

UBC Helping Physics Teacher-Candidates Develop Questioning Skills Through Innovative Technology Use Marina Milner-Bolotin¹, Heather Fisher² & Alexandra MacDonald² ¹Assistant Professor, ²Graduate Student, University of British Columbia, Department of Curriculum and Pedagogy

Background

Pedagogical Content Knowledge (PCK)

• A theoretical framework^{1,2} for investigating teaching that emphasizes the interplay between different types of knowledge:

- **1.** Content Knowledge (CK): Traditional knowledge of the subject matter, such as *physics*
- 2. Pedagogical Knowledge (PK): The knowledge of students' difficulties, of various approaches to teaching specific content, and how this knowledge fits within the larger student learning experiences
- 3. Pedagogical Content Knowledge (PCK): The knowledge of traditional subject matter in the context of teaching it: includes ways of helping students construct a deep meaningful understanding, being aware of what makes subject matter easier/more difficult, and how student conceptual difficulties impact their learning

Technology-Enhanced Pedagogies in Teacher Education³

- An extension of the PCK framework includes how technological knowledge interacts with Pedagogical and Content Knowledge²
- **Problem:** Few teacher-candidates have experienced student-centered technology-enhanced science
- or mathematics pedagogies as students during their K-12 or post-secondary education • Solution: Modeling technology-enhanced pedagogies in physics methods courses serves multiple purposes. It helps teacher-candidates to:

- Experience these pedagogies in two capacities – as students and as future teachers; - Identify gaps in their conceptual understanding of physics while offering pedagogical approaches to address these gaps

- Build skills and confidence in using technology to promote active engagement in physics

PeerWise Online Collaborative Tool⁴

- Developed at the University of Auckland, New Zealand • Online tool that enables students to create multiple choice questions
- with an answer explanation
- All questions are shared in a course pool
- Authors can submit questions, add justifications, comment, tag content themes, and augment questions/justifications
- Peers can answer, comment, and rate questions, and make suggestions for augmented questions and solutions

Course Context

- Ten (10) teacher-candidates at a large research-based university in Canada
- Secondary Physics Methods course in a Teacher **Education Program**
- As a component of the course requirements, each week students:
- a. Submitted five (5) questions (original or modified from
 - other source)
- b. Included an answer justification for each question
- c. Answered ten (10) questions
- d. Commented on peers questions as appropriate

Sample Questions

From here we can see that if $v_i = 10$ m/s then $v_f = 14$ m/s and C is the right answ

