The Role of Scientific Societies in STEM Faculty Workshops

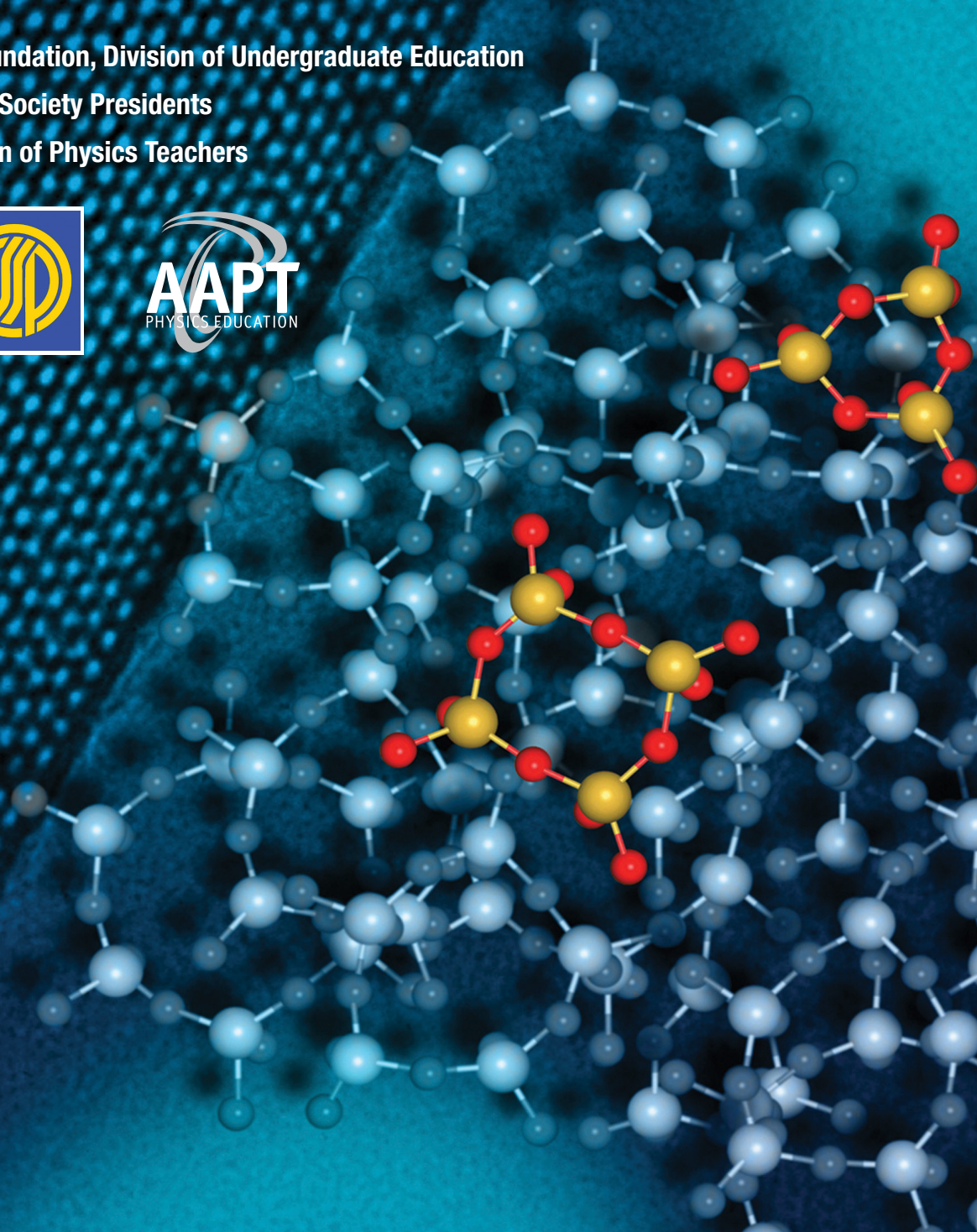
A Report of the May 3, 2012 Meeting

Supported by

National Science Foundation, Division of Undergraduate Education

Council of Scientific Society Presidents

American Association of Physics Teachers



The Role of Scientific Societies in STEM Faculty Workshops

A Report of the May 3, 2012 Meeting

Council of Scientific Society Presidents
American Chemical Society
Washington, D.C.

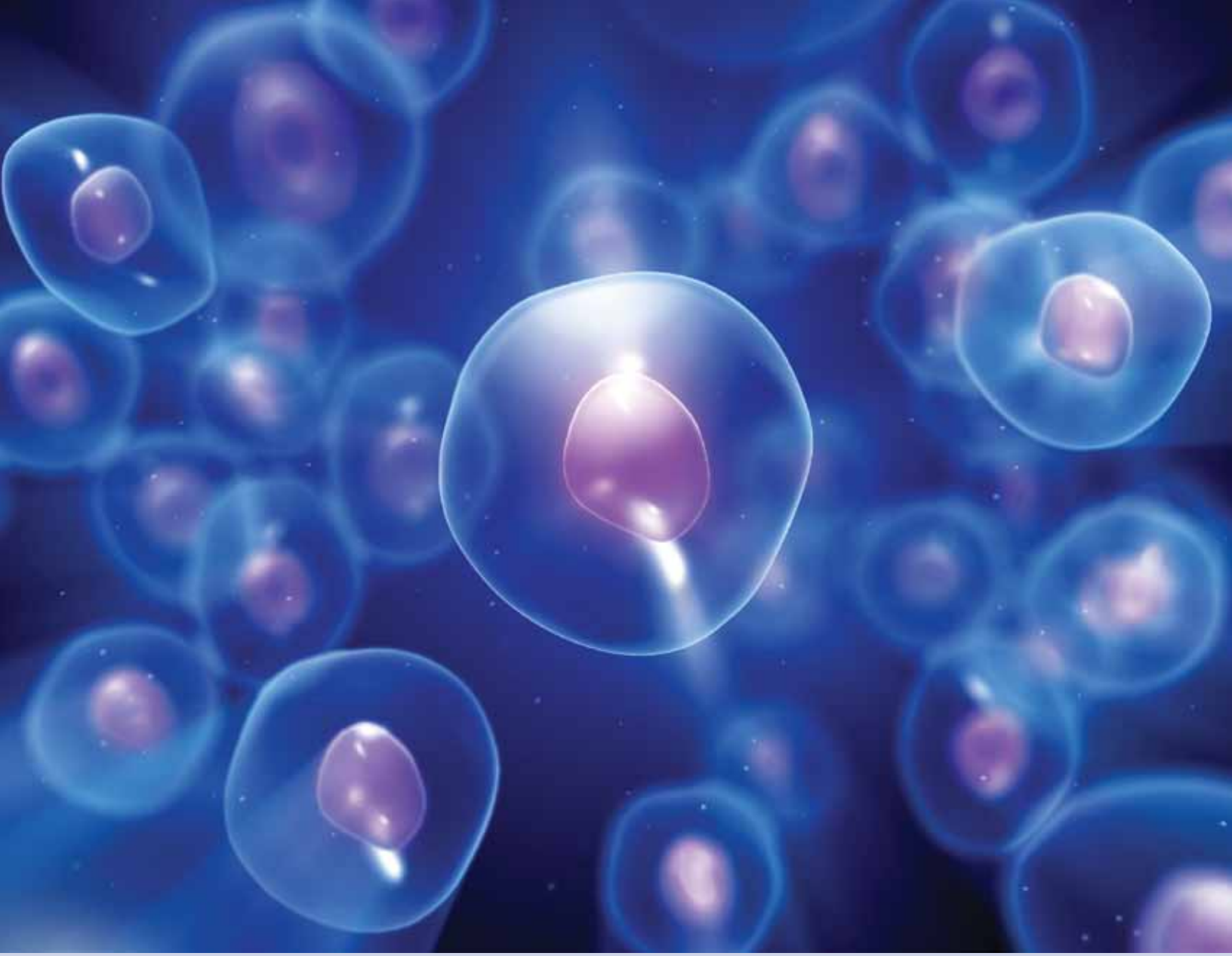
Supported by:

National Science Foundation, Division of Undergraduate Education
Council of Scientific Society Presidents
American Association of Physics Teachers

National Science Foundation
WHERE DISCOVERIES BEGIN

THE COUNCIL OF SCIENTIFIC SOCIETY PRESIDENTS

AAPT PHYSICS EDUCATION
American Association of **Physics Teachers**
Enhancing the understanding and appreciation of physics through teaching

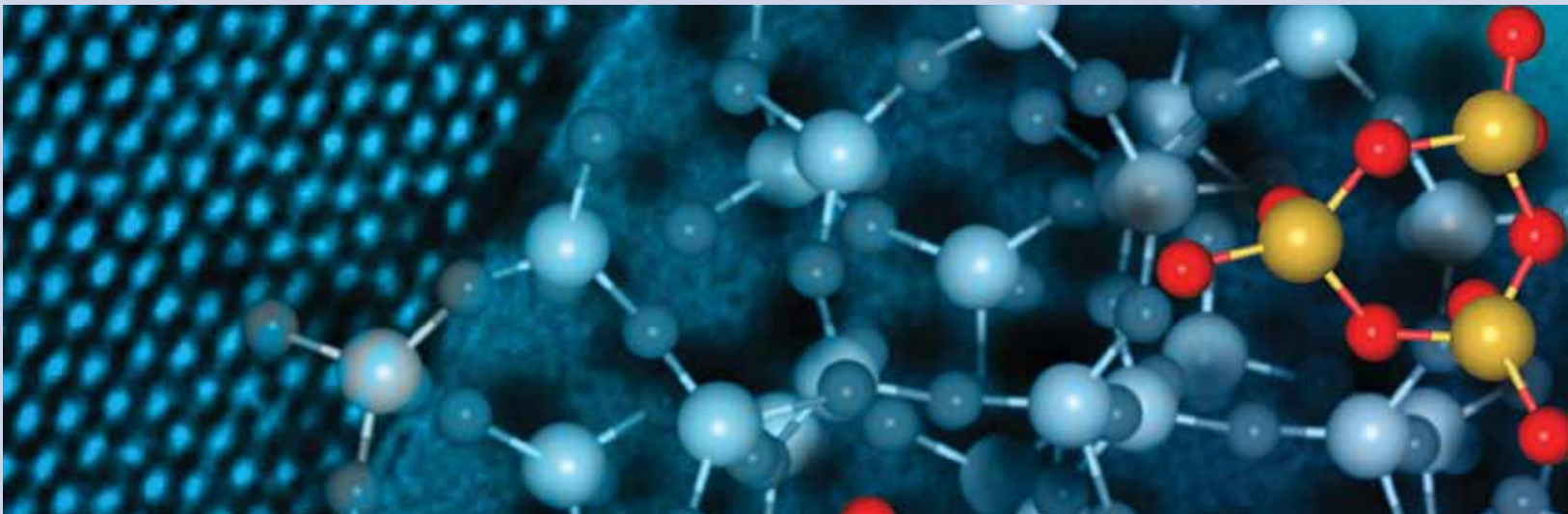


Preface

This report contains expanded versions of the presentations given at the May 3, 2012, conference on The Role of Scientific Societies in STEM Faculty Workshops, held in conjunction with the meeting of the Council of Scientific Society Presidents. Together, these contributions describe the current scientific society efforts to improve the teaching and pedagogical knowledge and skills of college and university STEM faculty members. Two education researchers address some of the evidence of the effectiveness of these efforts.

The May 3 meeting and the writing and dissemination of this report were supported by a generous grant from the National Science Foundation (DUE 1230391).

Table of Contents



The Role of Scientific Societies in STEM Faculty Workshops

Meeting Overview

Robert C. Hilborn, *American Association of Physics Teachers*

Introduction

Recent reports (AAU, 2011) (President's Council of Advisors on Science and Technology, 2012) that call for the enhancement of undergraduate Science, Technology, Engineering, and Mathematics (STEM) education have all recognized the importance of STEM faculty development in implementing those enhancements. Recognizing that most STEM faculty begin their teaching careers with little or no professional training in teaching and little or no knowledge about the evidence for effective teaching practices (The Boyer Commission on Educating Undergraduates in the Research University, 1998), several scientific societies have organized multi-day workshops and other professional development activities for STEM faculty members, most often focusing on those in the first few years of their tenure-track appointments. In what follows, I will refer to these workshops and related activities as "programs" since many of the "workshops" have continuing activities that go beyond an initial face-to-face meeting.

What do we know about how those STEM faculty programs are structured? What is known about the effectiveness of those programs in stimulating STEM faculty to implement successful teaching strategies and how do those implementations affect student learning? What should be the role of STEM disciplinary societies in these programs? To begin to answer those questions, a meeting was held in Washington, D.C., on May 3, 2012, bringing together the leaders of seven of those programs along with two science education researchers who have studied the effects of those programs. The programs, the disciplines, the sponsoring scientific societies, and the two education researchers are listed in Table I.

Table I. Programs and evaluators represented at the May 3, 2012 meeting.

PROGRAM	DISCIPLINE	SPONSORING SOCIETY
National Academies Summer Institutes on Undergraduate Education in Biology	Biology	Howard Hughes Medical Institute, National Academy of Sciences
Cottrell Scholars Collaborative New Faculty Workshop (Chemistry)	Chemistry	Research Corporation for Science Advancement, American Chemical Society
National Effective Teaching Institute	Engineering	American Society for Engineering Education
ExCEED	Civil Engineering	American Society for Civil Engineering
On the Cutting Edge – Geoscience Early Career Faculty Workshop	Geosciences	National Association of Geoscience Teachers
Project NExT	Mathematics	Mathematical Association of America
ASM Conference for Undergraduate Educators	Microbiology	American Society for Microbiology
Physics and Astronomy New Faculty Workshop	Physics and Astronomy	American Association of Physics Teachers, American Astronomical Society, American Physical Society
Diane Ebert-May	Faculty Institutes for Reforming Science Teaching, National Academies Summer Institute	Evaluation and Research
Charles Henderson	Physics and Astronomy New Faculty Workshops	Evaluation and Research

Each of the program leaders and the education researchers gave presentations at the May 3 meeting, which was held in conjunction with a meeting of the Council of Scientific Society Presidents at the headquarters of the American Chemical Society. A generous grant from the National Science Foundation's Division of Undergraduate Education supported the meeting expenses. The meeting schedule is found in the Appendix to this report. The meeting was attended by scientific society presidents, other representatives from scientific societies, program officers from funding agencies, and the leaders and evaluators of the STEM faculty workshops. Nobel Laureate and then Associate Director for Science at the White House Office of Science and Technology Policy Carl Wieman gave the keynote address.

In this overview, I provide a summary of the common practices used in the STEM faculty programs. I will also highlight distinctive features of some of the programs that might well be adopted by other professional societies. After providing a framework for thinking about STEM faculty programs that focus on pedagogy, I will articulate a set of arguments for the crucial role of scientific societies in sponsoring such programs. I summarize advice for other scientific societies that may wish to institute programs for faculty members in their disciplines.

In the sections of the report that follow this overview, the program leaders and education researchers provide summaries of the programs and the research that examines the effectiveness of such programs. A common template gives the basic facts and figures for each program and provides a link to websites providing more details. The data in the templates were compiled in the summer of 2012. Updated information can be found at each program's website or by contacting the contributors.

