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Integrated Approaches in Physics Education: A Graduate Level Course in Physics, Pedagogy, and Education Research

By John R. Thompson and Michael C. Wittmann

Physics education research (PER) has a decades-long documented history of research into student learning and evaluation of reform-based curricula. Major results on evaluation of teaching and studies of learning have been collected in a resource letter [1]. These and more recent results have allowed us create a class which moves past an apprenticeship or internship model to prepare teachers and researchers.

Our graduate level courses, "Integrated Approaches in Physics Education I and II," are designed to help students (primarily future teachers and academic faculty) learn about PER from three different perspectives: research into student learning, curricula developed based on these studies, and documentation of the effectiveness of these curricula. The course was co-designed by the authors and Noah Finkelstein, Dewey Dykstra, and Rachel Scherr. Students engage in the research cycle themselves, learning how to carry out research and develop curriculum - they are unable to evaluate their work, but the materials are tested in a group setting of peers.

Within this course, we use the research methods of physics education research to study the learning of the methods and results of physics education research. Our work builds on that of others [2-4], emphasizing observations of student learning in individual and group interviews and classroom settings as well as testing using ungraded quizzes and surveys. Only some of our observations are presented in the paper.

In the paper, we describe the structure of our two-semester course sequence and present results on student learning of PER results and materials in two areas: DC electric circuits (batteries and bulbs in parallel and series circuits) and motion and force (analyzing student results from a well-known survey [5]). Data come from ungraded quizzes and exam questions, collected over several years of instruction. We study knowledge of physics conceptual knowledge and pedagogical content knowledge in terms of an understanding of common student difficulties with the physics as well as an understanding of which existing curricula are most likely to help students learn the appropriate physics. We compare results from graduate students with and without previous physics backgrounds.

Results are generally strong. All students are able to learn the physics content, if they did not already begin the course knowing it. While content understanding is greater among the physics students, the non-physics students often appear to be better able to see which instructional materials might help students with specific conceptual difficulties.

In our course, we are implementing the recommendations of PER studies: to find what students need most, build on what they can already do, and help them adjust to unexpected and surprising results. It is always surprising to find out what students don't know, when we assume that they do. Only by asking them and observing them are we able to fully uncover their needs in ways that helps us teach them better.

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