

# Seeding Change: The Challenges of Transfer and Transformation of Educational Practice and Research in Physics (Part II)

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**Abstract.** These coupled papers examine the interrelated problems of supporting the development of PER, and the ‘transfer’ of what is known from PER to the more general populace of physics instructors. Two programs are examined to highlight these interrelated issues: the Postdoctoral Fellowships in Mathematics Science Engineering and Technology Education and the Preparing Future Physics Faculty Program. Data on successes and failures of these programs are presented and analyzed from a perspective of professionalism and attitudes and beliefs outlined in the first paper. We claim such programs set the seeds for inclusion of education and education research in the broader culture of physics.

## INTRODUCTION

In Part I of this paper we examined physics graduate school in terms of preparing physics professionals. We also considered physics faculty attitudes and beliefs about education and research on education. In both areas we noted an asymmetry between the emphasis placed on research and education. In Part II, we discuss two programs designed to address these coupled issues.

## TARGETING GRADUATE AND POST-DOCTORAL EDUCATION

During graduate school, physicists engage in authentic research experiences [1], but most often there is no corresponding apprenticeship regarding teaching and learning. In Part I we analyzed this discrepancy in terms of the professionalization of physicists. By extending the focus of physics graduate school to include structured attention to education, we may begin to give education greater prominence and validate education research in physics, by physicists. In this way, we can begin to shift the culture of physics to include education in the core practice of physicists.

We consider two preparation programs, one for physics graduate students and one for postdocs. Both programs focus on increasing the prominence of educational issues. After a description of the programs, we consider their impacts, sustainability, and interaction.

## Preparing Future Physics Faculty

In 1998, the American Association of Physics Teachers (AAPT) funded Preparing Future Physics Faculty (PFPF), a graduate program designed to augment traditional training in research. PFPF was a discipline-specific version of Preparing Future Faculty, a program initiated by the Council of Graduate Schools and the Association of American Colleges and Universities. PFPF and PFF were responses to calls for increased emphasis on preparation in the areas of teaching and professional development by the Association of American Universities [2] and the National Academy of Sciences [3]. The University of California, San Diego was one of the sites chosen for a PFPF program. One of the authors [NF] was involved with establishing the program; the other [EP] is a former participant and current director. The program ran with external support until 2000, and has since continued with the

support of the physics department and UCSD's campus-wide Center for Teaching Development. Over the six years of its existence, the program has undergone substantial changes and evolved to address four goals:

- Preparing graduate students for their future responsibilities as educators by promoting awareness and understanding of PER;
- Raising awareness of differences in the needs and opportunities at different academic institutions (i.e., community colleges, bachelor's granting institutions, and regional and research universities);
- Providing physics graduate students with professional and career development in areas such as conducting a job search and writing grant proposals;
- Creating an environment where physics graduate students can discuss issues in the physics community.

Graduate students participating in PFPF attend weekly seminars on topics relating to the goals discussed above. The sessions cover a range of topics, but can be grouped into four areas: physics education, academic settings, professional/career development, and exploration of the physics community. In addition to weekly seminars, graduate students are encouraged to participate in a range of practice-based activities: researching, developing curricula, and teaching. Research projects include graduate students engaging in PER-based studies of local practice (such as examining instructor beliefs about teaching). Curricular development often takes the form of graduate students appropriating PER-based activities and adopting them for local practice – for example, graduate students have augmented the complement of Interactive Lecture Demonstrations (ILDs) running in the introductory sequence by building an RC circuit ILD (and testing its effectiveness in the algebra-based course). Finally, teaching practice is heavily emphasized. All students are encouraged to conduct a 5-10 minute micro-teach (presenting a single topic to the rest of the PFPF seminar). Subsequently, students engage in observations and guest lectures in local introductory courses and at partner institutions (community and teaching colleges). Ultimately, several students have become instructors of record, taking responsibility for designing and implementing a full term class at these partner institutions. All of these activities are supervised both locally by the PFPF supervisors and at the host institutions by practicing faculty. These activities ground the seminar discussions in practical experience, making both more meaningful. The scope of engagement (ranging from

guest lecturing to teaching a course as instructor of record) depends on the participant's interests and constraints. Guest lecturing is valuable experience with a small time commitment. On the other hand, teaching a course provides a more comprehensive experience but is a demanding undertaking. Our most successful participant activities combine the best of both approaches by including a group planning component and a modular workload. By involving multiple participants, these programs achieve a significant impact, yet require only modest effort from individual graduate students.

