The Workshop for New Faculty in Physics and Astronomy*

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1. The Problem

The New Faculty Workshop (NFW) was developed by the physics community in the mid-1990's during the appearance of a disturbing national trend: a decline of about 25% in the number of baccalaureate physics degrees from 1990 to 1996.[1] The reasons for this decline are not well understood, but it was especially troubling for the physics community that simultaneously the number of baccalaureate degrees in the STEM (science, technology, engineering, and mathematics) disciplines was *increasing* by 10% and that the physics share of total U.S. baccalaureate degrees declined from one out of 200 to one out of 300.

The program of the NFW was organized around the premise that poor teaching at colleges and universities was at least partly responsible for the decline in the number of majors. This view was reinforced by the research of Seymour and Hewitt[2], who interviewed hundreds of current and former STEM students at 7 colleges and universities to try to elicit common trends among the reasons that students switched out of STEM majors. Their research revealed that poor teaching, especially in introductory science courses, was among the most commonly cited reasons for switching majors: "Students were very clear about what was wrong with the teaching they had experienced and had many suggestions about how to improve it. They strongly believed that the source of these problems was that SME faculty do not like to teach, do not value teaching as a profession, and lack, therefore, any incentive to learn to teach effectively....Students also made very specific criticisms of the pedagogical techniques of their SME professors. The most common of these were that lessons lacked preparation, logical sequencing or coherence, and that little attempt was made to check that students were following the arguments or ideas. Students interpreted poor preparation as reflecting faculty disinterest in how well their students were learning." The direct comments collected by Seymour and Hewitt from students about faculty are especially revealing, for example: "They just continually write. And they're standing in front of what they write, but they don't care. They'll look over their shoulder now and then, and say, 'Okay, you are all still there,' and just keep going. And the number of people that don't go to classes is amazing."

Further evidence of the problems with undergraduate teaching was presented in the study of U.S. research universities sponsored in 1995 by the Carnegie Commission, whose findings and recommendations were presented in a document commonly known as the "Boyer Report."[3] Among the panel's conclusions were: "The research universities have too often failed, and continue to fail, their undergraduate populations….Some of their instructors are likely to be badly trained or untrained teaching assistants who are groping their way toward a teaching technique; some others may be tenured drones who

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deliver set lectures from yellowed notes, making no effort to engage the bored minds of the students in front of them...Serious responses to complaints about undergraduate teaching have generated original and creative pedagogical and curricular experiments. But too often bold and promising efforts have vanished after external grant support disappeared, have withered on the fringes of the curriculum, or have been so compromised that their originality has been lost…Advanced research and undergraduate teaching have existed on two quite different planes, the first a source of pleasure, recognition and reward, and the latter a burden shouldered more or less reluctantly to maintain the viability of the institution." Among the recommendations to address these problems was the establishment of a "culture of teaching" that would recognize and reward teaching excellence, especially in large classes. While the commission did not deal specifically with science classes, the overlap with the Seymour and Hewitt results is persuasive.

2. The Proposal

In the late 1980s and early 1990s, the re-emergence of undergraduate science education projects funded by the National Science Foundation (NSF), following the elimination of funding for such projects in the early 1980s, spawned a number of successful models for effective physics teaching. A common thread among many of these projects was an increase in student involvement during class time, as a contrast to the traditional and passive lecture mode of teaching. Over the years these pedagogic techniques, which were classified under such rubrics as *cooperative learning* or *active engagement*, proved to be extremely robust and to enhance student learning in introductory physics classes at a wide range of institutions, from community colleges to research universities. Indeed, a common outcome among users of these techniques was a doubling of learning gains relative to traditional physics teaching methods.[4]

Dissemination of NSF-funded science education projects was supported in part during the early 1990s by the Undergraduate Faculty Enhancement (UFE) program, which allowed leaders of such projects the opportunity to conduct small workshops to acquaint potential adopters with their new developments. However, these projects tended to be rather specialized in nature, often dealing for example with advanced laboratory courses. Other disseminations took place through workshops conducted at the national meetings of the American Association of Physics Teachers (AAPT); such workshops can be mostly categorized as "preaching to the choir," because attendees at AAPT meetings tend to be self-selected based on their interest in physics teaching (and tend not to include faculty at research universities, only about 10% of whom are members of AAPT). Neither dissemination method afforded a direct confrontation with the situations addressed by the Seymour and Hewitt study or the Boyer Report.