Common goals and practices

Goals

Simply stated, the goals of all of the STEM faculty programs discussed here are to develop expert competence in teaching, to enhance faculty views of teaching as a scholarly activity, and to promote the use of evidence in evaluating the effectiveness of teaching practices. Underlying these goals is the broader goal of enhancing student learning in STEM fields and improving student attitudes about the importance of STEM in our society and in the attractiveness of STEM careers. All of the initiatives focus on the goals directly related to faculty professional development and there is reasonable evidence, to be described below, that indicates that they are successful in increasing faculty members' knowledge about effective pedagogy and encouraging them to adopt those pedagogical methods in their classes. On the other hand, evidence also indicates that the programs may not be as successful as one would like in having faculty continue to use effective pedagogical techniques. Furthermore, reliable measurements on effects on student learning are both difficult and expensive to carry out and are not used at all by the current approaches to examine the impact of these professional development experiences on their participants' students.

All of the initiatives promote, either explicitly or implicitly, the importance of "scientific teaching" (Handelsman et al., 2004). Scientific teaching is a way of thinking about teaching and learning that promotes investigation of teaching with the kind of rigor associated with traditional research in science. Scientific teaching promotes use of pedagogical methods that have been systematically tested and shown to enhance student learning. All of those techniques use "interactive-engagement" methods; that is, students are not viewed as passive recipients of knowledge handed down from authority, but are actively engaged in their developing their own mental models of the material at a deep conceptual level as well as integrating that knowledge into a larger framework for solving problems and seeing connections of major principles across STEM disciplines. In a subsequent section, I will elaborate these ideas in a more detailed theoretical framework.

Target audience

Some of the STEM faculty programs focus on early-career faculty members, typically in the first few years of their tenure-track appointments; others include both junior faculty and more senior faculty. For example, in the microbiology workshop, about half the participants have been teaching fewer than 10 years and 40-50% are new to the programs each year. Some focus on faculty from research-intensive universities, others include faculty from primarily undergraduate institutions and two-year colleges.

Number of participants

The number of participants ranges from about 40 for the newly established chemistry workshops through more than 325 for microbiology. Detailed numbers are given in the templates accompanying the leaders' contributions to this report.

Fraction of disciplinary faculty involved

What fraction of STEM faculty participates in these professional development experiences? That number varies widely from discipline to discipline. For example, about 6% of engineering faculty members across the country participate in one of the two initiatives described in this report. The physics and astronomy workshops for new faculty now engage about 50% of the new hires in those fields in recent years.

Length of the programs

It should be obvious that developing expert competence in a discipline as complex as STEM teaching requires a significant amount of time. The leaders of these initiatives recognize that the few days they spend with the participants can only begin the long process of professional development needed to achieve that competence. The process requires allowing for sufficient time to learn about and try out several pedagogical techniques and to have discussions, both formal and informal, with the presenters and other participants. The various approaches to professional development use several different time formats. The chemistry workshops are currently set for two days due to limitations in funding. The civil engineering programs run for six days. Project NExT in mathematics utilizes several two-day workshops spread out over a year.

Locations

Most of the existing STEM faculty programs are stand-alone workshops, not associated with other meetings. However, all three of the Project NExT face-to-face meetings are held in conjunction with the national meetings of the Mathematical Association of America. Most program organizers argue that the stand-alone meetings avoid the many distractions associated with larger professional society meetings and do not require the participants to be away from their labs and research groups for an excessively long period of time.

Some STEM workshops, not described in this report, are run locally. For example, Richard Felder runs a workshop for engineering and science faculty at North Carolina State University (Brent & Felder, 2012).

Presenters and leaders

The program presenters are a mix of the leading discipline-based education researchers in the field and peer leaders, who are experienced and knowledgeable in the implementation of teaching materials and pedagogical methods based on and validated by discipline-based education research (Singer, Nielsen, & Schweingruber, 2012).

Some programs (physics and astronomy, for example) use presenters who are pioneers for each of the pedagogies presented; other initiatives use faculty members who have implemented those pedagogies but are not necessarily the

"big names" in education in that discipline. Some include presenters who are actively engaged in formal STEM education research; others are faculty members who discuss the evidence for effective practices, but are not themselves STEM education researchers.

Schedules

The program descriptions that appear later in this report provide details of the schedules. The meetings generally consist of a mix of plenary sessions, often carried out with interactive engagement techniques—to model what the leaders hope the participants will implement in their home institutions—and smaller breakout and discussion sessions.

Some of the programs (biology, chemistry, and civil engineering) have the participants develop short lessons ("teachable tidbits") or the framework for an entire course, which are then critiqued by the other participants. This procedure gives the participants direct feedback as they implement the pedagogical strategies discussed in the meetings. The geoscience program has participants develop posters about a plan for their teaching. These plans range from single teaching activities to a framework for an entire course. Following reviews of the plans by other participants and leaders, the participants write up their reflections.

Disciplinary focus

While many effective pedagogical practices cut across disciplines, their effective implementation requires broad knowledge of the discipline and its modes of discussion and argument. Hence, all of the programs described here have the participants think about (and in some cases practice) effective pedagogical methods within the context of the discipline. This method builds on the content knowledge of the participants and prepares them more directly for the teaching decisions they will need to make in their own classrooms. Furthermore, having the presenters and leaders be disciplinary experts gives the programs a credibility that would be difficult to develop if the programs focused only on broadly applicable educational principles.

Financial support

Most of the programs use a business model in which funding is covered in large part by grants from federal funding agencies, private foundations and the host professional societies. In most cases, the participants' home institutions cover the cost of travel to and from the meeting. Typical costs (exclusive of travel to and from the meeting site) are about $250-$350/day for each participant. These costs include housing, meals, materials, and the travel and hotel expenses for presenters and leaders. The National Academies Institutes require that senior administrators on a campus commit to providing additional funds to support the participants' implementation of the techniques learned during the Institutes after they return to their home institutions. Most program leaders believe it is important for the participants' home institutions to pay some of the costs to indicate their commitment to the participants' professional development.

Other professional development activities

Most of the programs include, in addition to presentations and discussions on pedagogy, sessions on other professional development issues such as time management, mentoring research students, and preparing for tenure decisions. A few of the programs include presentations by program officers from federal and private funding agencies on developing effective research and education grant proposals; one includes a day of meetings at the National Science Foundation.

Follow-up activities

As mentioned previously, all of the program leaders recognize that a one-time workshop is unlikely to produce the kind of expert teaching competence required of an effective instructor. The programs use a variety of mechanisms to continue interactions among the participants (peer mentoring and coaching) and with the program leaders. For example, Project NExT uses experienced mathematics faculty members as consultants for the new faculty participants. The chemistry workshops use Research Corporations' Cottrell Scholars as peer mentors for their participants. The chemistry peer mentors call participants twice a year. The peer mentors are provided with talking points to facilitate conversations and ensure that critical topics (active learning) are covered. The *On the Cutting Edge* website provides resources to support early-career faculty.

Other programs use a variety of follow-up activities to keep the participants engaged. For example, the National Academies Summer Institutes program holds a meeting, funded by Howard Hughes Medical Institute, six months after the initial summer institute for one member from each participating university team. The American Society for Engineering Education hosts NETI-2 workshops for alumni of the NETI workshops and more experienced faculty. The Physics and Astronomy New Faculty Workshop series hosts Reunion Meetings every two years for participants from previous workshops. Informal gatherings are also held at the national meetings of the American Association of Physics Teachers and the American Physical Society. As mentioned previously, Project NExT, as part of its regular program, hosts three consecutive workshops at the national meetings of the MAA.

Theoretical framework for STEM faculty pedagogical professional development

In the previous section, I described some of the structure and common practices of the STEM faculty programs. What is the "theory" that lies behind these programs? At their core, these initiatives provide information to the participants about effective teaching practices and what is known about student learning. A valuable and accessible summary of what is known about learning and the evidence that supports those conclusions is found in the recent book *How Learning Works: Seven Research-Based Principles for Smart Teaching* (Ambrose, Bridges, Lovett, DiPietro, & Norman, 2010).

The seven principles for smart teaching are the following:

1. Students' prior knowledge can help or hinder learning.
2. How students organize knowledge influences how they learn and apply what they learn.
3. Students' motivation determines, directs, and sustains what they do to learn.
4. To develop mastery, students must acquire component skills, practice integrating them, and know when to apply what they have learned.
5. Goal-directed practice coupled with targeted feedback enhances the quality of students' learning.
6. Students' current level of development interacts with the social, emotional, and intellectual climate of the course to impact learning.
7. To become self-directed learners, students must learn to monitor and adjust their approaches to learning.

Although these principles might not be explicitly mentioned in this form in the STEM faculty programs, they nevertheless capture most of what is known about student learning and help give a structure to effective teaching practices.

The concluding section of *How Learning Works* is titled "Applying the Seven Principles to Ourselves." Here the authors note that for faculty members "…when it comes to teaching, most of us are still learning." They point out that becoming an effective teacher is a long-term process of continual learning and refinement and that as such, learning to improve one's teaching ought to be guided by the general learning principles articulated in their book. Thus, I argue, the STEM faculty workshops should be built around these seven principles as they apply to faculty learning to improve their teaching.

Here I have reframed the *How Learning Works* seven principles to apply to faculty members' learning about teaching. I use the word "teachers" to include college and university faculty members as well as K-12 teachers, though the education and professional development of K-12 teachers is not considered explicitly here.

The seven principles of learning to be an effective teacher are:

1. Teachers' prior knowledge can help or hinder teaching and hence student learning.
2. How teachers organize knowledge about teaching and learning influences how they learn about teaching and apply what they learn.
3. Teachers' motivation determines, directs, and sustains what they do to learn about teaching.
4. To develop mastery, teachers must acquire component skills, practice integrating them, and know when to apply what they have learned.
5. Goal-directed practice coupled with targeted feedback enhances the quality of teachers' pedagogical behavior and their students' learning.
6. Teachers' current level of development as professionals interacts with the social, emotional, and intellectual climate of the classroom and institution to impact learning.
7. To become self-directed professional educators, teachers must learn to monitor and adjust their approaches to teaching and learning.

I now illustrate how several of these principles ought to inform the structure of STEM faculty workshops. **Principles 1** and **2** remind us that many faculty members (both new and experienced) bring with them a flawed model of teaching and learning. For them, teaching is primarily information (content) transfer, and since PhDs are generally experts in the content of their disciplines, the faculty members should also be good teachers. Many faculty members believe that they learned well from listening to lectures and therefore they should focus on preparing and delivering polished lectures.

Principle 2 tells us that all of us have a "theory of learning" and that theory shapes both what we do and how we do it in our teaching. In addition, effective teachers are masters of not only content knowledge but know how students learn (or fail to learn) that content. The latter knowledge is called "pedagogical content knowledge" (Schulman, 1986). Good teaching requires more than strong content knowledge because the goals of effective teaching are more complicated: we want students to develop conceptual understanding, problem-solving skills, scientific and engineering practices, research skills, attitudes about STEM, and expert-like thinking—all of which are required for effective learning and the successful application of what has been learned.

Principle 3 reflects the reality that even if we know what constitutes effective teaching, we may not implement that knowledge because we believe that we will not be rewarded by our colleagues, our departments, and our institutions for taking the time to do that. In fact, many faculty members believe that they will be suspect professionally if they spend "too much time" on teaching. This principle reminds us that no matter how well constructed STEM faculty workshops are, the participants have to implement the practices in the reality of their departmental, institutional, and professional cultures. Alas, some aspects of those cultures actively work against the implementation of effective pedagogy.

Principles 4, 5, and **6** emphasize the importance of deliberate practice and feedback in developing expert competence in teaching. Just as students need appropriate and challenging practice and activities to learn organic chemistry or systems engineering, we as developing teachers need to try out pedagogical methods with the appropriate coaching in order to develop expert-like practices. These principles tell us that mechanisms need to be in place to assist workshop participants with deliberate practice and feedback once they are back in the home institutions. In some cases, the departments have enough faculty members with experience with scientific teaching to be able to coach and mentor workshop participants. Unfortunately, in many cases, that local support is not available and it is important for the STEM faculty workshop leaders and sponsors to find mechanisms that will support ongoing deliberate practice and feedback.

As an aside, I note that the concept of "deliberate practice" has been recognized as crucial for developing expert knowledge and behavior in many fields. For a readable discussion of this issue in the business world, Geoff Colvin's recent book (Colvin, 2010) provides a good introduction.

Principle 7 articulates the goal of having the faculty members reach a level of professional teaching competence that enables them to monitor their own development as teachers.

Are the STEM faculty programs effective?

Before we can answer this section's titular question, we need to specify the goals of the STEM faculty programs. As mentioned previously, the common goals are to develop expert competence in teaching, to enhance faculty views of teaching as a scholarly activity, and to promote use of evidence in evaluating the effectiveness of teaching practices. Those goals support enhancement of student learning in STEM fields and the improvement of student attitudes about the importance of STEM in our society and in the attractiveness of STEM careers. Of course, the specific objectives may vary from program to program. But once the goals are laid out, we can raise the question of evaluating the achievement of those goals. This evaluation can be carried out at three levels (Chism & Szabo, 1998) :

- **User Satisfaction**
- **Impact on Teaching**
- **Impact on Student Learning**

The first level is relatively easy to address and most STEM faculty programs administer post-meeting surveys that probe the participants' satisfaction with the program activities. In almost all cases, those satisfaction ratings are quite high, indicating that the participants believe that the programs have helped them with their teaching. In some cases, these results are confirmed by surveys administered to the participants' department chairs.

The second evaluation level is more problematic. Many participants claim that they are implementing the effective pedagogical techniques presented at the program meetings. But close examination of actual teaching practices (see the contribution by Ebert-May, et al. in this report) through classroom visits or examinations of video recordings of class sessions indicates that many of the participants have reverted to primarily passive lecture methods or use pedagogical practices in ways that are not faithful to what is known as effective for those practices. For example, many participants claim they are using peer instruction or think-pair-share methods of student discussion, when in fact they are using "clickers" (electronic response systems) primarily to take attendance or administer quizzes with no accompanying student-to-student discussion.

The third level of evaluation has been (and will probably remain) elusive. Although there is a substantial body of research-based evidence of the effectiveness of the pedagogical practices used in the STEM faculty programs (Singer, Nielsen, & Schweingruber, 2012), we would like to know if the faculty development programs are successful in getting the participants to implement those practices in an effective way.

There are many difficulties with measuring the impact of these faculty development experiences on student learning: there are few standardized sets of STEM learning objectives and few nationally normed assessment instruments (especially at the post-secondary level) to measure what students have learned. Those instruments that do exist may not assess the scientific practices and knowledge we want to emphasize. Even if appropriate instruments were available, carrying out randomized, controlled experiments on student learning is expensive and difficult, particularly in smaller institutions where there may be only one section of introductory physics, for example. In some cases, we

may need to rely on secondary measures of student learning such as retention rates as STEM majors, performance in upper-level courses or on discipline-focused graduate record examinations, or the number of non-STEM students who opt to enroll in STEM courses beyond the number that their college or university requires to fulfill degree requirements.

