

Maximizing the Benefits of Physics Education Research: Building Productive Relationships and Promoting Institutional Change

Charles Henderson, Tim Stelzer, Leon Hsu, and Dawn Meredith

Our group had the task of identifying how those of us in Physics Education Research (PER) might best cultivate productive relationships with other physics faculty members. Prior to the conference, the group leaders identified two objectives related to this topic: (1) Gaining respect for PER as a serious research area that belongs in physics departments; (2) Getting results of PER known and used by physics faculty. To help with this task members of the PER community were invited to complete a web survey prior to the conference. The full results of this survey are described elsewhere.¹ Based on the web survey and discussion within the working group, there appears to be agreement within the PER community that both of the above objectives are important goals for the PER community. The working group saw these areas as strongly connected, with one reinforcing the other.

Roles of PER faculty

In physics departments, PER is sometimes mistaken for a service enterprise whose purpose is to improve instruction in the department, rather than a scholarly pursuit similar to other subfields of physics research. Where this misperception exists, departments may miss opportunities to hire PER candidates; after hiring, this misperception can result in higher service and teaching responsibilities for PER faculty and difficulty in using PER work as a basis for tenure and promotion. This issue was addressed recently by Heron and Meltzer who argue that the success of PER depends on having a critical mass of PER faculty with appointments in physics departments.² Suggestions for improving the status of PER made by the working group and web survey largely mirror those made by Heron and Meltzer. These include improving the marketing of PER as well as improving the quality and

rigor of PER. The working group also discussed the advantages and disadvantages of making analogies between PER and traditional physics research and of portraying PER as interdisciplinary.

Adoption of PER tools and methods

In recent decades, researchers in PER have documented significant and reproducible results related to the teaching and learning of physics, and have demonstrated the effectiveness of instructional strategies and materials based on these results. PER is also a leader in discipline-based science education research, with other fields often turning to PER as a model. A challenge currently facing the PER community is dissemination. While increasing numbers of faculty use PER knowledge and products in their teaching, others are unaware of PER or question its relevance to their own teaching. Working group discussions revolved around both individual and institutional factors that might be related to an instructor's use of PER.

Emerging research^{3,4} and the experiences of group members suggest that potentially important barriers to change are existing frameworks that presuppose an unequal relationship between PER faculty and other faculty; e.g. an expert/novice or provider/client relationship. In such frameworks, PER faculty supply curricular products to other faculty who are then responsible for adopting the new products and techniques. These frameworks, unfortunately, fail to recognize faculty members' knowledge, skill, and unique teaching circumstances, and fail to acknowledge the independent scholarly pursuits of PER faculty. We suggest that a more effective framework might be one of mutually beneficial collaboration.

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Under this framework physics education researchers might work with instructors to customize PER products and knowledge to their individual teaching situations, personal preferences, skills, and goals, and physics education researchers might, for example, gain access to data supporting their research or gain valuable perspective on teaching. Both participants would be valuable to the process with learning occurring on both sides. Possible means of collaboration range from informal one-on-one interaction^{5,6} to more formally organized groups including both faculty interested in improving their instruction and physics education researchers conducting investigations relevant to that instruction.⁷ Other possibilities include instructional materials developed to facilitate local customization.⁸

Promoting institutional change

Even faculty strongly committed to PER-based instructional reforms may be inhibited by factors such as student expectations, questions on course evaluation forms that focus on presentation of material, room arrangement, content coverage expectations, faculty reward structures, and so forth.⁹ Such factors tend to support traditional instructional practices and may not become visible until change is attempted. For example, one of the major impediments to the success of the Technology Enhanced Active Learning (TEAL) program at MIT was student resistance to the new instructional style.¹⁰ At MIT, students were eventually persuaded to accept the reforms, thanks to expertise and perseverance among the TEAL faculty along with a significant commitment of institutional resources. However, student resistance to new instructional methods can derail instructional changes, especially for instructors working alone and with little institutional support.¹¹