During this same time, the NSF was seeking to enhance the role of the professional societies in dissemination of projects it supported. It thus seemed natural to address the need to acquaint recently hired faculty in physics with newly proven pedagogies through a national program operated through one of the physics professional societies, and the AAPT stepped forward in that role. In 1995 a steering committee was established and a proposal was submitted to the NSF for a national workshop for new physics faculty that would focus on a small number of well-tested pedagogic developments. It was decided to limit the workshop to the research universities (defined, somewhat more broadly than the traditional Carnegie classification, as those offering either a M.S. or a Ph.D. in physics), which comprise 70% of tenured physics faculty, provide 70% of introductory physics instruction, and produce a majority of majors. The NSF funded the project initially for 3 years to hold an annual workshop for 50 attendees (despite one reviewer's skepticism that we could attract 50 faculty members from research universities to a workshop about teaching), and the first program was held in the fall of 1996.

In preparing the NFW program, we consulted with and attended meetings of Project NExT, a program of the Mathematical Association of American for new faculty in the mathematical sciences.[5] However, it immediately became apparent that there were significant differences between the backgrounds of new faculty in physics and mathematics which rendered most of the Project NExT curriculum inappropriate for a physics workshop. Specifically, mathematics departments generally have fewer research assistantships than physics departments, and as a result it is common for mathematics graduate students to remain as teaching assistants during their entire Ph.D. programs, while physics graduate students generally serve as teaching assistants for only one or two years before switching to research assistantships. Furthermore, mathematics teaching assistants are often responsible for an entire class such as calculus, including delivering instruction and grading, but physics teaching assistants generally supervise laboratory sections in introductory physics, where they deliver no content and have no control over curriculum or final grades. As a result, new faculty in mathematics often have more exposure to and experience with various approaches to pedagogy than their colleagues in physics, and this difference materially affects the content of a workshop for new faculty.

3. The Workshop Realized

With the advice of the steering committee, it was decided to hold the workshop in the fall and not to couple it to any national conference of a professional society. The decision on the timing was made to avoid overlap with national conferences that focused on research as well as to balance the load on the meeting planners at the AAPT (which is responsible for major national conferences that are usually held in January and August). Summer was avoided because that is often when faculty at research universities are attending international research conferences or concentrating on advancing their research programs. We felt that new faculty at research universities would be unlikely to volunteer to attend a conference on teaching, so we sent letters to department heads inviting them to nominate their new faculty. Our target audience was faculty in the first 1-3 years of their initial tenure-track appointment.

We wanted funding not to be an issue that would affect attendance, so the NSF grant paid all workshop expenses except for the participants' transportation to the workshop site. We also felt that having all participants housed together at the same hotel would add to the bonding of the cohort group, and thus we did not want some participants on limited budgets to be shopping around for cheaper hotels. Expenses for the discussion leaders were also taken from the NSF grant, so it was not necessary to charge a registration fee. Moreover, contingency funds in the NSF grant were available for cases in which the home institution was unable to pay the transportation expenses (a rare occurrence for research universities) or in which special services were needed (such as child care).

It was decided to hold the workshops at the American Center for Physics (ACP) in College Park, MD. The ACP building is ideally suited for a small conference of fewer than 100 participants. Because the ACP is the national headquarters of the AAPT and other physics professional societies, AAPT support staff were available on site to assist with the logistics and personnel from the other societies could easily participate in and observe the workshops. Moreover, the participants gained a sense of "ownership" by holding the workshop in a facility that they support with their professional society dues, and there are fewer distractions as compared with a workshop sited in a hotel. This decision left us free to negotiate with area hotels over sleeping rooms and freed us from having to deal only with hotels that could offer sufficient meeting rooms. The University of Maryland allowed us to hold occasional workshop sessions in their physics building and also hired out buses to provide transportation between the ACP and the hotel.

The NSF grant included a budget for follow-up activities, which were planned to be of two types: (1) reunion meetings were to be held in conjunction with selected national meetings of the various professional societies, and (2) participants were invited to attend the summer meeting of the AAPT at which a session on concerns of new faculty was to be held. Because fewer faculty than anticipated chose to take advantage of these opportunities, we did not expend the funds allocated for these activities and as a result the original three-year grant was able to support the NFW program for five years. Although we advertised the program only to department chairs at research universities, each year we received requests from faculty at 4-year colleges and were able to include a few such faculty in the program. By year 4 we had decided that any future program under renewed NSF support should also include full participation by the 4-year colleges, so we opened up the program and attendance swelled to 73. In year 5 there were only limited funds remaining in the original budget so we held a small workshop for only 40 participants. In April 2001 we submitted a renewal proposal to the NSF for an expended 5-year program of up to 70 participants from any institution offering a baccalaureate in physics or astronomy or any related field. By this time the American Physical Society (APS) and the American Astronomical Society (AAS) had joined as co-sponsors of the program. The 6th workshop was held in 2001, funded by the AAPT because the new NSF grant had not yet been approved. The NSF renewal was received in early 2002; every program since that time has in fact exceeded 70 participants, but again having spent less than the budgeted amounts for the follow-up programs we have been able to run seven workshops under this grant. In 2008 we are again expanding the program by holding 2 workshops per year, one in June and one in November. In August 2008 we were notified that the NSF had awarded us another five-year renewal.