The role of STEM professional societies

Why should STEM professional societies, whose main purpose is the promotion of research within the various STEM disciplines, be involved in STEM faculty professional development programs? There are several reasons:

1. Most beginning college and university faculty members feel more loyalty to their disciplines than to their home institutions (The Boyer Commission on Educating Undergraduates in the Research University, 1998). Hence, many faculty members will listen closely to recommendations from STEM professional societies about the importance of effective teaching.
2. The disciplinary societies to a large extent set the norms and expectations for professional work within the disciplines: what counts as research in the discipline, what are the standards for publication, and what professional behaviors are rewarded and recognized by others in the discipline? Consequently, involvement of the STEM disciplinary societies in promoting the adoption of more effective teaching and the importance of disciplinary-based education research (Singer et al., 2012) is crucial for the health of the educational enterprise associated with that discipline and for the health of the discipline itself.
3. The disciplinary societies can provide a national venue for STEM faculty professional development in teaching that transcends the confines of individual institutions and embeds that educational professional development with other forms of STEM professional development with resources generally not available to individual colleges and universities.
4. The meetings of the disciplinary societies, attended by many college and university faculty, provide a venue for continued interaction among the participants in the STEM faculty workshops and educational leaders in the discipline.
5. The disciplinary societies provide a forum for the disciplinary community to articulate learning goals and objectives for educational programs in each discipline. That activity has a long history in chemistry and engineering, where professional certification plays an important role. More recent efforts in microbiology (see the report by J. Washington and T. Primm in this volume) have been successful in engaging a large fraction of the community. The physics community is just beginning efforts to articulate common goals and expectations for physics undergraduate programs.
6. If they were to collaborate actively, the disciplinary societies can provide a venue for the development and dissemination of nationally normed assessments of student learning and student attitudes across the STEM disciplines. While the development of those assessments requires the skills and expertise of disciplinary-based education researchers, the disciplinary societies can provide the community-wide support that is necessary for those assessment efforts to be widely adopted.

What is needed to enhance the adoption of effective pedagogy?

In spite of several decades of STEM education research, undergraduate STEM curriculum development projects, and many STEM faculty workshops focusing on innovative and effective pedagogical techniques, there is evidence that the

STEM faculty community has not yet widely adopted such techniques. For example, the recent National Research Council report on Discipline-Based Education Research (DBER) (Singer, Nielsen, & Schweingruber, 2012) states (p. 3):

> "… that DBER and related research have not yet prompted widespread changes in teaching practice among science and engineering faculty. Different strategies are needed to more effectively translate findings from DBER into practice. These efforts are more likely to succeed if they are consistent with research on motivating adult learners, include a deliberate focus on changing faculty conceptions about teaching and learning, recognize the cultural and organizational norms of the department and institution, and work to address those norms that pose barriers to change in teaching practice.
>
> "To increase the use of DBER findings, the committee recommended that current faculty adopt evidence-based teaching practices to improve learning outcomes for undergraduate science and engineering students, with support from institutions, disciplinary departments, and professional societies. Moreover, institutions, disciplinary departments, and professional societies should work together to prepare future faculty who understand the findings of research on learning and evidence-based teaching strategies."

Some of the reasons for this lack of widespread adoption have been explored in the contributions by Ebert-May and Henderson in this report and the references cited therein. Here I want to emphasize the importance of the departmental and institutional environment and expectations and the role of scientific societies in shaping those environments and expectations.

Several reports have concluded that for successful reform of higher education pedagogy, the department is the crucial unit of change and that departmental expectations are highly influenced by the expectations of the relevant disciplinary societies (as well as by local, institutional expectations). The reports on the Strategic Programs for Innovation in Undergraduate Physics (SPIN-UP) (Hilborn & Howes, 2003) and Achieving Excellence in Engineering Education (Graham, 2012) efforts provide both arguments and case studies for this point of view. A recent paper by Wieman, Perkins, and Gilbert (Wieman, Perkins, & Gilbert, 2010) also emphasizes the role of the department in transforming science education in large research universities.

The SPIN-UP report emphasizes that what happens outside the classroom (mentoring, student research, student engagement in outreach programs, career information, and so on) is often just as important as what happens in classes in determining whether students stay on as STEM majors and graduate. In that regard, professional societies can provide case studies and analysis of "thriving" undergraduate programs to give guidance to other departments that wish to enhance their programs. For example, the Building Strong Geoscience Departments program provides much information on developing thriving departments at http://serc.carleton.edu/departments/index.html.

Advice for other STEM disciplinary societies

From the contributions included in this volume, I summarize some advice for STEM disciplinary societies that would like to initiate faculty workshops for their members:

1. Use workshop leaders who are strongly grounded in the discipline, well known in the field, and who have themselves adopted the active learning techniques that the programs described in this report have attempted to impart to participants.
2. To increase the reach of the workshops, recruit faculty participants broadly among institutions, particularly minority-serving institutions and community colleges (see below), which historically have been less connected with professional societies.
3. Develop a funding model that allows faculty from institutions with modest resources to participate.
4. Provide a suite of follow-up activities and mentoring and coaching opportunities for participants to help them persist in their adoption of effective pedagogical practices.
5. Use the professional society's publications and meetings to highlight effective teaching practices and those who implement them.
6. Work with departments to encourage support and adoption of effective pedagogy and to recognize and reward those faculty members who are successful in this area.
7. Host prominent sessions on teaching and education at the society's national meetings and sponsor education sections in the society's journals.

Future directions

Workshops for STEM graduate students and post-docs

The work of Ebert-May and colleagues described in this report suggests adding professional development in teaching to activities for graduate students and post-docs who are interested in academic careers. In particular, they write about the FIRST II and FIRST IV workshops, the latter revised for future faculty (rather than currently serving faculty) based on the authors' research into the effectiveness of the FIRST II and Biology Summer Institutes in changing faculty teaching. Scientific societies might well make use of their national meetings to host such activities. Such support emphasizes the disciplinary community's recognition of the importance of effective teaching for the health of the discipline.

Two-year colleges

In the United States, two-year colleges now enroll about 40% of all undergraduates and 26% of full-time undergraduates (NCES, *Digest of Education Statistics 2010*, Table 202). A disproportionate fraction of low socio-economic students, students from ethnic backgrounds under-represented in STEM fields, and students who will go on to become K-12 teachers of STEM subjects begin their college educations in two-year colleges. Thus, for many reasons, it is important to provide professional development for STEM faculty members at two-year colleges. Some of the workshops in this report serve two-year college faculty. Others do not. The leadership team of the geoscience early-career workshop includes a two-year college faculty member. New physics faculty members in two-year colleges are served by the

American Association of Physics Teachers Two-Year College New Faculty Experience program (not described in this report) funded by the National Science Foundation. Scientific societies should play a more aggressive role in providing professional development activities for faculty at two-year colleges.

Programs for adjunct and temporary faculty

Higher education in the United States has seen a dramatic increase in the fraction of undergraduate teaching done by adjunct lecturers and instructors, many of whom are excellent teachers, but who lack long-term connections to a department, its curriculum, and to the institution. Many of these temporary faculty members teach the crucial "gateway" courses in the first two years of a STEM student's undergraduate career. Historically, adjunct and temporary faculty members have not interacted with STEM professional societies. But the rapid growth in the ranks of such faculty members suggests that STEM profession societies should find a way to engage those faculty members in professional development activities.

Experienced faculty programs

Many experienced STEM faculty would benefit from and enjoy participating in the kinds of faculty development programs described in this report. Some of those programs already are available to experienced faculty members. Physics and astronomy will, with National Science Foundation support, host the first physics and astronomy experienced faculty workshop in spring 2013. Many experienced faculty members find themselves in leadership positions, mentoring junior faculty about research and teaching, evaluating faculty members for promotion and tenure, and helping their departments make decisions about curriculum and teaching. Having knowledge of and experience with effective pedagogical methods will benefit them in all of these roles as well as their roles as STEM educators.

Acknowledgments

I thank the National Science Foundation (grant 1230391), which supported the Council of Scientific Society Presidents (CSSP) May 3 workshop and the writing and dissemination of this report. Special thanks are given to CSSP Executive Officer Marty Apple and Vice President Robert Barnhill, who were generous in their logistical and intellectual support for the workshop.

References

AAU. (2011). F*ive-Year Initiative for Improving Undergraduate STEM Education* (Discussion Draft October 14, 2011), (Washington, D.C:. Association of American Universities).

Ambrose, S. A., Bridges, M. W., Lovett, M. C., DiPietro, M., & Norman, M. K. (2010). *How Learning Works: Seven Research-based Principles for Smart Teaching* (San Francisco: Jossey-Bass).

Brent, R., & Felder, R. M. (2012). "Just-in-time vs. just-in-case: Orientation for new faculty in STEM disciplines,"*Chem. Eng. Education* **46** (2), 87-88.

Chism, N. V. N., & Szabo, B. (1998). "How faculty development programs evaluate their services," *Journal of Staff, Program, and Organizational Development* **15**(2), 55-62.

Colvin, G. (2010). *Talent is Overrated: What Really Separates World-Class Performers from Everybody Else* (New York: Penguin).

Graham, R. (2012). *Achieving Excellence in Engineering Education: The Ingredients of Successful Change* (London: The Royal Academy of Engineering).

Handelsman, J., Ebert-May, D., Beichner, R., Bruns, P., Chang, A., DeHaan, R., et al. (2004). "Scientific teaching," *Science* **304**, 521-522.

Hilborn, R. C., & Howes, R. H. (2003). "Why many undergraduate physics programs are good but few are great," *Physics Today* **56**(9), 38-44.

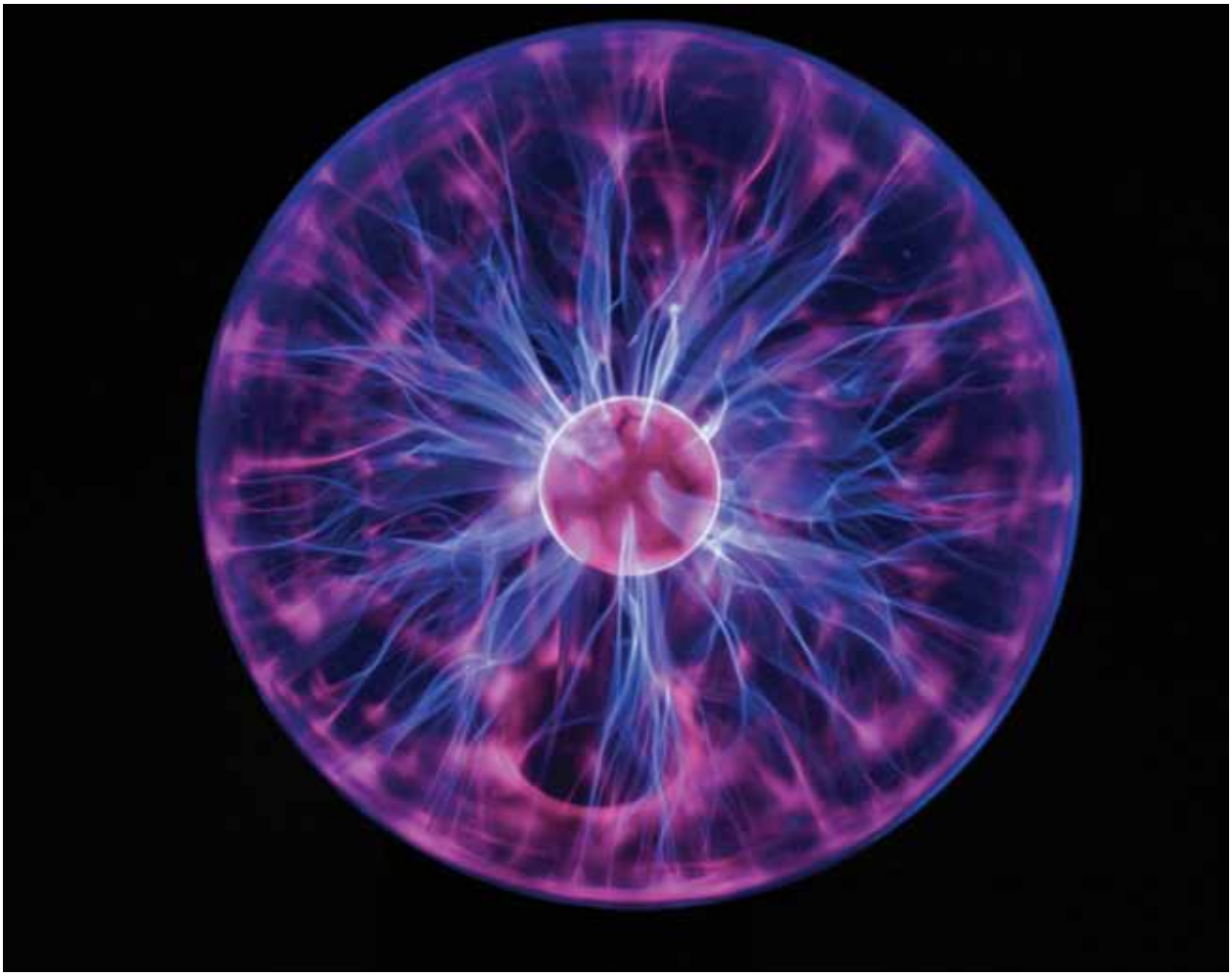
President's Council of Advisors on Science and Technology. (2012). *Engage toExcel: Producing One Million Additional College Graduates with Degrees in Science, Technology, Engineering and Mathematics*. (Washington, D.C.: President's Council of Advisors on Science and Technology, Executive Office of the President).

Schulman, L. (1986). "Those who understand: Knowledge growth in teaching," *Educational Researcher* **15**, 4-14.

Singer, S. R., Nielsen, N. R., & Schweingruber, H. A. (Eds.). (2012). *Discipline-based Education Research: Understanding and Improving Learning in Undergraduate Science and Engineering* (Washington, D.C.: The National Academies Press).

The Boyer Commission on Educating Undergraduates in the Research University. (1998). In Kennedy S. S. (Ed.), *Reinventing Undergraduate Education: A Blueprint for America's Research Universities* (Princeton, NJ: Carnegie Foundation for the Advancement of Teaching).

Wieman, C., Perkins, K., & Gilbert, S. (2010). "Transforming science education at large research universities: A case study in progress," *Change,* March/April, 7-14.



Keynote Address

Carl Wieman, *Former Associate Director for Science, White House Office of Science and Technology Policy, University of Colorado-Boulder, University of British Columbia*

Carl Wieman

Abstract

I spoke at the afternoon plenary session on the hows and whys of improving science, engineering, and math education. After a brief intro, I discussed the conceptual framework for teaching methods covered in workshops, and the reasons to believe they will have an impact. I then elaborated on why professional societies are vital to improving STEM education through improving teaching methods and closed with some thoughts on models of faculty training workshops.

Introduction

Improving STEM education is more important now than it has ever been. We need a much more scientifically literate public to make the tough decisions that our society is faced with (e.g., global climate change) and for our modern economy. There is a much broader spectrum of occupations that require serious STEM competency. We need better science, engineering, and math education, for a more scientifically literate public and our modern economy is built on science and technology, a major reason why improving STEM education is a presidential priority.

There is a great opportunity now available for making major improvements in STEM education, because of major advances from three different areas of research: science and engineering classroom studies, brain research, and cognitive psychology. Results from these three areas are giving us a very compelling and consistent picture of what is important in achieving learning, particularly for learning complex expertise like math and science.

We have good data showing the impact of different undergraduate STEM teaching practices compared to the standard lecture; learning is improved and there is a higher retention rate (supported by research from Froyd, Handelsman, Wieman, NRC DBER, and around 1,000 more references). Over the past couple of years, there have been many activities for improving undergraduate STEM education. These include: a recent PCAST study and a soon-to-be-released NRC study that discuss overwhelming evidence showing better teaching practices and calling for implementation; an AAU initiative on improving STEM education, calling for major changes in teaching practices and accountability; various government activities, pushing for transparency in STEM undergraduate teaching practices and NSF programs to improve upon the adoption of effective teaching methods; and several others. None of these can succeed without the support of the professional societies, and vice-versa.