Our working group identified institutional change as a major factor in successful PER-based instructional reform and therefore in productive relationships with non-PER faculty members.¹² For example, at the University of Illinois, Urbana-Champaign, organizers relied

on three key changes in departmental structure to support reform of the introductory calculus-based physics sequence.¹³ First, a team of ten faculty members substantively worked on the project, rather than one or two PER-immersed individuals. The team approach – common for research projects, but rare for teaching innovations – provided a critical mass not only for implementing the changes, but also for sustaining the changes and gaining acceptance of the reforms throughout the faculty. Second, the department provided resources (including release time) for the team to effectively plan and implement its instructional vision. Third, the department created a position with the authority to allocate the resources necessary to maintain the quality of the courses, including appropriate staffing for the courses. As a result of these institutional changes, over 50 faculty members have successfully taught in the reformed courses. Many of these faculty members have incorporated reforms into their upper division courses.

PER is only beginning to look at change from the perspective of PER-supportive institutional reforms. As Sheila Tobias recently noted, “physics education reform has been focusing largely on classroom-based innovation rather than on the more political and institutional conditions required for long-lasting change,”¹⁴ Our working group acknowledged the need for tools to help us better understand these institutional factors and their often political origins.

Summary

PER has made significant progress in understanding the teaching and learning of college level physics in recent years. Building on this foundation we suggest that new work is required in the frontier areas of 1) understanding physics faculty and their teaching situations; 2) developing ways to support faculty in changing long-standing instructional practices; and 3) identifying and changing political and institutional conditions to make them more hospitable to PER-based instructional reforms.

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Lobbying for Discipline-based Education Research

Paula Heron and David Meltzer

This working group began its discussions with an assessment of the current state of funding for physics education research (PER). Most PER work is funded directly or indirectly by the National Science Foundation (NSF), primarily through the Directorate for Education and Human Resources (EHR). Within this Directorate three separate divisions fund physics education work, although the funding programs—and therefore the projects that are funded—rarely designate research explicitly as a primary objective. The Division of Elementary, Secondary, and Informal Education (ESIE) funds teacher preparation and curriculum development projects targeted at grades K-12, while the Division of Undergraduate Education (DUE) funds course, curriculum, and laboratory development projects for college and university-level instruction. Research in the teaching and learning of physics is sometimes a component of these projects, and many PER groups are able to partially support their research endeavors by linking them to the development projects funded by ESIE and DUE. A similar situation exists for education researchers in chemistry, geoscience, and other science disciplines.

Projects with a primary focus on research are funded by the Division of Research, Evaluation, and Communication (REC). Although individual projects funded by REC generally receive substantial amounts of support, only a very small percentage of REC-funded projects have a focus on physics education (approximately one in 20), or for that matter any specific science discipline. Most funding goes to researchers with back-

grounds and interests in K-12 math and science education, cognitive science, educational psychology, school systems administration, etc. PER and other discipline-based research groups have found it very difficult to persuade review panels and program directors in REC to designate significant amounts of funding for discipline-based education research. Moreover, the new federal budget proposed this year for NSF incorporates very substantial budget cuts for REC, and this leaves the future of NSF-funded science education research very much in doubt.

Very recently, the Division of Undergraduate Education has established new funding programs within its broader Course, Curriculum, and Laboratory Improvement (CCLI) program specifically targeted at discipline-based education research. Although this new program has yet to make its first set of awards, it represents a promising development in the establishment of ongoing funding mechanisms for research in physics education and similar fields.

Finally, it should also be mentioned that the NSF Directorate for Physical and Mathematical Sciences (MPS)—the home of funding in traditional research fields in physics, chemistry, astronomy, and mathematics—has taken a few tentative steps to participate in funding discipline-based education research. Several modest projects in PER have been funded by MPS over the past few years and, although these projects represent a potentially important first step, the future of such MPS funding remains very uncertain.

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