PHYS 7685: Introduction to Discipline-based Education Research

Course Overview

Instructor:

Natasha G. Holmes
Assistant Professor, Laboratory of Atomic and Solid State Physics, Department of Physics

Contact info:

Email: ngholmes@cornell.edu
Office: 406 Physical Sciences Building
Lecture: TR 10:10am - 11:25am, Clark Hall 294G
Office hours: Tuesdays, 11:25am, Clark Hall 294G
Required Reading: The ABCs of How We Learn, by Daniel L. Schwartz, Jessica M. Tsang, and Kristen P. Blair
Online course information: On Blackboard: Phys 7685 Special Topics Holmes, N (8565_2017FA)

Course Description and objectives

The aim of this course is to introduce students to the topics, literature, and methods of discipline-based education research. By the end of the course, students will be able to:

- Describe the development and goals of discipline-based education research in post-secondary institutions
- Consider issues of ethics for working with human subjects in education research
- Draw on a number of fundamental results about how people learn to motivate or explain DBER studies
- Use results from research to design and evaluate classroom activities
- Discuss methods of studying learning including cognitive interviews, research-based assessments, and observations
- Evaluate the mechanisms and issues for encouraging adoption of research-based teaching methods in universities

Teaching and learning philosophy

There are many resources that can deliver facts and equations, but my role as an instructor is to help students develop skills that will support them in their future work and learning. As a researcher in physics education, my teaching philosophy is heavily shaped by research-based teaching and learning practices. In this course, we will use a 'flipped classroom' model, whereby students are given pre-reading assignments so that class time is reserved for deeper engagement, application, and problem-solving with the material. There will also be larger out-of-class activities that span multiple weeks. I distinguish learning from performing: performing is something that should be done well when being judged (or graded); learning often happens when something does not go right the first time, but we have an opportunity to reflect and improve. For that reason, I will provide several opportunities for students to revise and improve submitted work before being evaluated. I will treat our classroom as a community of practice and expect students to support each other in learning, provide constructive feedback when elicited, and ask for help and support.

Activities and grading

Throughout the course, students will engage in a number of in-class and out-of-class activities, including:

Reading education research articles and leading and participating in discussion of the readings

Students will be assigned 2-3 readings per week, which they will be expected to be prepared to discuss in class. Each student will be responsible for leading discussions about an assigned reading. Students are strongly encouraged to apply lessons from this course when facilitating in-class discussion.

Evaluating classroom activities or examples from research based on the learning mechanism being considered

Each week, there will be an out-of-class activity related to the assigned reading. These will be discussed in-class so each student can obtain feedback on their assignment. Students will be expected to come to class with a draft of the assignment, which they can then revise based on the in-class feedback, before submitting for instructor feedback.

Collecting and analyzing education research data

Throughout the course, students will collect and analyze data related to education research activities. These will include using a classroom observation protocol, conducting a cognitive interview, and developing a research-validated multiple-choice assessment item. Students will work in pairs on these projects (does not need to be the same pair each time).

Final portfolio, reflection, and presentation

At the end of the course, students will submit a final portfolio and reflection document that includes final versions of all submitted work throughout the course. These versions can be updated since obtaining instructor feedback or can be exact versions of previously submitted work. This portfolio should also describe some of the ways work was improved over the course. In the last two weeks of class, students will present a short summary of one of the course activities to the whole class.

Academic integrity

Each student in this course is expected to abide by the Cornell Code of Academic Integrity. "Any work submitted by a student in this course for academic credit will be the student's own work." While learning in the course will be collaborative, each student is expected to submit products that are their own. Students are encouraged to obtain and incorporate feedback, resources, or ideas from other sources, as long as appropriate credit is provided. We will impose the highest penalties permitted for violation of this policy. For further details see: http://cuinfo.cornell.edu/aic.cfm.

