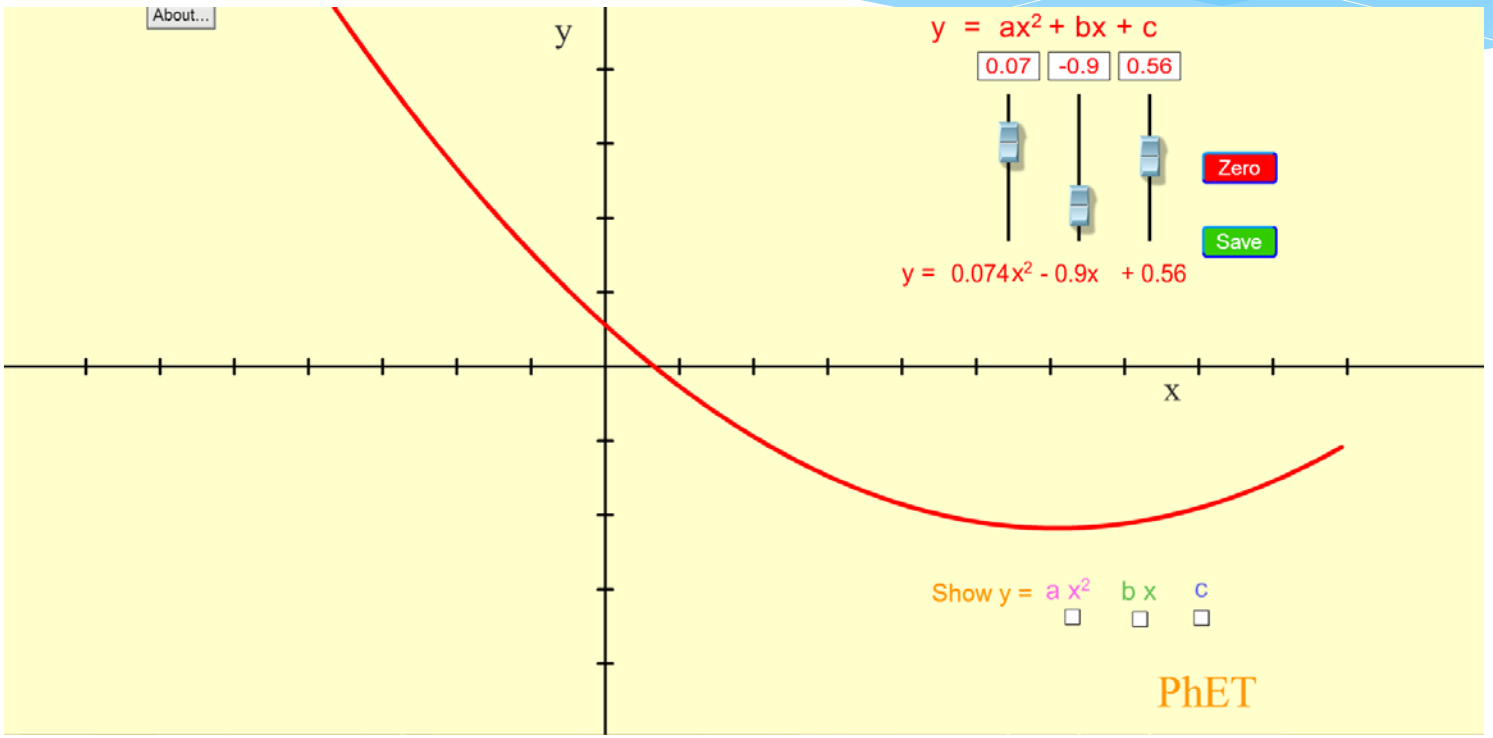
Thinking like a scientist means being able to analyze real life situations using real data.