Conceptual framework for teaching methods covered in workshops

Development of expertise requires development of the brain. It requires intense targeted practice in *all* essential mental skills of the discipline, with guiding feedback. Cognitive psychologists have done a lot of research on what makes up expert competence across many different human activities. They find there are a few core components that

are quite generic, and there is also quite a consistent way that expertise is developed. (1) Experts in any given area have a lot of knowledge about that subject; (2) In any particular discipline, experts in that discipline have a particular framework unique to that discipline by which they organize all that knowledge. These organizational frameworks allow them to retrieve and apply that knowledge very effectively. (3) Ability to monitor one's own thinking and learning in the discipline.

Research shows that these aspects of expertise are fundamentally new ways of thinking; nobody is born with these capabilities. Acquiring this expertise requires brain "exercise," with the teacher as the "cognitive coach," and it takes intense practice. Research has shown that particular things are important. First, the learner has to engage in challenging but doable tasks and questions—things that are so hard that they can only make progress if they have their full focused effort and attention on achieving them; simply doing low-level problems over and over again does not achieve expertise. It's not only being hard that matters, however. These problems have to have quite an explicit focus on the expert-like thinking the learner is trying to achieve. Tasks have to involve certain general features of thinking like a scientist, including: concepts and mental models, recognizing relevant and irrelevant information, self-checking, sense making, self-reflection on how they did the problem and what they learned, and feedback from the teacher.

Implementation of this method is discipline-specific. The area being studied will determine the particular concepts, models, patterns, content, language, and sense-making tests, as well as determining what and why particular concepts are hard and what engages students, etc.

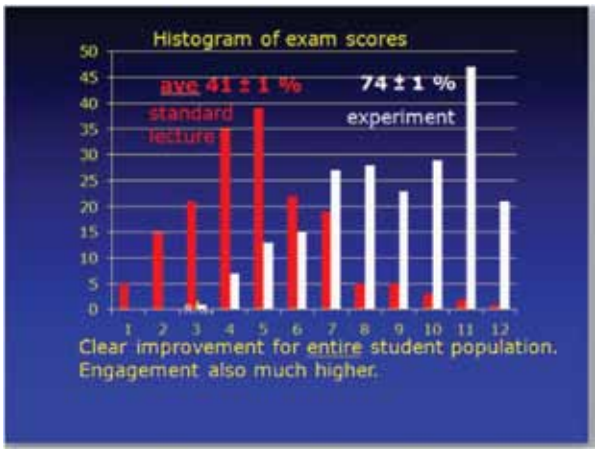
Reason to believe they will have an impact: Effect of training on college teachers

A study, "Improved Learning in a Large-Enrollment Physics Class" (Deslauriers, Schelew, & Wieman, 2011), was done in identical sections of first-year physics courses to compare the traditional style of teaching directly with the "scientific teaching" method. The control classroom was a standard lecture class taught by a highly experienced professor with good student ratings. The experiment classroom was taught by a postdoc who was well trained in scientific teaching methods and using the "expert-thinking practice" approach. The classes had an identical set of learning objectives to be covered in the same amount of class time, and each gave the same exam jointly prepared by the two professors.

In the standard lecture class, the average exam score was 41% (+/- 1%). In the experimental class, the average score was 74% (+/- 1 %). The experimental class showed clear improvement for the *entire* student population, as well as a much higher level of engagement. This is not a more effective way of learning for just the top or the bottom students, but for all students across the board; this is how the human brain works.

A different experiment was done at Cal Poly San Luis Obispo, where nine instructors changed their teaching approach over eight school-terms (Hoellwarth and Molter, 2011). Instructors came in with an average learning gain of 0.3 using standard instruction methods. They then introduced a new way of teaching involving a set of research-based activities that all the students worked through, and the instructors facilitated the students working through the same set of activities. Learning gains for all sections was within statistical uncertainty of 0.6. This showed not only the effectiveness of the teaching method, but also that it is the mental activities of the students that dominate the learning, not who the

instructor is. These same faculty members simply changed their teaching methods and their students learned much more.



Why professional society workshops are vital

Professional societies have a vital role to play in academia. They define professional norms and will be the ones to set the course for universities to continue using traditional, ineffective lectures or move to modern, more effective methods.

"Learning to teach" does not work in the abstract. Effective teaching of physics, microbiology, chemistry, etc. needs to be grounded in the discipline, along with the norms and views of the discipline about teaching. University administrators say they "can't get faculty to do anything their disciplines do not support." To change teaching, professional societies have to lead.

References

Ambrose, S. A., Bridges, M. W., Lovett, M. C., DiPietro, M., & Norman, M. K. (2010). *How Learning Works: Seven Research-based Principles for Smart Teaching* (San Francisco: Jossey-Bass).

Deslauriers, L., Schelew, E., & Wieman, C. (2011). "Improved learning in a large-enrollment physics class," *Science* **332**, 862-864.

Hoellwarth, C. & Molter, M. J. (2011). "The implications of a robust curriculum in introductory mechanics," *American Journal of Physics* **79**(5), 540-545.

"Resource" section of cwsei.ubc.ca website, under the instructor guidance tab

- guide to effective use of clickers
- clicker videos
- group work, videos, and two-page summary
- two-page summaries on: learning goals, course alignment; assessment to support learning, teaching expert thinking

National Academies Summer Institutes on Undergraduate Education in Biology

Discipline: Biology, but increasingly with connections to other disciplines

Workshop Leaders (PIs): Depends on the location of an Institute (there will be seven Institutes during summer 2013). Leaders of the Executive Committee for the Summer Institutes include Jo Handelsman, Yale University, and William Wood, University of Colorado (Emeritus). Jay Labov serves as the liaison representative from the National Research Council.

Funding Source(s): Howard Hughes Medical Institute

Cost per participant: Because the new regional institutes vary greatly in the facilities and services used for their institutes, the cost per participant is also different for each of them. We calculate that the range of costs per person for the 2011 Institutes was about $550 to $900 per person.

Costs/Fees paid by the participants (or their home institutions): This also varies by Institute. For example, because of differences in costs to stage the Institutes at universities, in 2011 some required that participants or their home institutions pay only for travel to the site while others also asked participants to cover part or all of the cost of lodging and meals.

Target Audience: Teams of faculty. We recommend strongly that there be at least one senior faculty member or administrator as part of the team of two people (sometimes three people if a reasonable case for adding a person is made in the college's or university's application).

Typical Attendance: about 35 participants at each Institute.

Workshop Duration: typically five days – begins Monday with dinner and ends on Saturday at noon.

When Offered: During the summer, this year at seven locations around the country (up from five in 2011, seven in 2012, and one in Madison, WI from 2004-2010)

Workshop Website (url): http://www.academiessummerinstitute.org/.

Program Description

Jay Labov, *Board on Life Sciences, National Research Council*

James Young, *Yale Center for Scientific Teaching*

Introduction

Introductory science courses at large universities in the United States serve as the portals that connect undergraduates to frontiers in research and scientific ways of thinking. An introductory undergraduate biology class might be the only exposure many students have to the life sciences, or to any of the sciences. It often serves as the best opportunity to interest students in a biomedical research or other life science career. However, according to the 2003 NRC report, *BIO2010: Transforming Undergraduate Education for Future Research Biologists*, teaching practices have not kept pace with advances in scientific research. Consequently, the gateway through which most students pass is antiquated, misrepresents the interdisciplinary, collaborative, evidence-based culture of science, and fails to implement current knowledge about how people learn. *Bio2010* identified faculty development as a crucial component in improving undergraduate biology education and suggested the creation of a Summer Institute during which life sciences faculty would work to improve their educational skills by integrating current scientific research with new pedagogical approaches and to create courses that actively engage students in the ways that scientists think.

The Summer Institutes

One substantive result of this recommendation has been the development of the annual National Academies Summer Institutes for Undergraduate Education in Biology. These unique Institutes are designed to model the scientific teaching principles on which they are founded and draw on the expertise of both participants and presenters. The Summer Institutes have provided a venue since 2004 for teams of faculty from primarily research-intensive universities to meet for five days of in-depth discussions, demonstrations, and working sessions on research-based approaches to undergraduate biology education. The idea is to generate the same atmosphere as a Cold Spring Harbor research course, but with the topic being issues in education rather than, for instance, phage genetics. Current research in effective practices in undergraduate science education, active learning, assessment, and diversity are woven through the week, creating a forum for participants to share ideas with each other and develop innovative instructional materials that they are expected to implement when they return to their own campuses. The current target audiences have been faculty and academic leaders from universities where large classes, especially at the beginners' level for both life sciences majors and for students with other career goals, provide

The 2011 Madison Summer Institute.

significant impediments to reform. Some universities have sent a team of two to three people to one Institute. Others have sent multiple teams (consisting of different people each year) over two or more years. There is a particular emphasis on including pre-tenured as well as more senior faculty as members of the team.

The Institutes also train a cadre of mentor/facilitators who work with participating teams each summer. Many of these facilitators are alumni from Summer Institutes in previous years, selected for this honor based upon observations of their performance during the Institute they attended. Each annual session consists of a series of plenary sessions in the mornings and facilitated small group activities during the afternoons. All plenary sessions model the kinds of evidence-based active teaching and learning that the Institutes stress for improving undergraduate education. Topics include subjects such as active teaching, how people learn, formative and summative assessment, teaching to diverse student populations, mentoring, and working with colleagues to improve teaching and learning.

Each small group consists of participants from two or three university teams and focuses on producing a "teachable tidbit" within some broad area of biology or interconnected disciplines (e.g. biology/chemistry, biology/mathematics). A tidbit is an integrated module that combines aspects of classroom, laboratory or field experiences, assessment, and techniques to help diverse student populations learn more effectively. Small groups are given time to interact with each other during the week to critique each other's tidbits as they are developed. Each team then presents its "tidbit" on the next-to-last day. Each tidbit is peer-reviewed by other participants, facilitators, and members of the organizing committee. All resources and products of each Institute are collected on a portal and made available to all participants, current and previous.

At the 2012 Summer Institutes, 213 individuals from 74 universities participated. Over the course of the Institutes (2004-2012), 710 people have participated from 167 institutions in 46 states and the District of Columbia. Because so many of these participants serve as instructors in large lecture-style courses, collectively they have taught more than 250,000 undergraduates.

The National Academies recognizes the commitment of these participants by naming each as an "Education Fellow in the Life Sciences" for the year following their attendance at the Summer Institutes and by notifying key academic leaders on their campuses about this honor. From its inception, the Summer Institutes have been a research project. Data from participants are collected and analyzed regularly to determine the impact of this initiative. In addition, HHMI sponsors a mid-year meeting for one representative from each university team approximately six months after their participation in an Institute to measure success, challenges, and new activities that have emerged from their participation.

Because of their success to date, HHMI has provided a new award to the Summer Institutes that will enable their expansion to several Institutes each year in various regions across the United States. Four of these regional institutes were organized in 2011, seven in 2012. Seven regional institutes will be held each year over the next four years of the grant.

The 2013 Summer Institutes are scheduled as follows:

- Southeast, May 13-17, 2013, University of Georgia, Athens
- West Virginia, June 2-7, 2013, West Virginia University
- Midwest, July 8-13, 2013, University of Minnesota-Twin Cities
- Mountain West, July 22-26, 2013, University of Colorado-Boulder
- Gulf Coast, July 22-26, 2013, Louisiana State University
- West Coast, July 22-27, 2013, University of Hawaii-Manoa
- Northeast, Aug. 4-9, 2013, Stony Brook University

Links to the individual regional institutes in 2013 and in the future are available at www.academiessummerinstitute.org/.

These institutes adhere to the structure and emphasis of the Madison Institute but also will expand the pool of educators beyond faculty in research-intensive universities. Data about the participants in these institutes and how they change their approaches to teaching and student learning will continue to be collected and analyzed.

Research and evaluation

Robust evaluation provides essential feedback for program development and decision-making. The current and evolving evaluation plan for the Summer Institutes, 2011-2015, incorporates the major program activities, evaluation questions, participants or data sources, evaluation measures, evaluation design, approach to analysis, and the current reporting process. The evaluation plan guides the complex array of activities associated with assessing the institutes. It will adapt as the circumstances of program implementation require and is not intended to be rigid and inflexible.

The primary purpose of the Summer Institute (SI) evaluation is to identify and assess scientific teaching faculty outcomes (active learning, assessment, diversity) at their home institutions as a direct result of attending the National Academies Summer Institutes on Undergraduate Education in Biology, both from 2004-2011 as the Madison SI as well as from 2011-2015 for the regional SIs. A secondary purpose of the evaluation is to assess whether the scientific teaching curriculum was successfully implemented from 2004-2011 (the Madison SI) as well as to assess whether the Madison SI model can be successfully implemented at seven regional institutes each summer from 2011 through 2015. Aspects include past, present, and future SI curriculum structure and instructional materials.

As regional SI implementation progresses, how the SIs and the principles of scientific teaching (active learning, assessment, and diversity) are implemented nationwide by trained faculty is of central interest. Historical data will establish baselines for comparison at the regional level. Moving forward, there are three specific evaluation questions for 2011-2012:

1. To what extent do SI participants demonstrate knowledge, skill, and attitudes concerning the core principles of scientific teaching (active learning, assessment, and diversity)?
2. How do individual regional site leaders perceive and implement the SI? (What do they see as the key objectives? What implementation choices do they make? What are their reasons for these decisions?)
3. To what extent do SI participants indicate satisfaction with their SI experience? Does this vary substantially across regions?

The measures currently in use or development for the present evaluation period (2011-2012) include an SI "teachable tidbit" observation checklist, ongoing participant reflections, daily facilitator debriefings, a post-SI interview protocol for each regional leader, and ongoing refinement of the SI self-report exit survey.

Direct Observations of the Outcomes of Faculty Professional Development

Diane Ebert-May, *Michigan State University*
Terry Derting, *Murray State University*
Janet Hodder, *University of Oregon*

Introduction

Professional development (PD) of faculty is an integral component of curriculum reform efforts in STEM. Traditionally, PD occurs through workshops that last from hours to several days. Regardless of the particular model of PD used during a workshop, its effectiveness is usually assessed through self-reported surveys of faculty satisfaction, perceived learning, and reports of applications by faculty in their classrooms. We focus on ways of assessing the effectiveness of PD models, with an emphasis on the need for objective measures of change in faculty teaching (Ebert-May et al. 2011).

The data we present raise two significant questions about professional development of faculty who teach undergraduates in STEM. Are traditional approaches to faculty PD effective in changing classroom practices and improving student learning? What evidence is needed to determine the effectiveness of different PD models?

Self-reported data are useful in identifying variables that can influence the extent to which faculty implement new teaching strategies (Henderson et al. 2012). These variables include faculty beliefs about student learning, self-efficacy, level of dissatisfaction with student learning, departmental rewards for teaching and learning, time limitations and peer interactions. Self-reported data do not, however, provide a complete or necessarily accurate assessment of the impacts of PD on classroom practices and student learning. Objective assessment of teaching and learning is also necessary, yet seldom conducted.

In this report, we summarize and disseminate recently published data (Ebert-May et al 2011) to illustrate one of several approaches that we used to assess professional development, specifically, direct observations of faculty teaching. We focused on two national professional development programs: Faculty Institutes for Reforming Science Teaching (FIRST II; Hodder and Ebert-May, NSF DUE 88847) and the National Academies Summer Institutes (SI) at the University of Wisconsin, Madison (Handelsman and Wood, funded by the Howard Hughes Medical Institute). In the FIRST II program, faculty attended workshops for a total of 6-12 days over a period of three years. These faculty were from all types of institutions, ranging from community colleges to research institutions. In the SI program, faculty attended a 5-day institute during the summer and all participants were from research institutions. The workshop goals were similar for both programs and were based on the principles of scientific teaching (Handelsman et al. 2004). The courses targeted for reform were at the introductory biology level (e.g., cell/molecular biology, organismal/population biology, ecology, genetics, and evolution). Teams of faculty participated in the workshops and designed instructional units that included learning objectives, assessments of student learning that were aligned with the objectives, and active, learner-centered teaching strategies such as cooperative learning.