Activities and assignments schedule

Reading	In-class activity	Out-of-class activity	Due dates
Week 1 - History and introduction to DBER (Aug 22-25)			
• Singer SR, et al. (2012) Discipline-Based Education Research: Understanding and Improving Learning in Undergraduate Science and Engineering ○ Chapter 1, sections: Defining DBER and Relation of DBER to other research areas (p9-14) ○ Chapter 2, sections: The emergence of DBER (focus on your discipline)	Tues: • Overview of course and structure • Concept map of DBER (what, why, and how?) Thurs: • Discuss readings (Facilitation by NH) • Peer discussion of ethics in education research	• Ethics training	• Fri Aug 25
Week 2 – Deliberate Practice (Aug 28-Sept 1)			
• D is for deliberate practice • F is for feedback • Roediger HL, Karpicke JD (2006) Test-Enhanced Learning: Taking Memory Tests Improves Long-Term Retention. *Psychol Sci* 17(3):249–255.	Tues: • Discuss readings (student-led facilitation) • Check in on course, structure, and out-of-class activity Thurs: • Peer discussion of deliberate practice tasks • Brainstorm research questions and methods about learning from deliberate practice	• Take an existing classroom activity and: ○ describe ways in which it does or does not provide deliberate practice ○ modify it to add components of deliberate practice	• Draft: Thurs Aug 31 • Final: Mon Sept 5
Week 3 – Discovery-learning and constructivism (Sept 5-8)			
• C is for contrasting cases • G is for generation • J is for just-in-time telling	Tues: • Discuss and synthesize readings (student-led facilitation) Thurs: • Peer discussion of activities • Brainstorm research questions and methods about learning from contrasting cases, generation, and just-in-time telling	• Find existing classroom activities that do and don't involve elements contrasting cases, generation, and/or just-in-time telling and explain how they do, don't, or could be modified to	• Draft: Thurs Sept 8 • Final: Mon Sept 11)
Week 4: Identifying prior knowledge and misconceptions and developing conceptual understanding (ZPD) (Sept 11-15)			
• K is for knowledge • U is for undoing • P is for participation	Tues: • Discuss and synthesize readings (student-led facilitation)	• Find examples of research characterizing student	• Draft: Thurs Sept 14 • Final: Mon Sept 18