• Question, answer justification, comments, and ratings included

• Indicative of quality from beginning, middle, and end of term

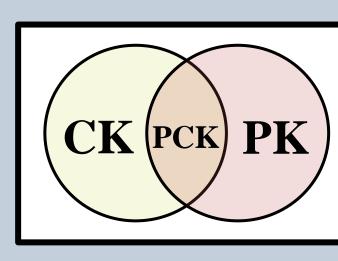
Week 1

Field Value ID 692642 Created 2013-09 16:43:13 Created 9:41 pm, 02 Dec 2013	h of the following diagrams could accurately represent this system?		
Created 2013-09-09 16:43:13	h of the following diagrams could accurately represent this system?		
Created 2013-09-09 16:43:13	h of the following diagrams could accurately represent this system?		
	h of the following diagrams could accurately represent this system?		
Question Bill Nye weighs 720N on Earth. Given that the acceleration due to gravity on Earth is 9.8m/s ² and that the acceleration due to gravity on Mars is 3.7m/s ² , how many Newtons does Bill Nye weigh on Mars? Answer to the nearest Newton.	n of the following diagrams could accurately represent this system:		
A 74N			
B 162N			
C 272N vacuum	vacuum		
D 720N medium A			
An object's weight in Newton's is obtained by multiplying mass (in kg) by the appropriate acceleration due to gravity, F=mg. First find Bill's mass in kg by dividing 720/9.8=73.5. So Bill's mass, which is independent of gravitational field, is 73.5kg. To find his weight on Mars, multiply 73.5*3.7=272. Therefore Bill Nye weighs 272N on Mars.			
Tags Gravity, Forces			
Author Question Vacuum			
Avg Rating 3.0000			
Avg Difficulty 0.0000 medium B			
Total ratings 1			
Comment 1 (alexmot) - t through the calculations to get to 162 N? Can you explain to me how a student would have arrived at this answer? (by: alexmacd	vacuum		
Week 6	medium C		
Field Value A, B, and C.			
ID 767518 B A and B.			
Created 8:01pm, 27 Oct 2013			
Question An object with mass "m" is moving at a velocity of 10 m/s. In order to double this object's kinetic energy, what must its final velocity be? A and C.			
A 7 m/s D A only.			
B 10 m/s E None of the diagrams accurately represent the system.			
C 14 m/s The refractive index of a vacuum is 1. Every other medium that exists has a la			
D 16 m/s line. Medium A passes this test, medium B does not and medium C causes th	more optically dense. When light travels from one medium to a medium that has a larger index of refraction, the light ray bends toward the norma line. Medium A passes this test, medium B does not and medium C causes the light to travel straight through with no "bending". Because mediu		
E 20 m/s C does not cause the light to bend, we must know that medium C is a vacuum. This would mean that the light ray travels <i>faster</i> than the speed of light while it			
In order to double the object's kinetic energy we must have:			
$2 \cdot E_{ki} = E_{kf}$ Tags Optics			
Explanation $\frac{2 \cdot 1}{2} \cdot mv_i^2 = \frac{1}{2} \cdot mv_f^2$ $\frac{4 \text{uthor}}{4 \text{vg Rating}} = \frac{1}{0.0000}$ $\frac{4 \text{uthor}}{4 \text{vg Rating}} = \frac{1}{0.0000}$			
Explanation 2 x ² x ² Avg Rating 0.0000			
$\frac{2 \cdot v_i^- = v_f}{v_i \cdot \sqrt{2} = v_f} \qquad \qquad$			

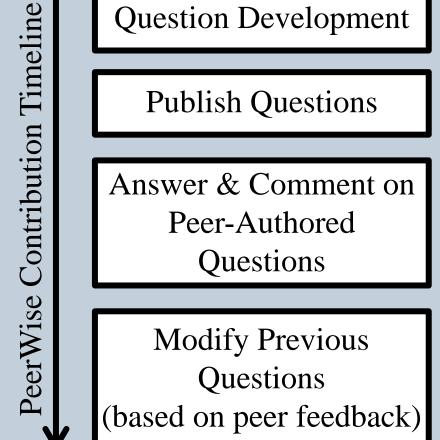
Total 0



a place of mind









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Objectives

Course Goals

Implement the PeerWise system into a secondary physics methods course in a teacher education program