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

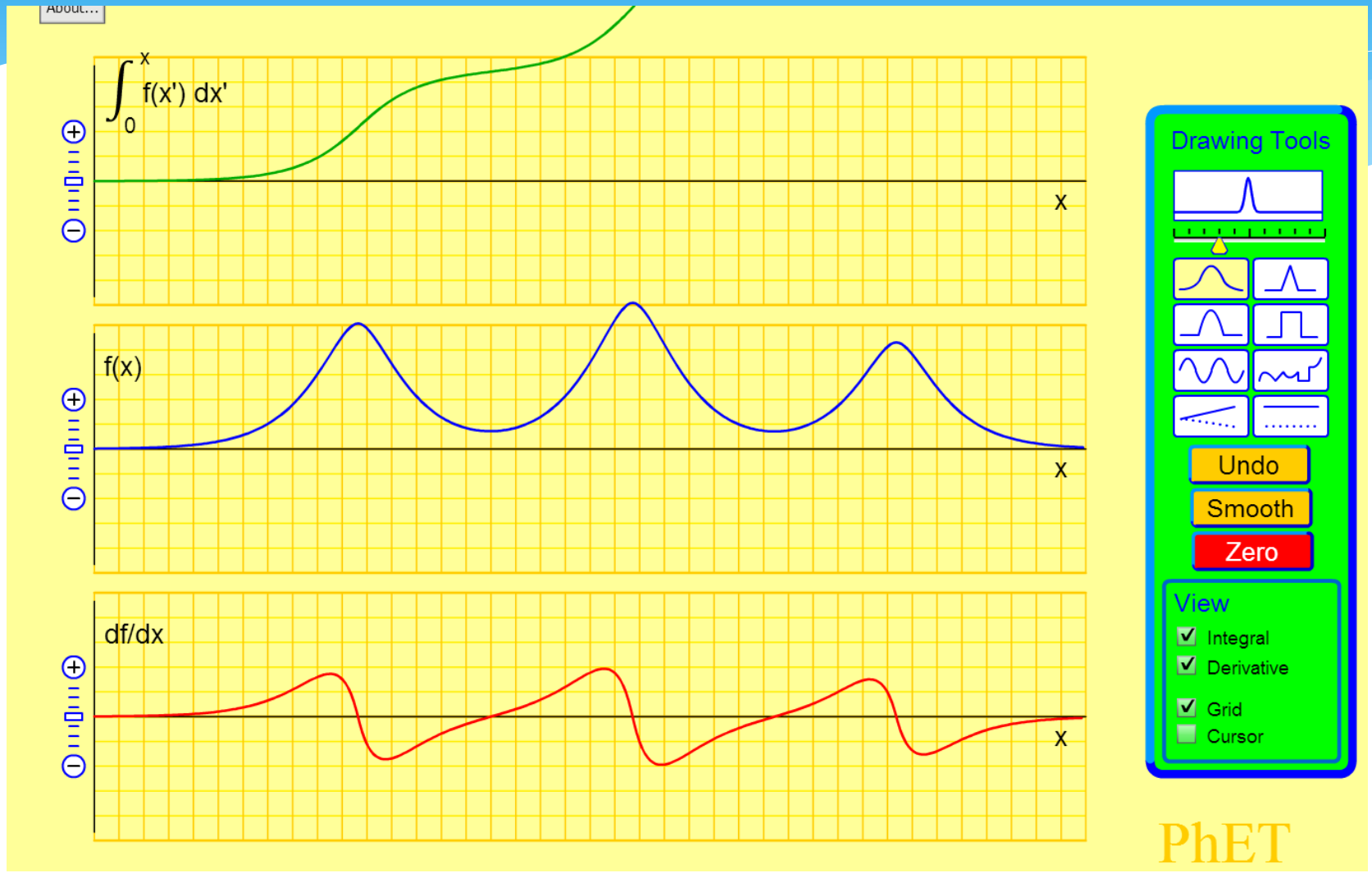
III. Using Computer Simulations



Developing Intuition & Visualization

- Experimentally testing different scenarios: WHAT IF…?
- Developing models of invisible phenomena
- Teachers must **be deliberate in creating meaningful assignments**.