<table>
<tr><td rowspan="2"></td><td>• What is a cognitive interview?</td><td rowspan="2">understanding of concepts in your discipline
• Design questions for a cognitive interview to measure student understanding and prior knowledge, and identify misconceptions</td><td></td></tr>
<tr><td>Thurs:
• Peer discussion of cognitive interview questions
• Discuss research studies on disciplinary conceptual understanding</td><td>• Draft: Thurs Sept 14</td></tr>
<tr><td colspan="4">Week 5: How people learn grab bag (Sept 18-22)</td></tr>
<tr><td rowspan="2">Read two of the following:
• A is for analogy
• S is for self-explanation
• Q is for question-driven
• W is for worked examples
• E is for elaboration</td><td>Tues:
• Jigsaw discussion (facilitated by NH)</td><td rowspan="2">• Design and pilot questions for the cognitive interview</td><td rowspan="2">• Draft: Thurs Sept 21</td></tr>
<tr><td>Thurs:
• Peer discussion of cognitive interviews</td></tr>
<tr><td colspan="4">Week 6: Attitudes and motivation (Sept 25-29)</td></tr>
<tr><td rowspan="2">• R is for reward
• X is for excitement
• Y is for Yes I can</td><td>Tues:
• Discuss and synthesize readings (student-led facilitation)</td><td rowspan="2">• Design and pilot questions for the cognitive interview
• Evaluate two existing classroom activities in terms of how they affect student attitudes, motivation, belonging, or identity</td><td>• Draft: Thurs Sept 28</td></tr>
<tr><td>Thurs:
• Discuss classroom activities for student motivation
• Check in on cognitive interviews</td><td>• Draft: Thurs Sept 28
• Final: Mon Oct 2</td></tr>
<tr><td colspan="4">Week 7: Epistemology and resources (Oct 2-6)</td></tr>
<tr><td rowspan="2">• D. Hammer, “Student resources for learning introductory physics,” Am. J. Phys., PER Suppl. 68, S52–S59 (2000)
• Redish EF (2014) Oersted Lecture 2013: How should we think about how our students think? Am J Phys 82(6):537–551.
• Elby A (2001) Helping physics students learn how to learn. Am J Phys 69(S1):S54–S64.</td><td>Tues:
• Discuss and synthesize reading (student-led facilitation)
• Create a general rule to define and distinguish terms (epistem-ology,-ic, frames, resources, etc.)</td><td rowspan="2">• Summary of cognitive interview</td><td rowspan="2">• Draft: Thurs Oct 5
• Final: Wed Oct 11</td></tr>
<tr><td>Thurs:
• Discuss cognitive interviews</td></tr>
<tr><td colspan="4">Week 8: Research methods: Diagnostic assessments of student learning Part I (Oct 11-13)</td></tr>
<tr><td rowspan="2">• Reeves TD, Marbach-Ad G (2016) Contemporary Test Validity in Theory and Practice: A Primer for Discipline-</td><td>Tues: No class</td><td rowspan="2">• Develop presentation about an existing research-based</td><td rowspan="2">• Mon Oct 16 (presentations due Tues Oct</td></tr>
<tr><td>Thurs:</td></tr>
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Based Education Researchers. *CBE Life Sci Educ* 15(1):rm1-. • Either: ○ Scott M, Stelzer T, Gladding G (2006) Evaluating multiple-choice exams in large introductory physics courses. *Phys Rev Spec Top - Phys Educ Res* 2(2):20102. ○ Hubbard JK, Potts MA, Couch BA (2017) How Question Types Reveal Student Thinking: An Experimental Comparison of Multiple-True-False and Free-Response Formats. *CBE Life Sci Educ* 16(2):ar26. ○ Wilcox BR, Pollock SJ (2014) Coupled multiple-response versus free-response conceptual assessment: An example from upper-division physics. *Phys Rev Spec Top - Phys Educ Res* 10(2):20124.	• Discuss and synthesize readings (student-led facilitation) • (optional additional reading) Adams WK, Wieman CE (2011) Development and Validation of Instruments to Measure Learning of Expert-Like Thinking. Int J Sci Educ 33(9):1289–1312.	diagnostic assessment of student learning in your discipline (to be presented on in Week 9)	17 or Thurs Oct 19)
Week 9: Research methods: Diagnostic assessments of student learning Part II (Oct 16-20)			
• Articles on selected diagnostic assessment (see out of class assignment)	Tues: • Diagnostic Presentations Thurs: • Diagnostic Presentations • Run open-response questions to sub-group and discuss process	• Convert cognitive interview question(s) into multiple-choice format	• Draft: Wed Oct 25
Week 10: Active learning and dealing with large lectures (Oct 23-27)			
• L is for listening and sharing • T is for teaching • Either: ○ Freeman S, et al. (2014) Active learning increases student performance in science, engineering, and mathematics. *PNAS* 111(23):8410–8415. ○ Stoltzfus JR, Libarkin J (2016) Does the Room Matter? Active Learning in Traditional and Enhanced Lecture Spaces. *CBE Life Sci Educ* 15(4):ar68.	Tues: • Discuss and synthesize readings (student-led facilitation) Thurs: • Peer discussion of large-lecture activities • Run diagnostic multiple-choice questions	• Describe how an existing large-lecture activity does/could incorporate concepts from course so far • Analyze data on multiple-choice questions	• Draft: Thurs Oct 26 • Final: Mon Oct 30 • Mon Oct 30
Week 11: Adoption of RBI at universities (Oct 30-Nov 3)			
• Either: ○ Brownell SE, Tanner KD (2012) Barriers to faculty pedagogical change: lack of training, time,	Tues: • Discuss and synthesize readings (student-led facilitation)	• Collect and analyze observation protocol data for	• Collection (1 class): Thurs Nov 2