How did faculty teach following professional development programs?

First, we examined the self-reported and directly observed teaching practices by faculty after completion of the FIRST II and SI workshops. For FIRST II faculty, self-reported data were used to determine change in faculty knowledge of and experience with different aspects of active-learning pedagogy. As expected, there were significant improvements in knowledge of each pedagogical area. There were also significant improvements in faculty perceptions of their first-hand experience with each pedagogical area (e.g., science education reform, use of technology in instruction, assessment, cooperative learning), except for course and curriculum planning. Faculty already had substantial experience with the latter variable before the workshops (Ebert-May et al., 2011). For SI faculty, there were significant increases in pedagogical knowledge before and after PD, as well (Pfund et al. 2009). These self-reported data sets from faculty participants in FIRST II and SI were remarkably consistent.

Faculty from both FIRST II and SI also reported perceptions of their use of active-learning strategies after completing their PD workshops. A majority of the faculty reported use of specific inquiry-based or learner-centered teaching practices (Fig. 1). These practices were used at least weekly or monthly, and often in each class period. So according to these data, more than half of the faculty were using active-learning techniques one year after completing professional development (Ebert-May et al. 2011, Pfund et al. 2009).

We collected two to four videos from faculty in FIRST II and SI teaching their students after the workshops (see Ebert-May et al. 2011 for details). "The videotapes were rated using the RTOP (Sawada et al. 2002), which allows a trained observer to characterize the degree to which faculty implement active, learner-centered teaching techniques in their courses. The RTOP defines and allows the assessment of learner-centered teaching and is aligned with the theoretical underpinnings of inquiry-based teaching (MacIsaac and Falconer 2002). The RTOP is a highly reliable instrument with strong predictive validity for student achievement (Lawson et al. 2002)" (Ebert-May et al. 2011 p. 552). An RTOP score is an indicator of the degree of active learning instruction and student involvement observed in a classroom (Sawada et al. 2002) and can be categorized into five progressive categories of teaching practice. Categories I and II indicate teacher-centered classrooms that range from

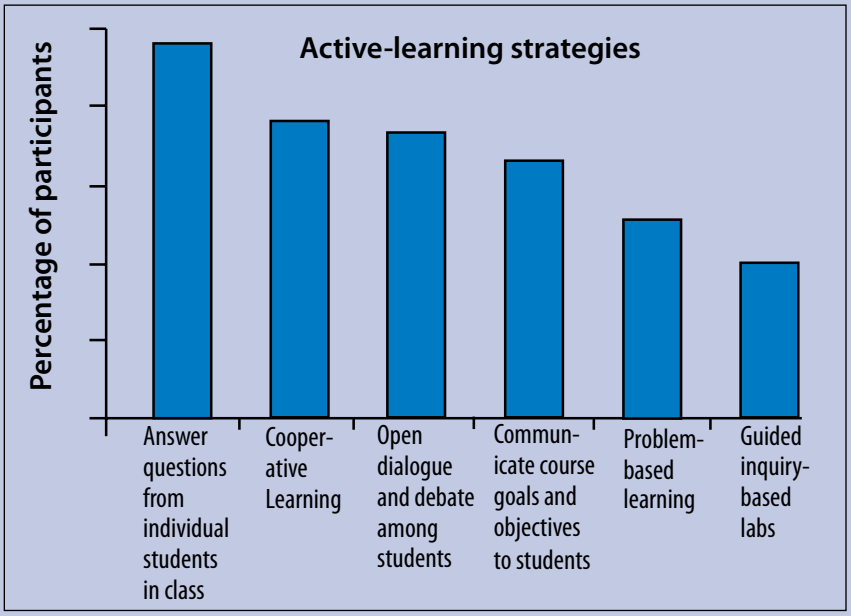


Fig. 1. Reported use of active learning strategies by FIRST II faculty after professional development (n=96; Ebert-May et al. 2011 p. 554)

straight lecture to minor student involvement. Categories III-V indicate increasing levels of learner-centered classrooms.

We examined the change in participants' RTOP scores from when they taught right after they completed the first PD workshop to when they taught one to two years later. "In contrast with the self-reported data, observations of faculty classrooms indicated that a majority of faculty (75%) implemented a lecture-based, teacher-centered pedagogy, which was determined by mean RTOP scores for the videotapes submitted. Furthermore, in the two years following PD, we observed no major shift in faculty practices. Fifty-seven percent of the participants were in the same RTOP category from their first to their final videotape. Of the remainder, 23% moved to a lower RTOP category following their first tape, whereas 20% moved to a higher RTOP category. There were no significant differences in the total RTOP scores or the subscale scores between faculty who participated in the FIRST II program and those who participated in the SI program (t-test, $p > .05$)." (Ebert-May et al 2011, p. 554-555).

The directly observed data conflicted with the self-reported data from participants who indicated that they implemented the active-learning practices they learned in the FIRST II and SI workshops. What happened? Here we note that faculty did not intentionally report misinformation; in fact, they were truly motivated and excited about changes in their courses. However, their ***perceptions*** of teaching did not match their teaching practice. We hypothesize that the faculty did not fully understand what active, learner-centered teaching is and how to implement it, nor did faculty change their beliefs about how students learn and how they teach (Henderson et al. 2011). Thus, although faculty did implement components of learner-centered teaching, it was not of sufficient depth and breadth to transform the basic nature of their teaching practice.

In terms of types of data used to evaluate professional development programs, we claim that self-reported data are useful, especially for formative evaluation, but are incomplete. Direct measures of faculty practice are necessary.

What variables predict teaching practices of faculty?

To help us better understand faculty teaching practice, we used the data collected to try to predict the type of teaching implemented by faculty. We wanted to know what variables predict teaching practice. Based on our experience with PD and relevant published literature, we predicted that the following variables were important: (1) ***experience***, defined by number of years teaching, knowledge and practice with active learning, type of professional development program, and self-confidence; (2) ***class size***, including all of the associated challenges with implementing anything new with a large number of students; and (3) ***faculty appointment***, in terms of percent teaching, tenure status, and departmental support for teaching.

The results indicated that the predictor variables for teaching practices in our model accounted for 19% of the variation in mean RTOP score that contributed to explaining observed classroom teaching after PD (Table I). For example, faculty with less teaching experience engaged in more learner-centered teaching compared with faculty with more years of teaching experience. Also, department and peer support for faculty use of non-lecture approaches to teaching had no significant relationship with the classroom practice used by faculty. These data suggest that assumptions about the

Table I. Results of a general linear model analysis for total RTOP score. The sign in parentheses indicates whether the relationship between the variable and RTOP score was positive or negative.

Variable Entered into Model	*Model r^2*
Teaching experience (-)	0.08
Class size (-)	0.13
Proportion for teaching[1] (-)	0.16
Experience with reform[2] (+)	0.19

1. The proportion of faculty appointment devoted to teaching activities.
2. Cumulative firsthand experience with science education reform, course and curriculum planning, theories of learning, technology in instruction, interdisciplinary approaches to inquiry and problem solving, assessment, cooperative learning, case studies, independent project, problem-based learning, inquiry-based laboratories, inquiry-based field projects, and teaching portfolios (from Ebert-May et al. 2011).

effectiveness of traditional models of professional development need validation using both objective and subjective measures. The data also indicate a need for new models of PD for STEM faculty that include multiple-year programs, formative feedback about teaching (e.g., mentoring), and reform of an entire course. New models of PD must be coupled with valid and reliable measures of student performance. Evaluation of the effectiveness of models of faculty professional development must be rigorous and data-driven.

What is the reformed model of professional development?

We used the data from the study of FIRST II and SI to revise and implement Faculty Institutes for Reforming Science Teaching, now called FIRST IV. We changed the target audience from faculty to future faculty; that is, FIRST IV focuses on postdoctoral (postdoc) scholars in the biological sciences. FIRST IV is a national professional development program designed to shape postdocs' beliefs about and abilities to implement learner-centered biology courses that result in improved student learning. FIRST IV is currently training 200 postdocs (approximately 75 of whom are now in faculty positions) in learner-centered teaching and course design, impacting ~10,000 undergraduate students annually who learn science by doing science, even in large enrollment courses. To date, objective and self-reported assessment data provide consistent evidence that the professional development model is effective, resulting in postdocs who successfully design, implement, and teach inquiry-based, learner-centered courses. Compared with FIRST II faculty, significantly more FIRST IV postdocs are implementing learner-centered classrooms (Fig. 2).

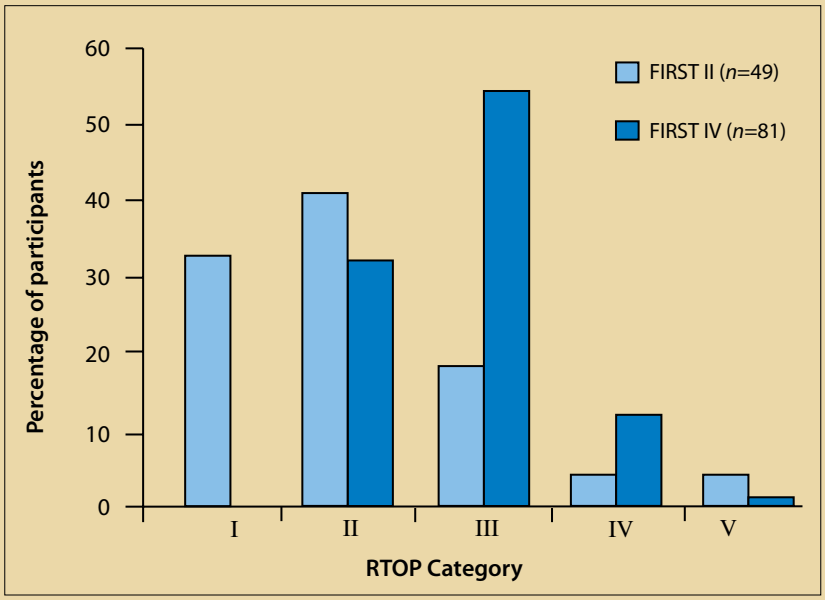


Fig. 2. Distribution of RTOP scores from videos of classroom teaching by FIRST II faculty and FIRST IV post-docs.

The key outcome for any professional development model is student learning. Course materials (syllabi, learning objectives and assessments) can be evaluated in terms of the alignment of objective and assessment item. The degree of correlation in Bloom's scores provides a proven method for measuring alignment of assessments with objectives, an indicator of successful backward design (Freeman et al. 2011, Momsen et al. 2010). What do assessment data tell us about instruction? If faculty members want students to achieve higher-cognitive skills in the process of learning science, students need to practice these skills both in and outside class using student-centered pedagogies. What faculty members want students to know and be able to do is reflected in the exams.

Performance and self-reported data from students indicated improved learning and classroom environments in courses taught by FIRST IV PDs. Evidence also shows that the FIRST IV model of professional development provides a well-established support network for PDs as they practice teaching and begin academic positions.

References

Ebert-May, D., Derting, T.L., Hodder, J., Momsen, J.L., Long, T. M., & Jardeleza, S.E. (2011). "What we say is not what we do: Effective evaluation of faculty development programs," *BioScience* **6**(17), 550-558.

Handelsman, J., Ebert-May, D., Beichner, R., Bruins, P., Chang, A., DeHaan, R., Gentile, J., Lauffer, S., Steward, J., Tilghman, S., & Wood, W. (2004). "Scientific teaching," *Science* **304**, 521-522.

Henderson, C., Beach, A., & Finkelstein, N. (2011). "Facilitating change in undergraduate STEM instructional practices: an analytic review of the literature," *Journal of Research in Science Teaching*, **48**(8), 952–984.

Henderson, C., Dancy, M., & Niewiadomska-Bugaj, M. (2012). "Use of research-based instructional strategies in introductory physics: Where do faculty leave the innovation-decision process?" *Physical Review Special Topics. Physics Education Research* **8**, 020104.

Lawson, A.E., Benford R, Bloom, I., Carlson, M.P., Falconer, K.F., Hestenes, D.O., Judson, E., Pilburn, M.D., Sawada, D., & Wycoff, S. (2002). "Reforming and evaluating college science and mathematics instruction," *Journal of College Science Teaching* **31**, 388–393.

MacIsaac, D. & Falconer, K. (2002). "Reforming physics instruction via RTOP," *The Physics Teacher* **40**, 479–485.

Pfund, C., et al. (2009). "Summer Institute to improve university science teaching," *Science* **324**, 470–471.

Sawada, D., Piburn, M.D., Judson, E., Turley, J., Falconer, K., Benford, R., & Bloom, I. (2002). "Measuring reform practices in science and mathematics classrooms: The Reformed Teaching Observation Protocol," *School Science and Mathematics* **102**, 245–253.

Cottrell Scholars Collaborative New Faculty Workshop

Discipline: Chemistry

Workshop Leaders (PIs): Andrew Feig (Wayne State University) and Rory Waterman (Univ. VT)

Funding Source(s): Research Corporation for Science Advancement, American Chemical Society

Cost per participant: ~$400

Costs/Fees paid by the participants (or their home institutions): travel to and from workshop

Target Audience: new faculty either just starting or just finishing their first year

Typical Attendance: 25

Workshop Duration: two days

When Offered: Annual, early of August

Workshop Website: http://csc.rescorp.org/faculty-workshop/index.html

Program Description

Andrew Feig, Wayne State University

Rory Waterman, University of Vermont

Overview

The Cottrell Scholars Collaborative (CSC) is a collection of chemistry and physics faculty who are past recipients of the Cottrell Scholars Award, a distinction given out by Research Corporation for Science Advancement (RCSA) to faculty demonstrating excellence in both the classroom and the laboratory. The mission of the CSC is to "develop, promote and implement transformative programs to improve STEM education through the integration of research and teaching." The CSC, in partnership with RCSA and the American Chemical Society, is implementing a New Faculty Workshop program to improve the penetration of research-validated pedagogies in chemistry departments around the country. By introducing new faculty to the scholarship behind scientific teaching before they enter the classroom, members of the CSC believe that we can help faculty develop great habits for effective teaching and student learning, and foster a new generation of more effective teacher-scholars. The workshop will also help the faculty develop a national cohort with whom they will become comfortable talking about teaching and pedagogy in addition to their research accomplishments.

Participants Emily Weinert (Emory University, Dept. of Chemistry) and Qiu Wang (Duke Univ., Dept. of Chemistry) working together on an active learning exercise during the 2012 CSC New Faculty Workshop.

Introduction and scope

There is an increasing body of literature that suggests that the classic lecture model of teaching is ineffective based on measurement of student learning (Hake, 1998. National Academies of Science, 2003. Knight &Wood, 2005. Handelsman, Miller, & Pfund, 2007. Derting & Ebert-May, 2010). Despite this fact, the standard lecture format is still widely practiced at the university level. Since the late 1990s, there have been several calls to improve undergraduate STEM education, but the uptake of these methods by chemistry faculty has overall been rather poor (National Academies of Science, 2003; Brewer & Smith, 2011) Though there are acknowledged faults in the chemical and science education literature, high-quality studies have shown that alternative methods to teaching (i.e. student-centered approaches as opposed to teacher-centered models) improve student learning (Singer, Nielsen, & Schweingruber, 2012). Additionally, these methods often lead to enhanced perception of science by the students. Interestingly, these advances in science education are compartmentalized by discipline, and there is less cross-communication in science education research than might be expected given the common goals. Although there have only been limited studies in this area historically, poor academic and learning experiences are believed to contribute strongly to student attrition. Therefore, improving the educational experience for students is highly likely to improve retention of students in higher education in general and more specifically, to help retain students within STEM fields.

