Promoting Conceptual Change Through Course Design: Supporting the Physics CK and PCK Development of Pre-Service Teachers

Will Stoll, Kadir Demir, Brett Criswell

Department of Middle-Secondary Education and Instructional Technology
Georgia State University

Physics Principles & Teaching Problems Course

Goal – produce science teachers who have the capability of facilitating deep conceptual understanding in high-school physics students

Collaboration –

- Physics Faculty from the College of Arts and Sciences
- Science Education Faculty from the College of Education

Physics Principles & Teaching Problems Course

Specific Objectives

- Strengthening and developing conceptual understanding of future physics teachers
- Focus on awareness and basis of physics misconceptions
- PCK for bridging the gap between students' everyday view and scientifically-accepted views
- Collaboration between faculty from two colleges strengthen the knowledge base of each faculty

Context- MAT Program

Master's of Arts in Teaching (MAT) secondary science

- Broadfield science certification –
  - Requires 15 credit hours in physics
- Options
  - No prior college-level physics
    - Take 8 credit hours in a graduate section of undergraduate physics
      - Additionally tutor and teach mini-lessons in undergraduate course

Context- MAT Program

Broadfield Certification Options (physics background)

- *Physics for Secondary School Teachers*
- *Directed Study in Physics*
  - Participate in physic education research projects
  - Function as teacher assistants (TAs) in PHYS 7111/7112
  - Research physics pedagogy (e.g. Mazur's (1996) *Peer Instruction*)
- Challenges
  - Tailored for individual
  - Untenable for large classes

Course Development Background

Pilot Course – Summer 2010 (n=9)

- Participated in ‘Studio’ Physics – PHYS 1111
  - Based on Beichner et. al. (2007) Student-Centered Active Learning Environment for Undergraduate Programs (SCALE-UP) model
  - Initial observations followed by interaction with the undergraduate students.
  - End of semester designed an activity and delivered a mini-lecture.
- Studied physics teaching pedagogy
  - Read Physics Education Research (PER) literature on inquiry-based and interactive teaching methods.
  - Discussion with instructor following PHYS 1111 classes on students’ experiences and insights gained in developing conceptual understanding in introductory physics students

Course Development Background

Redesigned Course – Summer 2011

- Invited Science Education Faculty to present guest lectures on teaching for conceptual change
  - Misconceptions associated with physics topics
  - Study of literature on conceptual change

    (Clement (1993) – bridging analogies, diSessa's (1993) – p-prims model, Slotta's and Chi's (2006) – ontological misclassification framework)

Physics Principles & Teaching Problems
(PHYS 7210/7220)

Formalized Course – Summer 2012

"The separation of instruction in science (which takes place in science courses) from instruction in methodology (which takes place in education courses) decreases the value of both for teachers" (McDermott, Heron, & Shaffer, 2005, p. 22).

Collaboration

- Weave together the physics content with the discussion of models of teaching for conceptual change
- Resulted in a joint STEM Proposal for the formalized course PHYS 7210

Physics Principles & Teaching Problems
(PHYS 7210/7220)

- Aims
  - Learn content (acquisition)
  - Talk about teaching of the content (discussion)
  - Practice teaching of the content (modeling)

"There is a need for special physics courses for teachers from the elementary through high school grades. These courses should be laboratory based and have intellectual objectives and an instructional approach that are mutually reinforcing. The topics should be relevant to the K-12 curriculum and taught in a manner that is consistent with how teachers are expected to teach" (McDermott, Heron, & Shaffer, 2005, p. 20).