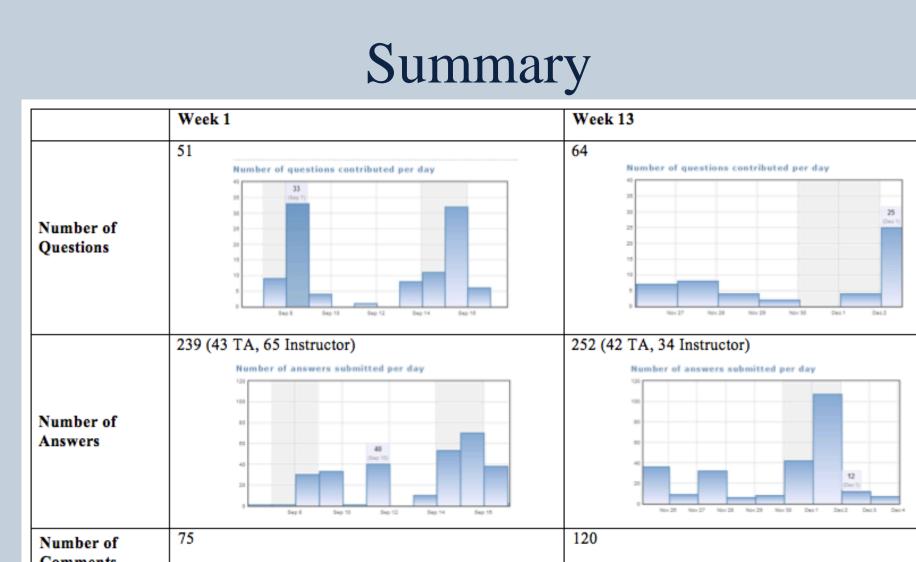
Research Goals

Compare the traditional benefits of the PeerWise system with the impacts in a small teacher education course

Investigate the effect of an online collaborative tool on teacher-candidates questioning and commenting skills

Explore teacher-candidates' expressions of PCK:

a) How do these expressions change over the course of a teacher education methods course? b) How do teacher-candidates' conceptions of the different areas of knowledge interact?



Scales		W1	W13
	Bloom's Taxonomy Level	2.3824	2.9219
Questions	Distractor Quality	4.0588	4.2031
	Answer Justification	3.333	3.5859
Comments	PK	3.10448	2.9
	CK	2.9403	2.9167
	РСК	2.41791	2.2417
	Overall Quality	2.94030	2.8083

						Results	
		Sun	nmary				
Number of Questions	of 28	ther of questions contributed per day	64 Number of questi 569 10 Nov 27 N	ons contributed per day	•	 Total number of questions, answers, and comments increased Students met course requirements in W1 and exceeded course requirements in W13 for: a. Number of questions submitted 	 D d C R
Number of Answers	of	a, 65 Instructor) mber of answers submitted per day 40 569 1 569 10 569 12 569 14	540 10 Nov 27	uctor) ers submitted per day		 b. Number of answers submitted (allowing instructors to decrease number of answers) Questions 	be re • N
• Free	quency	Results or questions and	comments		•	Utilized previous tool to assess students' development and demonstration of questions with higher cognitive skill	st
	Scales Questions	W1 Bloom's 2.38 Taxonomy Level Distractor 4.05 Quality Answer 3.33 kestification	88 4.2031		•	Ran ANOVAs to measure significant difference between W1 and W13 on all scales	• C ta
•	Comments	Justification PK 3.10 CK 2.94 PCK 2.41 Overall Quality 2.94 cies of ratings on	03 2.9167 791 2.2417	nent scales	•	 Bloom's Taxonomy Level Statistically significant difference between W1 and W13; F(1, 118) = 24.204, p < .01 	
1 W1 11 W13 13	PK 2 3 4 9 18 34	CK 5 1 2 3	PCK 4 5 1 2 3 23 7 18 20 25	Overall Quity 4 1 2 3 4 12 7 17 29 18 16 4 47 44 18	5 4 7	 Distractor Quality No significant difference between W1 and W13 	
W1 20 W13 6	Bloom's Taxon 1 2 3 30 45 18 84	omy Level 4 5 1 7 0 6 20 0 0	Distractor Quality 4 5 2 3 4 5 4 18 24 50 8 7 26 29 66 6		5 3 6	 Answer Justification No significant difference between W1 and W13 	
			Futu	ro Diro	otio	nc	

FUTURE DIRECTIONS

1. Course Goals

- a. Revise course requirements and instructions in order to integrate PeerWise efficiently and effectively into the physics methods course, with the goal of developing students Pedagogical Content Knowledge b. Develop a process for participating in PeerWise that students will "buy in" to, allowing instructors and students to take
- advantage of the benefits of PeerWise in an authentic and meaningful way c. Develop students skills commenting online in a constructive and thoughtful manner
- 2. Research Goals
- a. Repeat study in a second cohort, altering course requirements and research questions to reflect our first year experience b. Explore the long-term effects of the role of questioning on teacher-candidates practice and PCK 1. Follow up during long-practicum experience and at the end of the Teacher Education Program through interviews
- and focus groups