It is important to catch new faculty early. Senior faculty members often cite a lack of time and the research-focused university reward structure as reasons why they continue to use passive lecture formats. Our view, supported by the recent work of Diane Ebert-May, is that one can provide great impact on the long-term teaching styles if the intervention occurs prior to the development of that style (Derting & Ebert-May, 2010; Ebert-May & Weber, 2006). If new faculty learn to teach using active classrooms from the very beginning of their careers, they need not "unlearn" the classical lecture style. It is our opinion that it takes no more time to teach effectively than it does to give a lecture, so long as one knows the tools and tricks of implementing active learning approaches.

Workshop participation

The first CSC New Faculty Workshop took place in Washington, D.C., in August 2012. The workshop was two days in length running from the evening of Wednesday, Aug. 8, to the afternoon of Friday, Aug. 10. Our venue could accommodate approximately 40 participants, but the current funding from RCSA was only sufficient to cover the local costs (~$450/pp) for 25 participants. Departments were asked to support the transportation costs to and from the workshop for all participants. We invited nominations from chemistry departments at ~100 research-intensive universities across the U.S. Nominations were open for faculty who began their appointments between June 1, 2011 – Aug. 31, 2012. Thus faculty were either newly appointed or would have just completed their first year on the job at the time of the workshop. Nominations were received for 45 new faculty members from 32 universities. Of those, we admitted 25 persons outright based on our funding and offered an additional 15 persons admittance on the condition that their department or university bears the entire cost of the workshop. Most of the people on the conditional admission list were able to identify funding sources from their institutions and ultimately 38 faculty attended the inaugural workshop. Approximately half the attendees were about to start their first faculty position in August 2012

while the other half had just finished their first year. Approximately 1/3 were women and three self-identified as from underrepresented minorities.

Key components of the workshop

Our primary goal is to provide new chemistry faculty training in modern, interactive teaching methods. The workshop format was designed around developing an interactive lesson on a topic relevant to a class the participant would teach in their first year. Through a series of interactive sessions, we first demonstrated active learning exercises so that the workshop participants, who may never have been students in a learner-centered environment, would experience these techniques first-hand. The participants then had a series of structured breakout sessions where they designed and revised their exercise.

In the first pass, they were challenged to identify a piece of content around which the lesson would revolve. Then, after a discussion about learning goals and assessments, they focused on whether the exercise was aligned with the stated learning goals and they revised it accordingly. At this point they began thinking about how to assess whether or not the lesson was effective. They were tasked with selecting an appropriate classroom assessment technique that could be used as a formative assessment of the unit. Finally, the participants were challenged with the topic of scale. What would happen if this exercise were done in a large classroom? Would there be issues in its implementation? How could it be modified to ensure that a class of 300 could all do it simultaneously and still obtain suitable feedback on their work in the wrap-up phase of the discussion?

On the second day of the workshop, the participants tried out their exercises on the other attendees. Working in groups of ~eight, they taught their lesson to their colleagues and received feedback on their concept and implementation. While this design exercise phase of the workshop worked quite well, this implementation exercise was particularly informative to us as workshop organizers. The kernels of the ideas were quite sound in most cases, but the actual implementation often fell short: faculty members reverted to lecture, talking about what the students should do and observe rather than actually getting the “students” to do the exercise itself and discover on their own. This element provided a terrific teachable moment where we stopped the instructors and asked them to compare what they were doing relative to the active learning examples they had done the previous day. It illustrated that in the short workshop format we could teach participants the content knowledge to understand evidenced-based teaching practices, but they received insufficient practice to get the implementation right. With some on-going mentoring, we hope that the faculty members will then practice the art of active learning in their classes and over time develop their style to make their implementation effective.

The workshop modeled the scaffolding approach to knowledge development. We demonstrated for them the process by which learning is enhanced by progressively adding layers to knowledge and then is solidified through active participation in the process. The undercurrent of these sessions allowed a discussion of setting up and articulating learning gains to the stakeholders (most importantly the students), designing exercises to build understanding, and tuning formative assessments to determine whether the content knowledge was internalized. Additional discussions

on teaching included the use of classroom assessment techniques to gauge learning in real time, effective use of clickers and the identification and confrontation of misconceptions to enhance learning. While the sessions were short, what came out of these discussions was an awareness of the issues and a guide about where to find more information if needed.

In preparation for the workshop, we developed a website that serves as a convenient interface for our participants with detailed information about the event and the activities performed by the participants. It can be found at: http://www.chem.wayne.edu/feiggroup/CSCNFW/. This website contains a collection of information on modern pedagogy. Using the ACS Network, we also developed a discussion group where workshop alumni can keep in touch with each other to share additional exercises they develop as well as share notes on the implementation of the individual lessons. The goal here is to foster community engagement and shared responsibility among the cohort to help everyone become effective educators. By sharing the development of interactive exercises, each participant in the program will gain access to many additional exercises that they can use or adapt in their own courses.

While teaching about modern pedagogy is central to the workshop experience, we provided a somewhat broader set of orientation topics to ensure buy-in from departments who were being asked to support the transportation costs to and from the workshop. Our keynote speaker (Prof. Michael Doyle, Chair of the Chemistry Department at University of Maryland, College Park) talked about the competing demands placed on faculty members' time. Overall, the talk set the tone that there is a lot to do and hard work alone won't make you successful. Instead, one must be strategic with one's choices. He shared with the new faculty an historic perspective on the calls for changes in the field of chemistry and chemistry education that had gone unanswered and the difficult task of changing departmental cultures.

We held a grantsmanship session (with program officers from NSF and RCSA) and a session on mentoring students in the laboratory. In the latter session, we discussed issues related to motivating students, working with difficult students, giving feedback and criticism effectively, annual student evaluations, etc. The goal here was to make faculty more effective at mentoring their research team to improve their overall productivity.

The workshop provided a mix of activity types and session formats, modeling individual work time, large group discussions and breakout sessions and hands-on activities. The idea is to use the workshop as a model for how classroom time can be balanced between knowledge transfer exercises and skill-development time—the same approaches we challenge them to employ to enhance student engagement in their classrooms.

Post-workshop follow-up and mentoring

Unfortunately, a one-time intervention, no matter what its duration, alone is not likely to change people's patterns of behavior. Two days is also too short to immerse chemistry faculty in modern pedagogy, but it is long enough to pass along the key concepts and prepare them with materials necessary to further explore on their own. Therefore, our approach is to couple the workshop with ongoing mentorship. Workshop alumni have been paired with members of the Cottrell Scholars Collaborative who have volunteered to serve in this capacity. These mentors are responsible for calling their mentees twice per year to discuss their career progress and concerns. The mentors are provided with

talking points to facilitate the conversations and ensure that specific topics are covered, like the success in implementing active learning in their classrooms, job satisfaction, grant writing successes and challenges and departmental environment. In addition, the coaching sessions provide a sounding board outside of the department that the new faculty members can use if they wish to get advice about navigating local issues within their own institutions. By having an external mentor, it is guaranteed that the information cannot be used against the faculty members and may allow them to have more candid discussions than they would with a member of their own department.

Workshop assessment plans

The workshop is just in its first year, so we do not have longitudinal data at this time on its efficacy and impact on the careers of the participants. Our workshop structure is consistent with the best practices professed by the book *Scientific Teaching* (Handelsman, Miller, and Pfund, 2007) and was well-aligned with the presentations from the NAS/NRC workshops in biology and the AAPT workshops for physics and astronomy faculty described elsewhere in this report. The two differences are that our workshop is shorter than those due to funding constraints and we are targeting faculty slightly earlier in their careers relative to those workshops.

We have teamed up with a chemical education specialist to assess the impact of our workshops. Prof. Marilyne Stains is on the faculty at the University of Nebraska, Lincoln. Her research interests are in the area of modern pedagogy and the barriers that keep chemistry faculty from adopting these approaches. In collaboration with Prof. Stains, the workshop organizers have developed a tracking plan that will involve both periodic surveys of the workshop participants on several aspects of their career development. We will track workshop alumni over a six-year period in comparison to a control group to see if the career and teaching trajectories of these groups differ. Initial data on the survey work and classroom observations should be available in just over one year. We are assessing the level to which faculty adopt interactive pedagogies in their courses as well as a collection of job-satisfaction and job performance metrics. As a control group, we are surveying faculty who are slightly older (three-five years into their first faculty position) who started before the workshops became available. In addition to the survey assessments, workshop participants and control faculty volunteered to have their classes videotaped and assessed using the RTOP method (MacIsaac & Falconer, 2002) to compare self-reported use of active pedagogies against actual classroom practices. Finally, we will monitor our workshop alumni through their career milestones (first grant, teaching awards, tenure, etc.) to assess whether or not the workshops provided significant improvement in job performance relative to national norms.

There was extensive discussion at the May 3, 2012 CSSP workshop regarding the need to measure student learning gains themselves. There is already significant literature, largely from the Physics Education Research community, that interactive classrooms consistently outperform non-reformed classroom pedagogies when one assesses student learning through pre- and post-testing using validated instruments like the Force Concept Inventory (Hestenes, Wells, & Swackhamer, 1992). Given the large number of students spread out over many institutions and in a variety of class types (due to the disparate teaching assignments of our workshop participants), measuring all those individuals will be a significant task. It would be much easier to assess uptake of research-validated pedagogical methods as a proxy for

student learning gains. The organizers of the workshop are still conflicted about the level of effort that should be applied toward showing the workshops' impact directly on student learning given the level of effort involved. We are testing the use of a concept-map based assessment that can be administered online across the country. The concept maps can then be scored using pathfinder analysis but whether this method will provide sufficient clarity regarding student learning outcomes to justify its use as an assessment on this scale is as of yet unknown.

While we would like to measure whether the workshops successfully impact the culture of chemistry departments to provide a more balanced view of our jobs as teacher scholars, assessing the impact is difficult and is a process that will take many years. We are still looking for validated survey instruments that would effectively assess this facet of the workshop's success or failure, but have yet to identify one that is suitable for our needs. This is a long-term impact, however and it may not be viable to assess such shifts over the timescales available to us.

Conclusion

The CSC New Faculty Workshop is a new addition to the chemical community that directly addresses modern research-based pedagogy and the failure of the chemical community to broadly implement it in our university classrooms. The effort has the full support of the American Chemical Society and the RCSA. Our current funding will allow us to support the workshop for two years by which time we will need to have developed an alternative model for how to support the program. If we can show quick success, it is possible that departments and universities will help to bear the burden by paying the costs of their new faculty to attend. Also, at this time the workshop was only open to faculty at major research universities. Faculty from primarily undergraduate institutions were not invited to participate this year because of the limited funding available. The decision was made that training university faculty would have the greatest impact on the field. Once established, however, we would like to extend the invitations to provide this type of training to all chemistry faculty, regardless of institution type. Under such a model, we would add targeted break-out sessions to deal with the specific challenges faced by faculty at two-year, four-year colleges, four-year comprehensive universities, and research universities to ensure that all faculty received the mentoring they need to get off to a great start in their chosen positions.

References

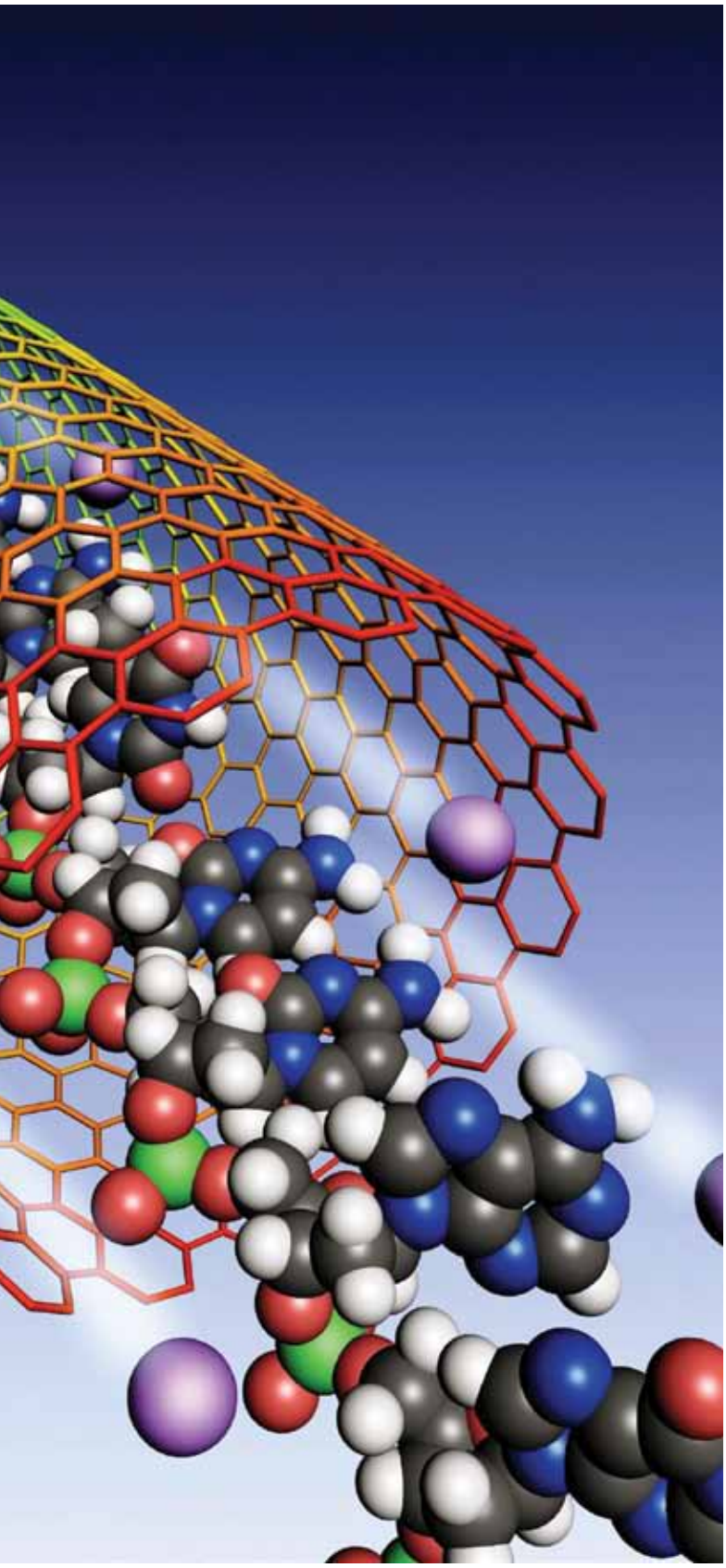
Brewer, A. D. and Smith, C. A. (Eds.). (2011). *Vision and Change in Undergraduate Biology Education, a Call to Action* (Washington, D.C.: AAAS).

Derting, T. L., & Ebert-May, D. (2010). "Learner-centered inquiry in undergraduate biology: positive relationships with long-term student achievement," *CBE Life Sciences Education* **9**, 462-472.

Ebert-May, D., & Weber, E. P. (2006). "FIRST—What's next?" *CBE Life Sciences Education* **5**, 27-28.

Hake, R. R. (1998). "Interactive-engagement versus traditional methods: A six-thousand-student survey of mechanics test data for introductory physics courses," *American Journal of Physics* **66**, 64-74.