### **Postdoctoral Fellowships in Science, Mathematics, Engineering and Technology Education**

Several years earlier, the NSF instituted the Postdoctoral Fellowships in Science, Mathematics, Engineering and Technology Education (PFSMETE) in order to support postdocs as they built the expertise necessary to create and to succeed within hybrid science – education environments. The primary objective of PFSMETE was the preparation of individuals with recently awarded doctorates in science for leadership roles in science, mathematics, engineering, and technology (SMET) education through the development of expertise in science education research [4]. Further analysis of the program guide suggests a number of subordinate objectives primarily related to PFSMETE research. The NSF expected that PFSMETE research would also promote: 1) the communication of scientific knowledge to a variety of learners, 2) the assessment of teaching and learning programs, 3) the application of interdisciplinary knowledge to curriculum development, and 4) the use of technology in SMET education.

During the three years of its existence, NSF granted 63 Fellowships to allow those who had recently been awarded doctorates in a scientific discipline to pursue education research of their own design. It is notable that the program adopted a student directed (Fellowship) model rather than an institution directed (Research Associate) model. That is, awardees brought funding with them to an institution to engage in research of their design, rather than engage in predefined research directed by others. In 1999, citing budget constraints, the program was cancelled, meaning that NSF would honor current awards, but offer no more Fellowships. The Fellows were distributed around the country and represented a host of disciplines, including mathematics, physics, geology, biology, chemistry, and engineering.

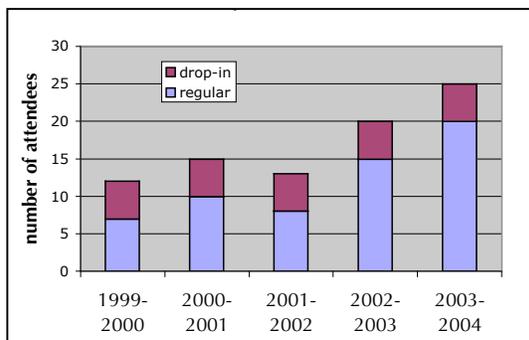


FIGURE 1. Physics graduate program weekly attendance

## RESULTS

While it should be clear that affecting students' choices and preparation is a long-term endeavor, we may assess the preliminary impact of these programs. First, it is worth considering whether students choose to participate in these voluntary programs. In the graduate program, participation has increased since its inception, as shown in Figure 1. Over this period, the UCSD physics department has averaged about 115 graduate students at any one time. Given an average of 5-6 years of graduate study, it can be seen that a significant fraction of the department's graduate students have participated in the PFPF program.

In the postdoctoral program, of the 63 participants, 12 Fellowships were awarded in physics. They were given to: Alicia C. Alonzo, Bruce B. Birkett II, Scott W. Bonham, Andrew R. Elby, Noah Finkelstein, Scott V. Franklin, Elaine Su-Eng Fu, Apriel K. Hodari, Leonardo Hsu, Beth Hufnagel, Catherine Ishikawa, and Gregory R. Schultz. Each of these Fellows continues in an academic or educational setting, making up roughly 1/4 of the current cohort of self-identified junior faculty in PER [5].

As measured by surveys of the participants, each of these programs has been successful at building bridges between physics and education, and infusing physics education research into traditional practices in physics. We have surveyed PFPF participants on their attitudes about the importance of teaching and what they have learned from the program. The results are summarized in Table 1 on the following page. While it is unsurprising that the graduate students consider education a substantive part of their future career (they have self-selected to participate in the program), it is striking how few felt education was valued by the physics research community. Undoubtedly this reflects the almost exclusive research emphasis of a traditional

physics Ph.D. program. Encouragingly, a very high fraction of participants report being more aware of the results of physics education research and plan to use those results in their own teaching, indicating that we have been preliminarily successful in achieving our goals of transferring traditional research skills to PER and to preparing students for teaching. Former participants who are now teaching report following through on these intentions.

Similar results were found in a survey of the PFSMETE participants issued in 2001. Postdocs report being satisfied with the Fellowship (9.5 out of 10 point scale) and well trained by the program (8.5 out of 10 points). Furthermore, nearly all participants report more interaction with educational programs as a result of the Fellowship, as shown in Figure 2.