Integrate the PeerWise system with other technology-enhanced pedagogies, such as Peer Response Systems and simulations

Questions Ratings

• Course Instructor and Masters Teaching Assistant rated all submitted questions on three scales for Bloom's Taxonomy level⁵, distractor quality, and answer justification

AREA OF	Evaluates questions in the context	Evaluates the quality of distractors	Evaluates the quality of the answ
RESEARCH	of Bloom's Taxonomy, providing	and the degree to which they	justification in addressing
INTEREST	insight into question complexity	address student difficulties	conceptual knowledge and stud
			difficulties
SUMMARY OF	1 – 5	1 – 5	1 – 5
RATING	(1 – Knowledge;	(All irrelevant distractors – all	(No answer justification –
SCHEME	2 – Comprehension; 3 –	distractors are meaningful)	complete and accurate justificat
	Application; 4 – Analysis;		of both correct and incorrect
	5 – Synthesis/Evaluation)		answers)

Comment Ratings

overall quality

SCALES	Pedagogical	Content Knowledge	Pedagogical Content	Overall Quality
	Knowledge		Knowledge	
AREA OF	Evaluates the quality of	students' thinking	Evaluates the quality of	Provides a secondary
RESEARCH	during commenting in t	erms of PK and CK,	students' integrated PCK	measure indicating overall
INTEREST	respectively		during commenting	value of students' comments
SUMMARY OF	1 - 5	1 - 5	1 - 4	1 – 5
RATING	(No demonstration –	(No demonstration –	(No PCK overlap – strong	(No P/CK or PCK value in
SCHEME	strong demonstration	strong demonstration	PCK overlap)	comment - strong P/CK or
	of PK + addresses	of CK + addresses		PCK value in comment
	student difficulties	student content		including direct suggestions
	pedagogically)	difficulties)		for improvement)

¹Shulman, L. S. (1986). Those Who Understand: Knowledge Growth in Teaching. *Educational Researcher*, 15(2), 4-14. ²Koehler, Mathew J., & Mishra, Punya. (2009). What is technological pedagogical content knowledge? Contemporary Issues in Technology and Teacher Education, 9(1), 60-70. ³Denny, P., Luxton-Reilly, A., & Simon, B. (2009). Quality of student contributed questions using PeerWise. In *Proceedings of the Eleventh Australasian Conference on Computing Education-Volume* 95 (pp. 55–63). Retrieved from http://dl.acm.org/citation.cfm?id=1862724 ⁴Morrison, S., & Walsh Free, K. (2001). Writing Multiple Choice Test Items to Promote and Measure Critical Thinking. Journal of Nursing Education, 40(1), 17–24. ⁵Milner-Bolotin, Marina, Fisher, Heather, & MacDonald, Alexandra. (2014). Modeling active engagement pedagogy through Classroom Response Systems in a Physics Teacher Education course. LUMAT: Research and Practice in Math, Science and Technology Education, In press.

Methods

• Course Instructor and two Research Assistants rated all submitted comments on four scales for PK, CK, PCK, and

Comments

- Developed new tool to assess students' development and demonstration of Pedagogical
- Content Knowledge
- Ran ANOVAs to measure significant difference between W1 and W13 on all scales, after
- removing instructor comments
- No differences between W1 and W13 were statistically significant

Impact

Considering question and comments results in tandem:

- Increase in Bloom's Taxonomy level, demonstrating increased cognitive level of students' questions, with a resulting maintenance of quality of distractors and answer justifications demonstrates an overall shift in students' capacity to question effectively
- Maintenance of Pedagogical Content Knowledge levels in comments with increasing frequency of comments shows promising results for students' increased capacity to critically evaluate questions
- Increased number of questions contributed during a one-week period with maintained distractor quality and answer justifications indicates students' ability to efficiently select, critique, and write questions is increased

References