PhET Calculus Grapher



Computer Sims and STEM Literacy

Protoplasma (2012) 249 (Suppl 1):S25–S30
DOI 10.1007/s00709-011-0346-6

REVIEW ARTICLE

The essence of student visual–spatial literacy and higher order thinking skills in undergraduate biology

Marina Milner-Bolotin · Samson Madera Nashon

Received: 11 June 2011 / Accepted: 17 October 2011 / Published online: 3 November 2011

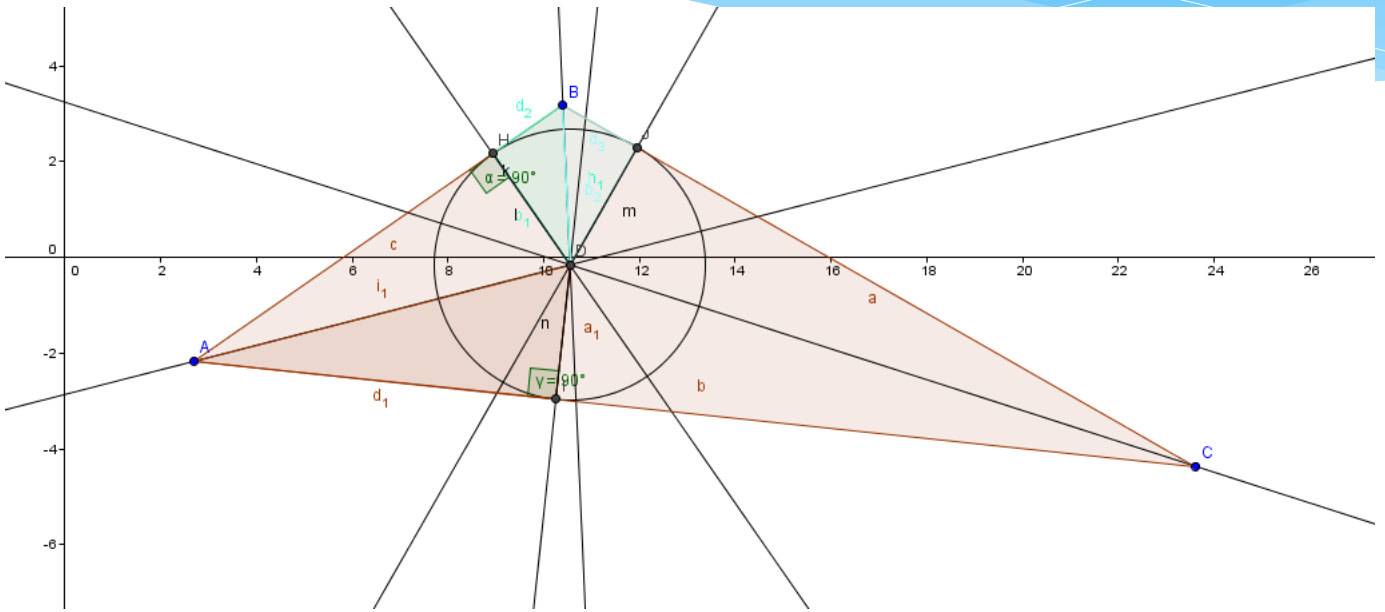
Abstract Science, engineering and mathematics-related disciplines have relied heavily on a researcher's ability to visualize phenomena under study and being able to link and superimpose various abstract and concrete representations including visual, spatial, and temporal. The spatial representations are especially important in all branches of biology (in developmental biology time becomes an important dimen

representations of scientific phenomena. This has been underscored by Richardson and Richardson (2002) who emphasize the increased importance of understanding 3D structure/function relationships to