Table 1 shows a summary of the attendance since the inception of the program. Astronomers and astrophysicists (including those employed by departments of physics) originally constituted about 10% of the participants but their numbers have grown to close to 20% in recent years when invitations have also been issued to departments of astronomy. Women have constituted a nearly constant 22% of the participants, which exceeds their 15% representation in the physics Ph.D. pool.

4. The NFW Curriculum

The NFW has three formal goals: (1) to involve a significant fraction of the newly hired faculty in physics and astronomy; (2) to acquaint and familiarize the participants with recent and successful pedagogic developments; and (3) to effect an improvement in physics and astronomy teaching when the participants implement new pedagogies at their home institutions.

The program begins on a Thursday afternoon and ends at noon on Sunday. East coast participants can usually travel to the site on Thursday morning, and we encourage west coast participants to travel on Wednesday by paying for the extra night's lodging from the NSF grant. All participants can return to their home institutions on Sunday. A detailed program can be found on the AAPT web site.[6]

Although the main focus of the program is on issues related to effective teaching, we also involve the participants in discussions of other issues of concern to new faculty, such as tenure, time management, effective mentoring of research students, and extramural funding (the latter including opportunities to meet with program directors from NSF and Research Corporation). Because delivery of information is a significant goal of the NFW, much of the program is lecture-oriented. But each plenary session is coupled with small breakout groups (each usually involving 1/3 of the participants, perhaps 25-30 people) that allow for more open discussion and questions about practical implementation of the ideas advanced in the plenary sessions. Plenary sessions and discussion leaders who have participated in most of the NFW programs since its inception include:
"Research as a Guide to Improving Student Learning" – Lillian McDermott
"Introduction to Peer Instruction" – Eric Mazur
"Using Technology in Physics Instruction" – Robert Beichner
"How to Get Your Students to Prepare for Every Class" – Evelyn Patterson
"How to Help Your Students Develop Expertise in Problem Solving" – Kenneth Heller
"How to Increase the Number of Physics Majors at Your Institution" – Robert Hilborn
"Practical Advice from the Trenches" – Diandra Leslie-Pelecky
"Making a Difference: Teaching for Retention" – James Stith
Additional plenary sessions on learner-centered teaching and interactive pedagogies have been featured at many or most of the workshops. In addition, each workshop has included a plenary session on assessment and evaluation. Breakout groups include those offering practical experience using the techniques introduced at the plenary sessions, as well as opportunities to discuss other topics of interest, including digital libraries, tenure and time management, and teaching specific courses such as introductory physics, quantum mechanics, or astronomy. Each workshop has also included a dazzling display of physics demonstrations under the direction of Richard Berg from the University of Maryland.

5. Assessing the Impact of the NFW

How well are we meeting our goals? The first goal was to achieve a significant penetration of the faculty rosters. Table 2 shows that nearly 1/4 of the new hires have attended the workshop. Roughly 76% of the PhD-granting institutions have sent at least one faculty member. Six PhD-granting institutions have sent 10 or more faculty. Penetration of the 510 baccalaureate departments is more difficult to assess, for these institutions average only 4 physics faculty and thus have new hires only rarely. Moreover, travel budgets are often limited in small departments, and it is more difficult for faculty to arrange replacements when traveling. Nevertheless the data show that in recent years we have attracted about 1/3 of the hires at baccalaureate institutions. We feel that we are succeeding admirably at our goal of attracting a broad representation of the new hires in physics and astronomy.

Assessing progress at meeting the second and third goals is more difficult. The extent to which we have been successful at acquainting the participants with new developments in physics teaching can be assessed only through surveys of the participants,[7] which do indeed show significant gains in knowledge about new pedagogies. Most remarkably, 93.7% of the participants indicated a desire to incorporate some of these new ideas into their teaching. These data indicate that the NFW has made significant progress in achieving the second goal.