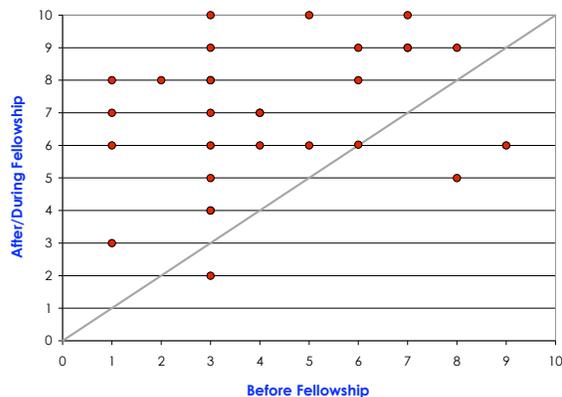


FIGURE 2. Contact with education programs as a result of PFSMETE. 0 represents no contact, 10 maximum of contact. (Notably two participants had joint degrees in education and science prior to PFSMETE)

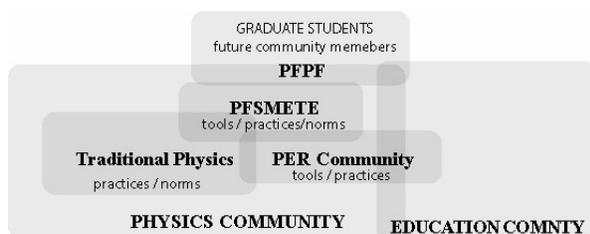
## PROFESSIONALIZATION REVISITED

One may revisit the characteristics of profession offered in Part I and observe that both programs, PFPF and PFSMETE, begin to develop a profession of education within the sciences. The role of these programs within the physics and education communities is illustrated in Figure 3. The PFPF and PFSMETE programs seek to extend the region of overlap between the PER and traditional physics communities. This may be seen as attempt to blur disciplinary boundaries and help foster cultural change – to produce a hybrid culture and introduce tools and practices from one intellectual domain into another. It

**TABLE 1. Survey of PFPF Participants.**

**33/38 students surveyed considered education a substantive part of their future career. Of those 33:**

Statement	Percent agreeing
Feel education is valued by the physics research community	18%
<b>After participation in PFPF</b>	
More aware of the results of PER	82%
Planning to incorporate PER results in teaching	94%
View PER as a legitimate research activity with in physics community	88%



**FIGURE 3.** Interactions between members of the physics and education communities, including the PFPF and PFSMETE programs.

is worthy of note that the PFSMETE Fellowship directly supported the development of the PFPF program, as one of the authors and architects of the PFPF program [NF] was supported by PFSMETE at the time the PFPF was established.

## SUSTAINABILITY

The establishment of these programs may be viewed as the creation of a *setting*, a new and sustained relationship between individuals [6]. PFPF and PFSMETE's structures, explicit (and implicit) goals, history, and surrounding context reflect their initial intent to sustain the particular relationships developed by participation in the programs and to infuse education into physics. Sarason contends that in developing settings, a program's success or failure depends upon two critical factors: the initial structure of the program and the adaptation of that structure to local conditions [6]. These two programs included these critical features – they coupled the program structures to the surrounding institutional structures while simultaneously building flexibility and autonomy of practice that allowed individuals and programs to adapt. This perspective provides insight into the continued success of UCSD's PFPF program; despite the loss of external funding, the program has been supported by the local institution and adapted to local interests and needs. Similarly, while the PFSMETE program was cancelled due to external factors (funding constraints), the program's impact continues via the contributions of former Fellows.

Using this idea of the creation of settings and Shulman's characterization of professional education, we posit that two key characteristics shape the success of both the programs and the experiences of the individuals within them: 1) a balance between academic autonomy (independent approach and voluntary participation) and institutionalization (directed work and inclusion); and 2) building potential for crossing established academic cultural boundaries (particularly between traditionally conceived disciplines and education). Again, the balance of program autonomy and institutionalization allow for inclusion by the surrounding institution, and allows the program to adapt and evolve to local concerns. The second critical feature, that of bridging, embodies the specific goal of these programs— to effect cultural change.

## ACKNOWLEDGMENTS

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## REFERENCES

1. J.S. Brown, et al. *Ed. Res.*, **18**, p32. (1989)
2. Association of American Universities, Committee on Graduate Education Report and Recommendations, Oct. 1998. <http://www.aau.edu/reports/GradEdRpt.html>
3. National Academy Of Sciences Committee On Science, Engineering, And Public Policy Reshaping the Graduate Education of Scientists and Engineers, 1995, <http://www.nap.edu/readingroom/books/grad/brief.html>
4. National Science Foundation, Postdoctoral Fellowships in Mathematics, Science and Technology Education, document number: NSF 97-42. (1997)
5. As listed by the Y-PER Physics Education Research—listserved by junior faculty.
6. Sarason, S.B.. *The Creation of Settings and the Future Societies*. SF, CA: Jossey-Bass Publishers. (1989)