molecular biolo

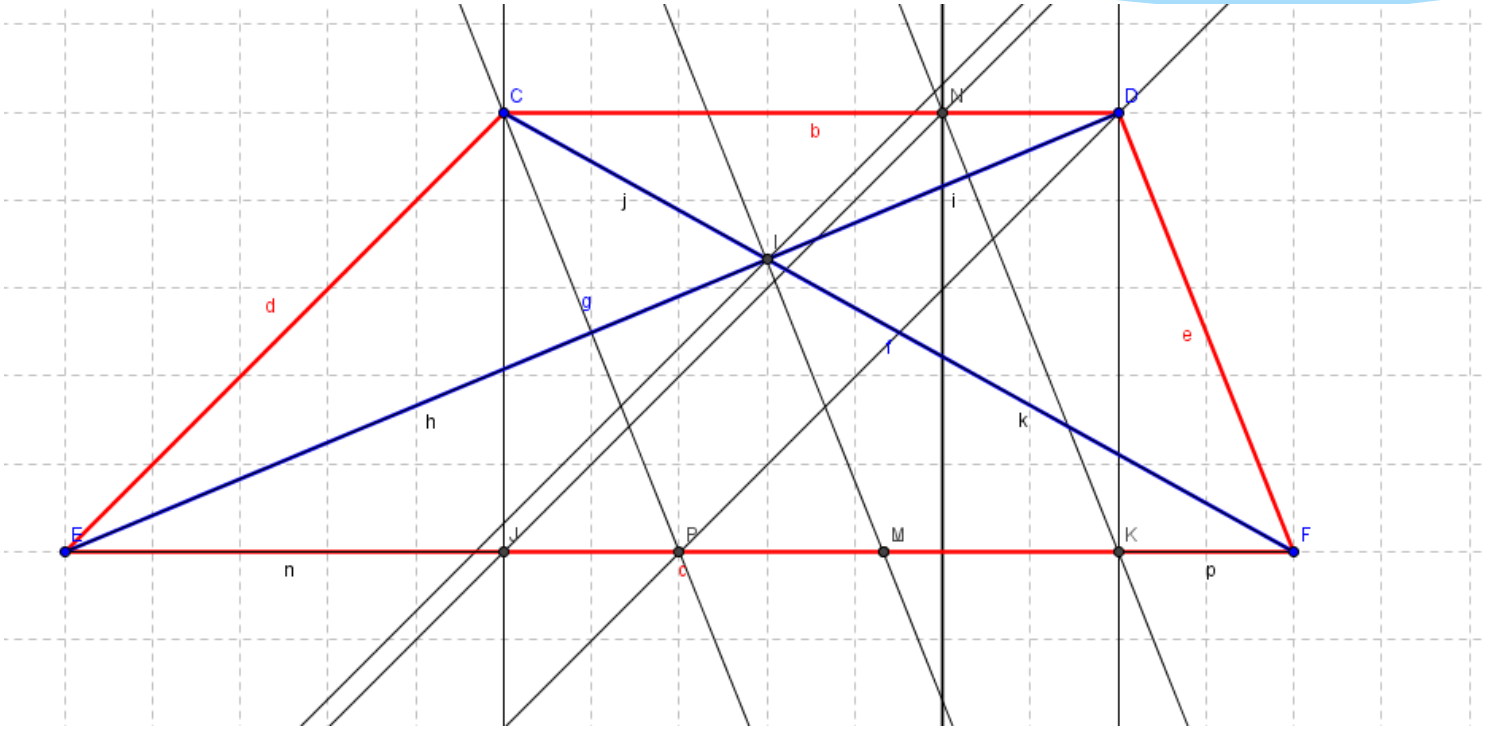
Richard

IV. Using GeoGebra



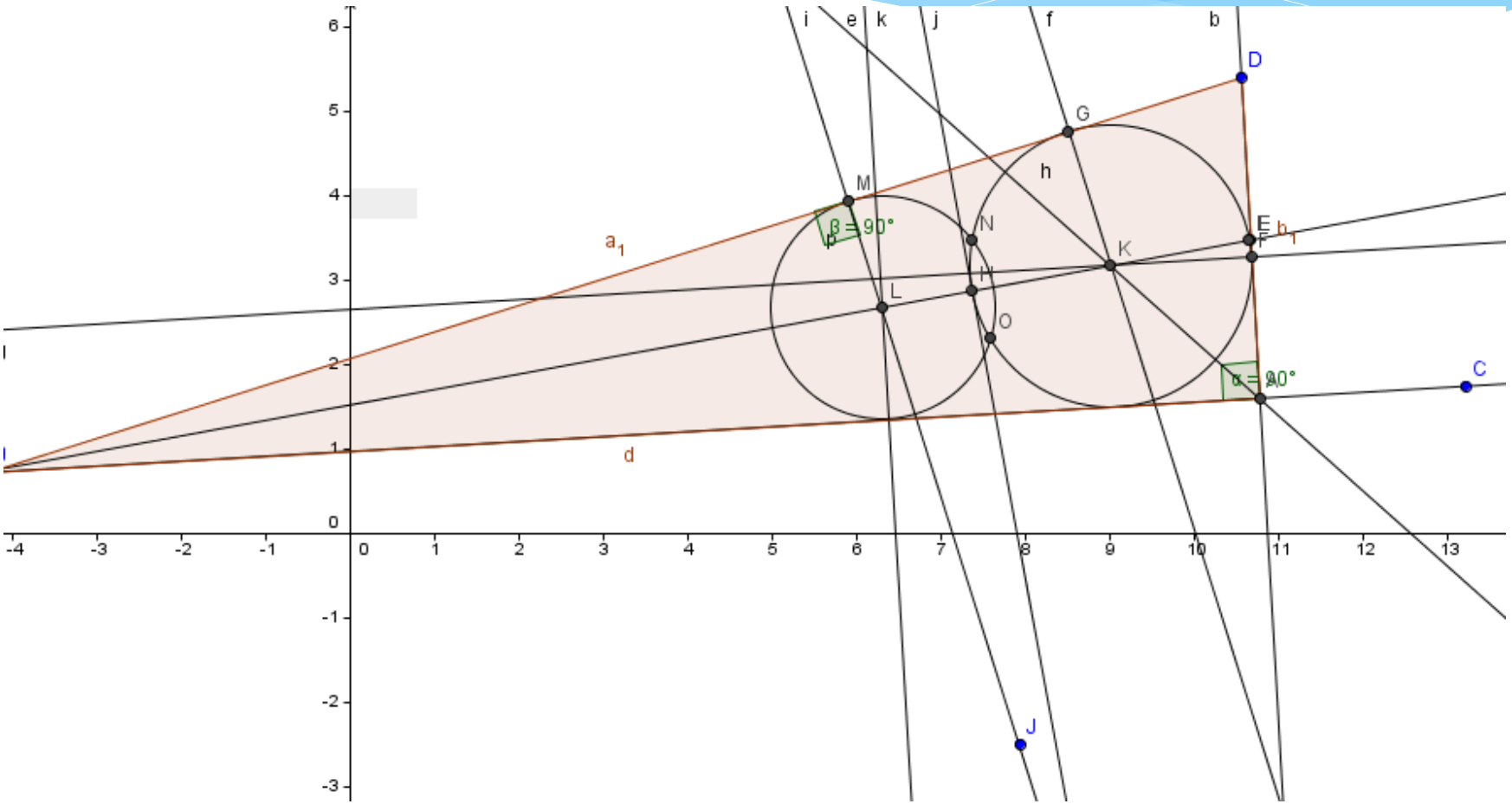
Questioning the obvious: using GeoGebra to stimulate Aha moments

Example of GeoGebra Exploration



An example of a problem in Geometry from the Kenyan math grade 10 final governmental exam.

GeoGebra as a Math Laboratory



Research Goals and Findings

(a) Pedagogical Content Knowledge

(b) Positive attitudes about technology in STEM

(c) Capacity for deliberate technology use.

Technology as a Vehicle to Promote Content Knowledge

VALUE OF CONCEPTUAL UNDERSTANDING

- Student understanding as beyond current classroom context
- Role of TCs previous conceptual understanding

"…physics is…not about applying formulas, and doing math. It is…about gaining an appreciation of the world around us. And, being able to use your understanding and extrapolate … explain what's happening around you. [It] has nothing to do with math formulas."

Post-interview 1

Technology as a Vehicle to Promote Scientific Thinking

VALUE OF CONCEPTUAL UNDERSTANDING

- Questioning what it means TO UNDERSTAND…
- Role of TCs previous conceptual understanding

"Coming into the program, we were all sort of thought that we were expected to be masters, and if the instructor puts up a clicker question, you think 'Jeez, I don't actually know the answer' – immediately you think well, we're all supposed to be masters, I'm probably the only one who doesn't know. But uh when the responses come in, you see other people think like you, it's definitely reassuring."