To what extent are we meeting the third goal of having this new knowledge showing an impact on teaching? Surveys of participants show that 70% rate their teaching as somewhat or significantly more innovative compared with that of others in their departments. That evaluation is reinforced by the views of the department chairs, 73% of whom believe that students in classes taught by NFW participants are better learners. Between 60% and 80% of the participants in the first 10 years of the NFW have responded that the workshop fully or considerably improved their skills in teaching, had a positive impact on their students, and motivated them to work to improve their teaching. More than half of the participants are using an interactive technique in every class or nearly every class. As many as 96% of the participants report changes in their teaching since attending the NFW, and of those 40-60% indicate that most or all of the changes are a direct result of their participation in the NFW. These survey responses indicate that the third goal is being met as well. It should be noted that this enthusiasm of the NFW participants to adopt new teaching strategies suggested by physics education research stands in contrast to the findings of the study by Henderson and Darcy[8], whose work revealed a significant resistance of physics faculty to implement these strategies to the fullest extent. Perhaps the format of the NFW offers a means of dissemination of the results of physics education research that is less threatening to and more supportive of newer faculty, providing realistic expectations for outcomes and allowing them to become agents for change at their institutions.

And while we are too modest to take credit for this, we note that soon after the inception of the NFW the declining trend in the number of physics baccalaureates was reversed into a steady growth, with the number now exceeding that at any time since the immediate post-Sputnik era of the 1960s.

What is most rewarding for the organizers of this program is to read the comments of the participants. From a faculty member, now tenured, at a Ph.D.-granting institution: “Following the workshop I tried using several of the new … tools that were presented…The results of these innovations have been so positive that other faculty who have subsequently taught the same courses have kept many of the same tools in place. In this sense, the New Faculty Workshop has benefited not only my own classroom performance but my entire department. The Workshop also helped me formulate goals for the educational activities associated with my NSF CAREER award. For young faculty thinking about writing a CAREER proposal, the Workshop is an incredibly valuable opportunity to find out what's going on in physics education."

From a faculty member, also now tenured, at a highly selective liberal arts college: "I consider this workshop to have been an invaluable contribution to my development as an effective physics educator. The workshop introduced me to a variety of cutting edge techniques in physics pedagogy, enabled me to develop a nationwide network of connections among new faculty members in physics, and introduced me to the community of physics education researchers. I have adopted several of the teaching techniques discussed at the workshop in my own teaching….I am delighted with the changes in classroom dynamics resulting from better-prepared students and my own new insights into the particular difficulties with which my students are struggling…"

And from a department head at a Ph.D.-granting institution where 1/4 of the faculty have attended the workshop: "As a department chair, I believe that these workshops are more effective than I could ever be at convincing new professors that both the teaching and research they do will be recognized by their profession… I believe the workshops have helped change the culture at my University to place greater value on excellent physics teaching. Our younger faculty have come to believe this with an enthusiasm with which they are gradually infecting the entire faculty of my Department." This department chair attributes the reversal in the declining number of physics baccalaureates in that department directly to the improvement in teaching.

6. Discussion and Conclusions

Like any successful program, the NFW must grow and develop as its audience changes. During the past 12 years, we have seen a significant change in state of prior knowledge of our participants about physics education reforms. For example, when we now ask participants how many have heard of Peer Instruction, most of the hands go up. That's a major change from the early years when perhaps 10% of the participants would respond. So in many aspects the role of the workshop is gradually changing from transmitting information to facilitating implementation.

We recognize that most of our audience has, at this stage of their careers, only a passing interest in pedagogy and in physics education research, because more "traditional" areas of research and scholarship are paramount in achieving tenure in most physics and astronomy departments. Many of the participants have never attended a physics education conference and may never do so. Recognizing that we may get only one shot at changing their teaching, what is our best approach? If attendance must be limited (as it occasionally has been), is it more effective to have two participants from different institutions or two from the same institution? That is, do we get a greater impact from spreading the word to two new schools or from providing a new faculty member with a supportive colleague? Should we offer a smorgasbord of reformed physics education ideas and let participants choose from among many options, or should we instead focus on a few selected techniques in more depth, including hands-on implementation? What is the proper mix of plenary and small-group sessions? The irony of offering lecture-based plenary sessions about the ineffectiveness of the lecture method has not escaped the notice of the organizers.