Handelsman, J., Miller, S., & Pfund, C. (2007). *Scientific Teaching* (New York: W.H. Freeman).



Hestenes, D., Wells, M., & Swackhamer, G. (1992). "Force concept inventory," *The Physics Teacher* **30**, 141-166.

Knight, J. K., & Wood, W. B. (2005). "Teaching more by lecturing less," *CBE Life Science Education* **4**, 298-310.

MacIsaac, D. L., & Falconer, K.A. (2002). "Reforming physics education via RTOP," *The Physics Teacher* **40**, 479-485.

National Academies of Science. (2003). *Bio2010 - Transforming Undergraduate Education for Future Research Biologists* (Washington, D.C.: National Academies Press).

Singer, S. R., Nielsen, N. R., & Schweingruber, H. A. (Eds.). (2012), *Discipline-Based Education Research: Understanding and Improving Learning in Undergraduate Science and Engineering* (Washington, D.C.: National Academies of Sciences Press).

Faculty Development Workshops Supported by Engineering Professional Societies

National Effective Teaching Institute

Professional Society: American Society for Engineering Education (ASEE)

Discipline: Engineering

Workshop Leaders (PIs): Richard M. Felder, Rebecca Brent, Michael J. Prince

Funding Source(s): Participant fees

Cost per participant: $950 (covers workshop registration, breakfast, and lunch on all three workshop days)

Costs/Fees paid by the participants (or their home institutions): $950 + costs of travel, dinners on the three workshop days, lodging, and other subsistence expenses

Target Audience: Engineering faculty members with at least one year of teaching experience, nominated by college dean

Typical Attendance: 50, limited to 50 participants at each offering

Workshop Duration: three days

When Offered: Every June in conjunction with the annual meeting of the ASEE, and (beginning in 2013) every January. These two offerings will be designated as NETI-1A (June) and NETI-1B (January).

Workshop Website: http://www4.ncsu.edu/unity/lockers/users/f/felder/public/NETI.html

Excellence in Civil Engineering Education

Professional Society: American Society of Civil Engineers (ASCE)

Discipline: Civil Engineering

Workshop Leaders (PIs): Allen Estes, California Polytechnic State University; Ronald Welch, The University of Texas-Tyler; Stephen Ressler, United States Military Academy; Norman Dennis, University of Arkansas; Debra Larson, Northern Arizona University; Carol Considine, Old Dominion University; Tonya Nilsson, San Jose State; Jim O'Brien, American Society of Civil Engineers; Thomas Lenox, American Society of Civil Engineers

Funding Source(s): Participant fees and ASCE Foundation.

Cost per participant: Applicants who are accepted to an ASCE ExCEEd Teaching Workshop will be named "ExCEEd 2012 Teaching Fellows." The entire workshop registration fee is $425. The ExCEEd Teaching Workshop is funded by a generous grant from the ASCE Foundation. The workshop costs $2,500 per participant to conduct. ASCE is investing $2,075 in each participant as a fellowship.

Costs/Fees paid by the participants (or their home institutions): None

Target Audience: Currently designed for civil engineering educators with less than ten years of teaching experience at the college level. Application must include a letter of support from the department chair/head.

Typical Attendance: 24, limited to 24 participants at each offering

Workshop Duration: six days

When Offered: Two times in the summer. Places and dates vary and may be found at the workshop website Application deadline is in mid-February.

Workshop Website: http://www.asce.org/exceed/

Program Description

Jeffrey Froyd, *Texas A&M University*

Introduction

Faculty development is one pivotal strategy for improving engineering education in the United States, because engineering faculty members make all decisions about engineering curricula: what should be taught, how it should be assessed, how it should be taught, and when it should be taught. Curricular change initiatives can offer alternatives to current practice in engineering education, but engineering faculty members at each institution make decisions regarding uptake (or not) of these curricular initiatives. If engineering faculty members continue thinking about engineering education in the same ways they have thought about it for the past 50 years, significant improvements in engineering education are unlikely. The American Society for Engineering Education (ASEE) has offered a three-day faculty development workshop for about 50 engineering faculty members each year since 1991, and there are currently over 1100 alumni of the program. The American Society of Civil Engineers has had six-day faculty development workshops, each limited to 24 participants, since 1999, and there are over 500 alumni of the ASCE workshops.

National Effective Teaching Institute 2012.

What is the size of the engineering education enterprise?

Faculty development is often mentioned as one of a set of approaches that should be pursued to improve engineering education across the country (Froyd, Beach, Henderson, & Finkelstein, 2008; Froyd, Layne, & Watson, 2006). Change initiatives must be planned, designed, and implemented with understanding of the magnitude of the intended change. To provide background on the size of the engineering education enterprise that is the focus of continuing efforts to improve engineering education, Table I provides numbers of engineering faculty members at various ranks in 2010, student enrollment, and numbers of degrees awarded in the United States.

Table I. Numbers of Engineering Faculty and Students in the United States in 2010.

Category	Number
Tenured/tenure-track faculty	24,435
Professor	12,179
Associate professor	6,896
Assistant professor	5,360
Non-tenure-track faculty	2,781
Undergraduate enrollment (2009-2010)	450,685
Bachelor's degrees (2009-2010)	78,347
Master's degrees (2009-2010)	43,023
Doctoral degrees (2009-2010)	8,995

To change the way engineering is taught at the undergraduate level, a significant fraction of the over 24,000 tenured/tenure-track faculty members and over 2700 non-tenure-track faculty members must change how they teach engineering courses. Faculty development has a role to play in promoting that change.

Two Engineering Faculty Development Workshop Initiatives

Two engineering professional societies have offered faculty development workshops for several years. The American Society for Engineering Education (ASEE) has offered the National Effective Teaching Institute (NETI) since 1991, and the American Society of Civil Engineers (ASCE) has offered the Excellence in Civil Engineering Education Teaching Workshop (ExCEEd) since 1999.

National Effective Teaching Institute (NETI)

The National Effective Teaching Institute (NETI) is a three-day workshop offered annually just before the ASEE Annual Conference & Exposition (Felder & Brent, 2009, 2010). Since 1991, when it was first offered, ASEE program staff invites all deans of engineering and engineering technology in the U.S. to nominate up to two of their faculty members. Invitations are sent in January, approximately five months before NETI is offered. The number of workshop participants is limited to 55, and applications are accepted on a first-come, first-served basis. NETI is sponsored by the Engineering Research and Methods and Chemical Engineering Divisions of the ASEE. Currently, participants' institutions pay the cost of the workshop ($950 in 2012) and expenses for participants. With this cost structure, NETI is self-sustaining.

Topics that are the major focus of NETI are the following:

- Student learning styles (Felder & Silverman, 1988)
- Writing learning objectives (Felder & Brent, 1997; Mager, 1997)
- Planning courses

- Active learning (Bonwell & Eison, 1991)
- Cooperative learning (Felder & Brent, 1994; Johnson, Johnson, & Smith, 2006)
- Effective lecturing
- Assessment of learning
- Teaching problem-solving skills
- Dealing with a variety of problems that commonly arise in the careers of engineering instructors

"For each topic addressed in the workshop, practical suggestions are offered and the research attesting to their effectiveness is cited and discussed" (Felder & Brent, 2009). Faculty issues are addressed on the second day of the workshop in two concurrent 90-minute sessions. One session addresses challenges faced by relatively new faculty members on getting academic careers off to a good start (Boice, 2000); the second concurrent session focuses on more experienced faculty members and how they can promote effective teaching on individual campuses. In addition to these major emphases, topics that are addressed, but receive less emphasis include the following:

- Inquiry-based learning
- PowerPoint
- Problem-based learning
- Web-based tutorials
- Distance education

Effectiveness of NETI, like all faculty development programs, can be evaluated at three levels (Chism & Szabo, 1998):

- **Level 1:** How satisfied were the participants with the program?
- **Level 2:** What was the impact of the program on the participants' teaching practices and on their attitudes toward teaching and learning?
- **Level 3:** What was the impact of the program on the participants' students' learning?

For the first level, NETI facilitators administered a survey at the conclusion of every workshop. Through 2012, NETI has had 1148 participants from 230 different institutions (Felder, n.d.). Responding participants have provided the following summative evaluations:

- **Excellent:** 801
- **Good:** 221
- **Fair:** 1
- **Poor:** 0 (Felder, n.d).

To evaluate NETI at the second level, Felder and Brent sent surveys to 607 NETI alumni (1993-2006) with valid email addresses. They received 319 completed surveys (53% response rate). To evaluate how participants have changed their teaching, the survey asked respondents how frequently they applied teaching practices described in the workshop. Figure 1 summarizes responses for five of the major NETI foci.

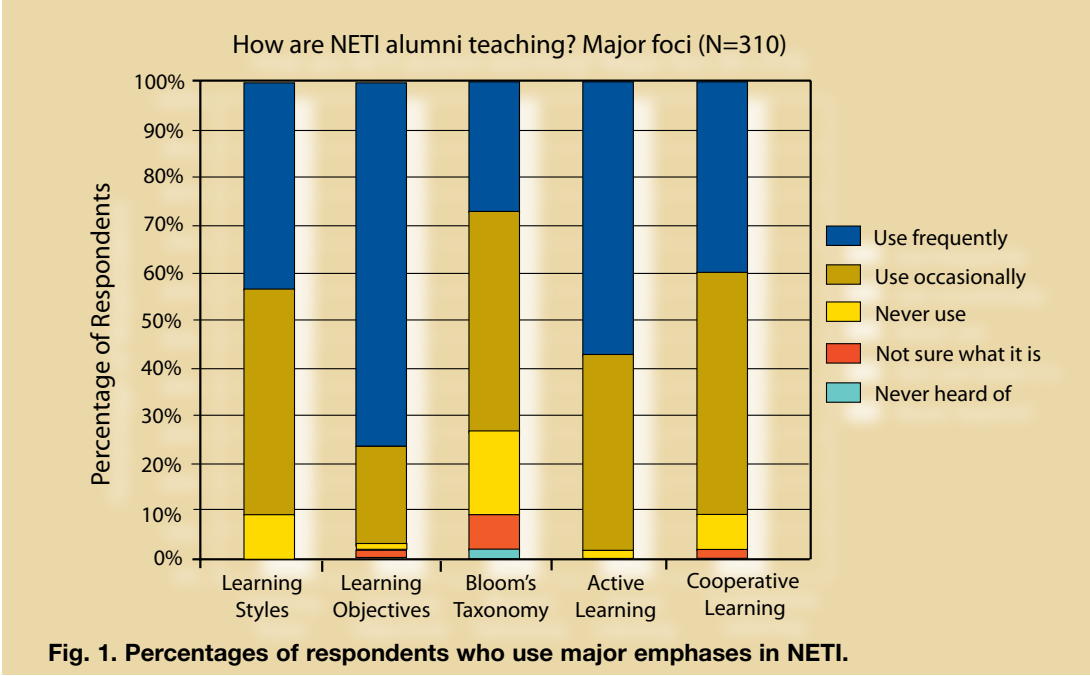


Fig. 1. Percentages of respondents who use major emphases in NETI.

The most frequently used teaching practice emphasized in the workshop is the formulation of learning objectives, reported by 775 of the respondents to be used frequently. The teaching practice that had the lowest percentage of frequent use (27%) is Bloom's taxonomy (Anderson & Krathwohl, 2001; Bloom, Englehart, Furst, Hill, & Krathwold, 1956). Only small percentages of the respondents reported that they had never heard about or were unsure of what these five major emphases were (Felder & Brent, 2010).

One way to check on validity of these responses is to examine respondent use of teaching practices that were minor foci of NETI. Since these were minor foci, expected adoption of practices related to the minor foci would be lower than adoption of those related to major foci. Adoption of teaching foci related to minor workshop foci is summarized in Fig. 2.

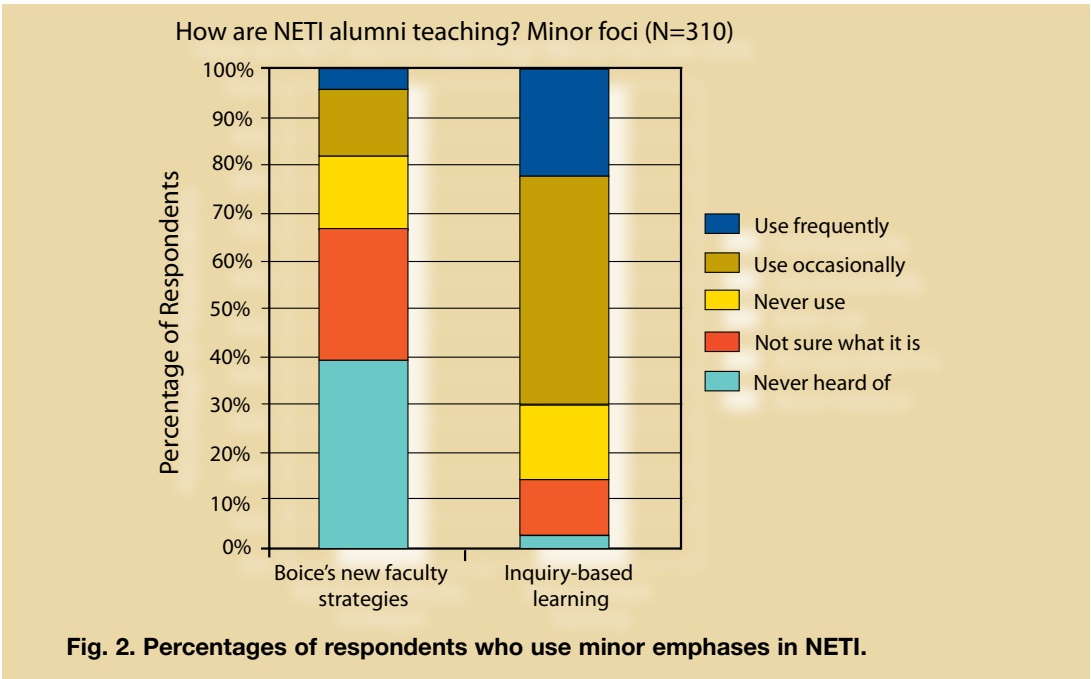


Fig. 2. Percentages of respondents who use minor emphases in NETI.

Examination of these responses shows less frequent use and more unfamiliarity and uncertainty about two topics (Felder & Brent, 2010), when compared to practices related to major foci. Survey respondents were also asked to respond to questions about the degree to which NETI has influenced their teaching practice. Percentages for five major and two minor emphases are shown in Figs. 3 and 4, respectively.

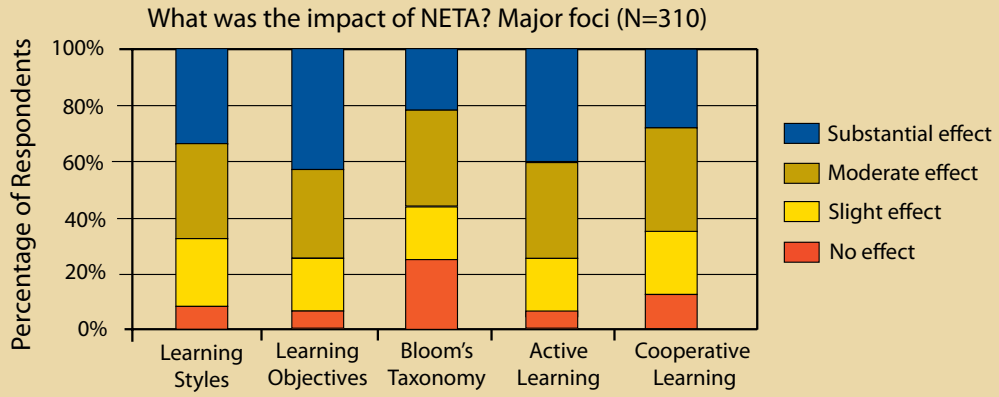


Fig. 3. Influence of major emphases of NETI on teaching practice.