Pre-Interview 2

Technology as a Vehicle to Promote Pedagogical Thinking

VALUE OF PEDAGOGICAL UNDERSTANDING

- Questioning what it means TO UNDERSTAND in order TO EXPLAIN…
- Focusing on the process of UNDERSTANDING

"It (clickers) really opens the door for … discussions between people … regarding a) … what is the right answer, and b) how would you explain that to … either teacher-candidates or to your potential students."

Pre-Interview 2

Technology as a Vehicle for promoting Student Engagement

"So, if you set it up in a dynamic where… different types of people have [different needs], so if you need to talk to someone, you still get that, if you need silence, you get to think on it on your own, and then people aren't so stressed… And they actually get to argue and talk back and forth and they'll remember it more. So for them, I think they'll master it more."

Post-Interview 2, Participant 20

Technology as a Vehicle for promoting Student Engagement

ROLE OF STUDENT ENGAGEMENT

- Necessary for conceptual understanding
- Classroom realities are single most limiting factor in application of this value

"… some of the physics 11s who are just doing it to do a science, and are just, 'Alright, Physics, I'll try it out.' Some of them were not as en-engaged, and I think doing the… voting-style questions helped get them more into it and more involved. So I'd say… it's helpful to get those students who hide at the back in these 30 person classes."

Post-interview 3

Promoting Deliberate Pedagogical Thinking with Technology

Technology as a Vehicle for Deliberate Pedagogical Thinking

TECHNOLOGY AS A Vehicle not a Goal

- Technology requires a pedagogical purpose
- Conceptual understanding as an important outcome
- Alternative mechanisms can achieve similar outcomes

"It wasn't just the clickers alone. It was also in…. the presentation of the question. It wasn't a simple plug in the answer-type question. It had to be conceptual, in which you could… , the Bloom's taxonomy, the higher learning of students. So, in itself, clickers… is only a tool. But it needs to be complemented with good conceptual questions in order to make it work."

Pre-Interview 5

Technology as a Vehicle for Deliberate Pedagogical Thinking

TC as TEACHERS AND LEARNERS

- Capacity and willingness to explore novel technological applications
- Capacity for Deliberate Pedagogical Thinking

"I'm there as a teacher, (pause) but I'm also there as a student. Conversely, they're there as a student, but they're also there as a teacher. That doesn't mean they're teaching necessarily, teaching me. They're teaching each other... You're always a student-teacher, regardless of whether or not, what your position says. The-the moment you step out, and you meet someone, you now are both a teacher and a learner."

Post-Interview 1

To Be Continued…

To be Continued: Big questions

1. HOW DO **WE LEARN** WITH TECHNOLOGY?
2. HOW DO WE **EMPOWER TEACHERS TO LEARN** WITH TECHNOLOGY?
3. HOW DO WE **UNCOVER OPPORTUNITIES** WITH TECHNOLOGIES INSTEAD OF DOING THE SAME OLD THING WITH NEW TOOLS?

Selected Resources

* Beatty, I., Gerace, W., Leonard, W., & Defresne, R. (2006). Designing Effective Questions for Classroom Response System Teaching. *American Journal of Physics*, *74*(1), 31–39.

* CWSEI Clicker Resource Guide: An Instructors Guide to the Effective Use of Personal Response Systems (Clickers) in Teaching. (2009, June 1).

* M. Milner-Bolotin, H. Fisher, and 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**, 525-544 (2013).

* Milner-Bolotin, Marina. (2004). Tips for Using a Peer Response System in the Large Introductory Physics Classroom. *The Physics Teacher, 42*(8), 47-48.

* Mishra, P., & Koehler, M. J. (2007). Technological pedagogical content knowledge (TPCK): Confronting the wicked problems of teaching with technology. In *Society for Information Technology & Teacher Education International Conference* (Vol. 2007, pp. 2214–2226). Retrieved from http://www.editlib.org/p/24919/