There are always significant questions about whether a four-day program can have a long-term impact on teaching habits. We recognize the importance of follow-up sessions, such as by bringing former participants together after a first level of experiences for more in-depth discussions of implementation or even post-tenure for a refresher course. In June 2007 a reunion was held for 50 NFW participants from the years 1996 to 2005. This program allowed the former participants, many of whom had attained tenure, an opportunity to re-connect with developments in pedagogy. It also provided the organizers with valuable feedback on the long-term impact of the NFW and the components of the program that were most valuable and effective for these participants.

Might a program of this type be effective for faculty in other STEM disciplines? There are several characteristics of the physics-astronomy community that have been essential for the success of the NFW: (1) Physics education research is a mature field with a large community of researchers. There is widespread agreement within this community about what constitutes "best practices" for teaching introductory physics, a course which is taken by virtually all majors in basic and applied science and engineering and which is offered with nearly identical content at institutions throughout the U.S. Within the physics academic ranks, there is thus a commonality of instructional challenges and remedies that transcends institutional types. (2) The small size of the physics community (compared with other STEM disciplines) allows our program to have a major impact on the field while keeping the number of participants small. We have found this size to be essential in fostering discussion and interactions among the participants and between the participants and the presenters. There are often lively discussions during the plenary sessions (where many of our speakers model good teaching practices by encouraging active engagement of the participants in small groups), and the plenary speakers can easily circulate among the 3 breakout groups to continue the conversations. These kinds of interactions would not be possible if the audience were significantly larger. (3) The program has enjoyed the strong support of all the major professional societies, whose emphases range from primarily teaching (AAPT) to primarily research (APS and AAS). In particular, the enthusiastic support by APS and AAS may in part be responsible for the active participation by the Ph.D.-granting institutions, many of which do not normally participate to a significant extent in AAPT programs.

Many of our former participants are now serving as department chairs, in which capacity they are sending their new faculty to the NFW. This represents a first step in changing the culture of physics and astronomy teaching in a manner that responds to the recommendation of the Boyer Report. The organizers of the NFW are pleased with these developments and look forward to further changes until faculty recognition and rewards for success in teaching are accorded parity with success in research.

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References

1. American Institute of Physics Report R-151.43 (September 2008).

2. E. Seymour and N. Hewitt, *Talking About Leaving: Why Undergraduates Leave the Sciences* (Westview Press, 1997)

3. Reinventing Undergraduate Education: A Blueprint for America's Research Universities (Report of The Boyer Commission on Educating Undergraduates in the Research University, 1998. http://naples.cc.sunysb.edu/Pres/boyer.nsf/)

4. R.R. Hake, "Interactive-engagement vs. traditional methods: A six-thousand-student survey of mechanics test data for introductory physics courses," *Am. J. Phys.* **66**, 64- 74 (1998).

5. http://archives.math.utk.edu/projnext/

6. http://www.aapt.org/Events/newfaculty.cfm

7. C. Henderson, "Promoting instructional change in new faculty: An evaluation of the physics and astronomy new faculty workshop," *Am. J. Phys.* **76**, 179 (2008).

8. C. Henderson and M. H. Darcy, "Physics faculty and educational researchers: Divergent expectations as barriers to diffusion of innovations," *Am. J. Phys.* **76**, 79 (2008).

Table 1. Summary of New Faculty Workshop Participation

Year	Highest physics degree of institution				Total	Astronomy & Astrophysics	Women
	None	BS/BA	MS	PhD			
1996	0	7	1	42	50	16.0%	22.0%
1997	0	9	1	47	57	10.5%	22.8%
1998	3	10	2	43	58	8.6%	12.1%
1999	1	30	3	39	73	13.7%	24.7%
2000	0	9	2	29	40	12.5%	22.5%
2001	3	32	5	25	65	24.6%	30.8%
2002	1	35	3	39	78	7.7%	23.1%
2003	6	40	5	40	91	19.8%	20.9%
2004	3	40	7	42	92	21.7%	17.4%
2005	1	39	6	40	86	18.6%	26.7%
2006	1	35	6	37	79	13.9%	27.8%
2007	2	29	4	47	82	19.5%	20.7%
2008	4	33	9	43	89	19.1%	19.1%
Total	**25**	**348**	**54**	**513**	**940**	**16.4%**	**22.3%**

Table 2. NFW Participants as a Fraction of New Hires

Year	Highest physics degree of institution			Total
	BS/BA	MS	PhD	
1998	9.6%	8.7%	31.4%	22.0%
2000	7.8%	7.1%	15.2%	11.9%
2002	28.2%	9.4%	19.8%	22.1%
2004	35.7%	20.0%	19.6%	25.5%
2006	29.7%	18.2%	18.0%	22.2%