incentives, and... tensions with professional identity? CBE Life Sci Educ 11(4):339?46. ○ Dancy M, Henderson C (2010) Pedagogical practices and instructional change of physics faculty. *Am J Phys* 78(10):1056. • AND One paper about an observation protocol (either RIOT, COPUS, RTOP, or other ones I haven't heard of).	Thurs: • Discuss different observation protocols and data collection	two different courses	
Week 12: Equity in education (Nov 6-10)			
• B is for belonging • N is for norms • Either: ○ Aguilar L, Walton G, Wieman C (2014) Psychological insights for improved physics teaching. *Phys Today* 67(5):43–49. ○ Tanner KD (2013) Structure Matters: Twenty-One Teaching Strategies to Promote Student Engagement and Cultivate Classroom Equity. *Cell Biol Educ* 12(3):322–331.	Tues: • Discuss and synthesize readings (student-led facilitation) Thurs: • Discuss observation protocol data collection and analysis – compare data across courses and protocols	• Collect and analyze observation protocol data for two different courses (continued)	• Draft Summary: Thurs Nov 9 • Final Summary: Mon Nov 13
Week 13: Topic of choice (Nov 13-17)			
TBD	Tues: • Discuss and synthesize readings (student-led facilitation) Thurs: • TBD	• Activity TBD • First draft of final reflections • Prepare final presentations	
Week 14: Student presentations (Nov 20-21)			
TBD	Tues: • Student presentations Thurs: No Class	• Prepare final presentations and reflections	
Week 15: Student presentations (Nov 27-Dec 1)			
TBD	Tues: • Student presentations Thurs: • Student presentations	• Final reflections due	• Thurs Nov 30

Additional topic suggestions (with possible readings):

Computer-based learning

- Finkelstein ND, et al. (2005) When learning about the real world is better done virtually: A study of substituting computer simulations for laboratory equipment. Phys Rev Spec Top - Phys Educ Res 1(1):10103

- Salehi S, Keil M, Kuo E, Wieman CE (2015) How to structure an unstructured activity: Generating physics rules from simulation or contrasting cases. 2015 Physics Education Research Conference Proceedings (American Association of Physics Teachers), pp 291-294.

Cognitive science and educational psychology
- Schoenfeld AH (1987) What's All the Fuss About Metacognitlon? Cogn Sci Math Educ:189.
- Bransford JD, Franks JJ, Vye NJ, Sherwood RD (1989) New approaches to instruction: because wisdom can't be told, pp 470–497.
- Nokes-Malach TJ, Mestre JP (2013) Toward a Model of Transfer as Sense-Making. Educ Psychol 48(3):184–207.
- Bransford JD, Schwartz DL (1999) Rethinking Transfer: A Simple Proposal with Multiple Implications. Rev Res Educ 24:61–100.

Labs
- Holmes NG, Wieman CE, Bonn DA (2015) Teaching critical thinking. PNAS 112(36):11199–11204.
- Wieman C, Holmes NG (2015) Measuring the impact of an instructional laboratory on the learning of introductory physics. Am J Phys 83(11):972–978.
- Auchincloss LC, et al. (2014) Assessment of course-based undergraduate research experiences: a meeting report. CBE Life Sci Educ 13(1):29–40.
- Brownell SE, et al. (2015) A high-enrollment course-based undergraduate research experience improves student conceptions of scientific thinking and ability to interpret data. CBE Life Sci Educ 14(2):14:ar21.

How to measure learning?
- Bissonnette SA, et al. (2017) Using the Biology Card Sorting Task to Measure Changes in Conceptual Expertise during Postsecondary Biology Education. CBE Life Sci Educ 16(1):ar14.
- Owens MT, et al. (2017) Classroom sound can be used to classify teaching practices in college science courses. Proc Natl Acad Sci U S A 114(12):3085–3090.

Demonstrations:
- Crouch C, Fagen AP, Callan JP, Mazur E (2004) Classroom demonstrations: Learning tools or entertainment? Am J Phys 72(6):835–838.
- Sokoloff DR, Thornton RK (1997) Using interactive lecture demonstrations to create an active learning environment (American Institute of Physics), pp 1061–1074.
- Miller K, Lasry N, Chu K, Mazur E (2013) Role of physics lecture demonstrations in conceptual learning. Phys Rev Spec Top - Phys Educ Res 9(2):20113.
- Moll RF, Milner-Bolotin M (2009) The effect of interactive lecture experiments on student academic achievement and attitudes towards physics. Can J Phys 87(8):917–924.

ABC's chapters not included
- H is for hands on
- I is for imaginative play
- M is for making
- O is for observation
- V is for visualization
- Z is for Zzzs