Physics Principles & Teaching Problems
(PHYS 7210/7220)

Acquisition & Discussion

Physics Faculty-Physics Content Knowledge (CK)

- "Five Easy Lessons – Strategies for Successful Physics Teaching" by Knight (2004)
- Target concepts in high school physics curriculum
- Address commonly identified misconceptions of these concepts by Physics Education Research community

- Science Education Faculty-Physics Pedagogical Content Knowledge (PCK)
  - Various models of teaching for conceptual change
  - Application of these models to addressing specific misconceptions in physics

Physics Principles & Teaching Problems
(PHYS 7210/7220)

Modeling

- In-class Teaching Experience - Studio Physics
  - Develop interactive teaching skills by observing, interacting, and leading activities
  - Journal on their experience
  - Lead a white board activity – a ‘ponderable’ in the SCALE-UP model – in the middle of the semester
  - Develop and lead a class activity near the end of the class

Proposed Research Study

Purpose:
The goal of this project is to study the initial implementation of a unique physics course designed for teacher candidates in the MAT secondary science program and to support the further development of the course.

Proposed Research Study

Research Questions:

1. What are the differences between pre-service teachers' views of teaching for conceptual change before and after taking the course?

2. How do the interactions between physics and science education faculty contribute to the physicist's understanding of students' misconceptions?

3. Can the newly designed course activities enhance the development of the pre-service teachers' self-reflections and metacognitions of teaching and learning? If so, in what ways?

4. To what extent does the course structure and implementation support gains in pre-service teachers' physics knowledge? What are the features of the course structure and implementation that most significantly contribute to any such gains?

Future Research Study – Data Collection

- Quantitative
  - Concept Inventory Tests – Pre/Post Scores
- Qualitative
  - Survey Instrument
  - Semi-structured interviews
    - Students
    - Faculty
  - Class observations
    - Audio-recorded class discussions
    - Video-recorded faculty instruction
  - Class artifacts
    - Journals and class assignments

Preliminary Findings and Discussion

Collaboration – **Strengths**

- Unity in commitment to education reform.
- Expertise are complementary
  - Science education faculty provide expertise in pedagogical approaches to addressing physics misconceptions.
  - Physics faculty provided specific examples for discussions on conceptual change models.
- Students benefit from simultaneous exposure to both experts in content and pedagogy

Preliminary Findings and Discussion

Collaboration – **Growth**

- Physics Faculty –"When I was listening to you, I realized how obvious those things were, but I still hadn't thought about them."
  - Miscommunicating – language issues
  - See electricity as a thing not as a process
- Science Education Faculty – "I want to learn the physics."
  - Oversees broad field certification students – needs to know enough physics to be able to evaluate the lessons of students

Preliminary Findings and Discussion

Collaboration – **Tensions**

- Negotiating what happens during class
  - Constraints of time
    - Concern of other faculty taking away time from teaching content.
    - Reduced time for pedagogy instruction
- Status issues – Science education faculty expert in pedagogy, physics faculty expert in content
  - Discussing teaching content - vectors
    - Science Education faculty asked leading questions, but not confident enough in the content to make specific recommendations

References

- Beichner, R. J., Saul, J. M., Abbott, D. S., Morse, J. J., Deardorff, D. L., Allain, R. J., . . . Risley, J. S. (Eds.). (2007). The Student-centered activities for large enrollment undergraduate programs (SCALE-UP) project. College Park, MD: American Association of Physics Teachers.
- Clement, J. (1993). Using bridging analogies and anchoring intuitions to deal with students' preconceptions in physics. Journal of Research in Science Teaching, 30 (10), 1241 – 1257.
- diSessa, A.A. (1993). Toward an epistemology of physics. Cognition and Instruction, 10 (2/3),105 – 125.
- Knight, R. D. (2004). *Five easy lessons: Strategies for successful physics teaching*. San Francisco, CA: Addison Wesley.
- McDermott, L. C., Heron, P. R. L., & Shaffer, P. S. (2005). Preparing K-12 teachers to teach physics and physical science. *APS Forum on Education Newsletter*(Summer 2005), 19-22.
- Slotta, J.D. & Chi, M.T.H. (2006). Helping students understand challenging topics in science through ontology training. Cognition and Instruction, 24 (2), 261 – 289.

QUESTIONS?

-- THANK YOU