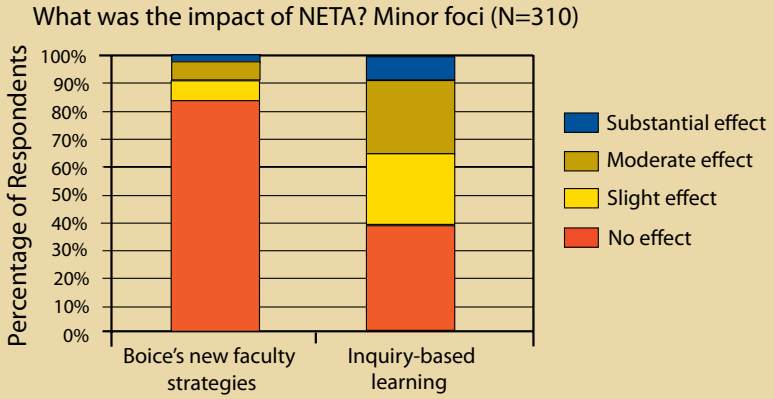


Fig. 4. Influence of minor emphases of NETI on teaching practice.

Over 50% of the survey respondents indicated that their participation in NETI had a substantial or moderate effect on their teaching in each of the five major emphases that were included in the survey. Less than 40% indicate that two minor emphases have influenced their teaching. So, participants reported the major emphases in NETI affected their teaching, but the minor emphases had a noticeable less effect.

Since nearly every recent NETI workshop has exceeded or nearly exceeded capacity, and since participant responses have been so positive, consideration of additional NETI offerings is reasonable. Starting in July 2012, ASEE program staff will invite deans to nominate faculty members to participate in a similar three-day workshop that will be offered in the following January. The workshop that has been offered in June (just prior to the ASEE annual conference) will be referred to as NETI-1A, and the January offering will be referred to as NETI-1B. Also, starting in October 2012, ASEE will

offer NETI-2, which is intended for both NETI-1 alumni as well as engineering faculty members who have acquired similar knowledge and practice through other avenues. NETI-2 will emphasize two teaching approaches: cooperative learning (Felder & Brent, 1994; Johnson, et al., 2006) and inductive teaching (e.g., problem-based learning, project-based learning, challenge-based learning) (Prince & Felder, 2006, 2007; Roselli & Brophy, 2006).

Excellence in Civil Engineering Education Teaching Workshop (ExCEEd)

The Excellence in Civil Engineering Education Teaching Workshop (ExCEEd) is a six-day workshop that has been offered by ASCE since its initial offering in 1999 at the United States Military Academy (Welch, Baldwin, et al., 2001; Welch, Hitt, et al., 2001). Each workshop offering is limited to 24 participants to provide multiple opportunities to apply the knowledge and skills they are acquiring. Invitations are sent to civil engineering (and related) departments across the country and faculty members apply. Currently, participants' institutions pay part of the cost of the workshop ($425) and participants' expenses, while ASCE invests $2075 for each participant to cover the $2500 per participant cost (American Society of Civil Engineers, 2012). With this cost structure, ExCEEd has been self-sustaining.

By summer 2010, 25 workshops had been delivered with approximately 545 alumni from over 200 different U.S. and international colleges and universities (Larson, Estes, Dennis, Welch, & Considine, 2010). At least four institutions have hosted ExCEEd workshops: United States Military Academy, University of Arkansas, Northern Arizona University, and University of Colorado, Boulder.

Topics covered in an ExCEEd workshop (Quadrato, Welch, & Albert, 2005) are listed below:

- Principles of effective teaching and learning
- Learning styles
- Communication skills
- Learning objectives
- Class organization and course organization
- Development of interpersonal rapport with students
- Teaching with technology
- Classroom assessment techniques

However, this list of topics fails to capture the essence "of this hands-on, learning-by-doing workshop" (Larson, et al., 2010). A crucial feature is that ExCEEd participants have three opportunities to practice what they are learning and receive feedback on their teaching. Participants prepare and teach three actual (although shorter than the traditional 50-minute period) classes in small-group settings. These practice sessions have been highlighted as valuable learning opportunities in workshop participant surveys. In addition to the practice sessions, participants also watch demonstration classes, which are models of high-quality teaching, presented by ExCEEd faculty mentors. Content, philosophy, and teaching approaches have been described in several papers on ExCEEd (Estes et al., 2008; Estes, Welch, & Ressler, 2005, 2006; Larson, et al., 2010; Quadrato, et al., 2005; Welch, Baldwin, et al., 2001; Welch, Hitt, et al., 2001; Welch, Ressler, & Estes, 2005).

ASCE conducted a survey of ExCEEd participants in 2007. One hundred twelve (112) faculty members responded to the survey (28% response rate) (Estes, et al., 2008). In response to a question "Would you recommend the ETW to a new faculty member in your department?" 93% of the respondents chose "Absolutely" over "Probably," "Neutral," "Probably Not," and "Absolutely Not," The other 7% chose participants chose "Probably." When asked about its important to their personal growth as a teacher, 43% said it was "Essential" and 46% said it was "Important" (Estes, et al., 2008). The survey also provided data about the need for a second workshop.

In response to requests for a more advanced workshop, ASEE began offering ExCEEd II, a day-and-a-half workshop, in 2009 at Northern Arizona University (Larson, et al., 2010). Learning objectives for ExCEEd II focused on a review of ExCEEd I, how learners develop from novices to experts, best practices in distance education, project-based learning, managing teams, large classroom techniques, and dealing with difficult students. It also featured a demonstration class, taught by a master teacher of the ExCEEd method, on introductory probabilistic design (Estes, et al., 2008).

Conclusions

To date, almost 1700 engineering faculty members have participated in faculty development workshops offered either by ASEE or ASCE. Using engineering faculty numbers from Table I, over 6% of the engineering professoriate has participated in a faculty development workshop sponsored by these two professional engineering societies. Participant responses indicate overwhelming satisfaction with the workshops, and the NETI survey results suggest that participation has influenced teaching practice.

A search of the literature on engineering faculty development did not find that the other professional engineering societies, for example, the Institute of Electrical and Electronic Engineers, the American Society of Mechanical Engineers, or the American Institute of Chemical Engineers, offered faculty development workshops on a regular basis.

References

American Society of Civil Engineers. (2012). ASCE ExCEEd Teaching Workshop, Retrieved July 12, 2012, from http://www.asce.org/exceed/.

Anderson, L. W., & Krathwohl, D. R. (Eds.). (2001). *A Taxonomy for Learning, Teaching and Assessing: A Revision of Bloom's Taxonomy of Educational Objectives: Complete Edition* (New York: Longman).

Bloom, B. S., Englehart, M. D., Furst, E. J., Hill, W. H., & Krathwold, D. R. (1956). *Taxonomy of Educational Objectives, Handbook 1: The Cognitive Domain* (New York, NY: Longman).

Boice, R. (2000). *Advice for New Faculty Members: Nihil Nimus* (Needham Heights, MA: Allyn & Bacon).

Bonwell, C. C., & Eison, J. A. (1991). *Active Learning: Creating Excitement in the Classroom* (Washington, D.C.: George Washington University Press).

Chism, N. V. N., & Szabo, B. (1998). "How faculty development programs evaluate their services," *Journal of Staff, Program, and Organization Development* **15**(2), 55-62.

Estes, A. C., Welch, R., Ressler, S., Dennis, N., Larson, D., Considine, C., . . . Lenox, T. (2008). *ExCEEd Teaching Workshop: Tenth Year Anniversary. Paper presented at the ASEE Annual Conference & Exposition,* Pittsburgh, PA. http://search.asee.org/search/fetch;jsessionid=ze2wbijlfnfx?url=file%3A%2F%2Flocalhost%2FE%3A%2Fsearch%2Fconference%2F17%2FAC%25202008Full1639.pdf&index=conference_papers&space=129746797203605791716676178&type=application%2Fpdf&charset=.

Estes, A. C., Welch, R. W., & Ressler, S. J. (2005). "The ExCEEd teaching model," *Journal of Professional Issues in Engineering Education and Practice* **131**(4), 218-222.

Estes, A. C., Welch, R. W., & Ressler, S. J. (2006). "The assessment of teaching," *Journal of Professional Issues in Engineering Education and Practice* **132**(1), 2-10.

Felder, R. M. (n.d.). The National Effective Teaching Institute, retrieved July 10, 2012, from http://www4.ncsu.edu/unity/lockers/users/f/felder/public/NETI.html.

Felder, R. M., & Brent, R. (1994). *Cooperative Learning in Technical Courses: Procedures, Pitfalls, and Payoffs* (Washington, D.C.: ERIC Document Reproduction Service Report ED 377038).

Felder, R. M., & Brent, R. (1997). "Objectively speaking," *Chemical Engineering Education* **31**(3), 178-179.

Felder, R. M., & Brent, R. (2009). *Analysis of Fifteen Years of the National Effective Teaching Institute,* paper presented at the ASEE Annual Conference & Exposition, Austin, TX. http://search.asee.org/search/fetch;jsessionid=1r7ua754q40xh?url=file%3A%2F%2Flocalhost%2FE%3A%2Fsearch%2Fconference%2F19%2FAC%25202009Full25.pdf&index=conference_papers&space=129746797203605791716676178&type=application%2Fpdf&charset=

Felder, R. M., & Brent, R. (2010). "The National Effective Teaching Institute: Assessment of impact and implications for faculty development," *Journal of Engineering Education* **99**(2), 121-134.

Felder, R. M., & Silverman, L. K. (1988). "Learning and teaching styles in engineering education," *Engineering Education* **78**(7), 674-681.

Froyd, J. E., Beach, A. L., Henderson, C., & Finkelstein, N. D. (2008). "Improving educational change agents' efficacy in science, engineering, and mathematics education," in H. Hartman (Ed.), *Integrating the Sciences and Society: Challenges, Practices, and Potentials* (Vol. 16, pp. 227-256), (London: Emerald Group Publishing Limited).

Froyd, J. E., Layne, J., & Watson, K. L. (2006). *Issues Regarding Change in Engineering Education*, Paper presented at the Frontiers in Education Conference, San Diego, CA. http://ieeexplore.ieee.org/xpls/abs_all.jsp?arnumber=4117139.

Johnson, D. W., Johnson, R. T., & Smith, K. A. (2006). *Active Learning: Cooperation in the College Classroom* (3rd ed.), (Edina, MN: Interaction Book Co.).

Larson, D., Estes, A., Dennis, N., Welch, R., & Considine, C. (2010). *ExCEEd II: Advanced Training for Even Better Teaching*, paper presented at the ASEE Annual Conference & Exposition, Louisville, KY. http://search.asee.org/search/fetch?url=file%3A%2F%2Flocalhost%2FE%3A%2Fsearch%2Fconference%2F32%2FAC%25202010Full134.pdf&index=conference_papers&space=129746797203605791716676178&type=application%2Fpdf&charset=.

Mager, R. F. (1997), *Preparing Instructional Objectives* (3rd ed.). (Atlanta, GA: Center for Effective Performance).

Prince, M. J., & Felder, R. M. (2006). "Inductive teaching and learning methods: Definitions, comparisons, and research bases," *Journal of Engineering Education* **95**(2), 123-138.

Prince, M. J., & Felder, R. M. (2007). "The many faces of inductive teaching and learning," *Journal of College Science Teaching* **36**(5), 533-568.

Quadrato, C., Welch, R. W., & Albert, B. C. (2005), "Training faculty to teach civil engineering," *Journal of Professional Issues in Engineering Education and Practice* **131**(2), 111-117. doi: 10.1061/(ASCE)1052-3928(2005)131:2(111).

Roselli, R. J., & Brophy, S. P. (2006). "Effectiveness of challenge-based instruction in biomechanics," *Journal of Engineering Education* **95**(4), 311-324.

Welch, R. W., Baldwin, J., Bentler, D., Clarke, D., Gross, S., & Hitt, J. (2001). *The ExCEEd Teaching Workshop: Participants' Perspective and Assessment,* paper presented at the ASEE Annual Conference & Exposition, Albuequerque, NM. http://search.asee.org/search/fetch;jsessionid=2useltih8926x?url=file%3A%2F%2Flocalhost%2FE%3A%2Fsearch%2Fconference%2F25%2FAC%25202001Paper377.PDF&index=conference_papers&space=129746797203605791716676178&type=application%2Fpdf&charset=.

Welch, R. W., Hitt, J., Baldwin, J., Bentler, D., Clarke, D., & Gross, S. (2001). *The ExCEEd Teaching Workshop: Hints to Successful Teaching,* paper presented at the ASEE Annual Conference & Exposition, Albuquerque, NM. http://search.asee.org/search/fetch?url=file%3A%2F%2Flocalhost%2FE%3A%2Fsearch%2Fconference%2F25%2FAC%25202001Paper376.PDF&index=conference_papers&space=129746797203605791716676178&type=application%2Fpdf&charset=.

Welch, R. W., Ressler, S. J., & Estes, A. C. (2005). "A model for instructional design," *Journal of Professional Issues in Engineering Education and Practice* **131**(3), 167-171. doi: http://dx.doi.org/10.1061/(ASCE)1052-3928(2005)131:3(167).

On the Cutting Edge Workshops and Web Resources for Early Career Geoscience Faculty

Workshop Title: Workshop for Early Career Geoscience Faculty: Teaching, Research, and Managing Your Career

Discipline: Geoscience

Workshop Leaders: Heather Macdonald, College of William & Mary (1999-2011) and Rachel Beane, Bowdoin College (2012 to present) have been the lead conveners of the workshop. Each workshop is led by two or more conveners and several additional leaders assembled from the spectrum of institutional types. The workshop was first offered in 1999. Since 2002, it has been offered as one of the workshops in *On the Cutting Edge*, a national professional development program for current and future geoscience faculty. Leaders in the first years included Barbara Tewksbury (Hamilton College), David Mogk (Montana State University), Bob Newton (Smith College), Randy Richardson (University of Arizona), Steve Semken (Diné College), and Ken Verosub (University of California, Davis). In the past several years, conveners have included Richelle Allen-King (University of Buffalo, SUNY) and Richard Yuretich (University of Massachusetts, Amherst). Carol Ormand (Science Education Resource Center at Carleton College) created the online resources for early-career geoscience faculty.

Funding Source(s): National Science Foundation Division of Undergraduate Education

Cost per participant: Has varied as location, lodging options, number of leaders, web support, and evaluation have changed over time (~$1000-2300 per participant, with participants paying the cost of their travel).

Costs/Fees paid by the participants (or their home institutions): Has varied. In early years, travel costs were paid by the participants or their home institution and onsite expenses were covered by grants. Currently, travel costs and a registration fee of $645 are paid by the participants or their home institutions. We offer stipends to participants from institutions that do not have resources to provide for the travel costs and/or registration fees.

Target Audience: Geoscience faculty in their first four years of full-time teaching, including those who will start a faculty position in the fall. Participants include faculty from across the geosciences (geologists, marine scientists, meteorologists, atmospheric scientists) and from two-year colleges, four-year colleges, comprehensive universities, and research universities.

Typical Attendance: 40-50 faculty participants per year

Workshop Duration: four days with an optional one-day visit to the National Science Foundation

When Offered: once a year in the summer

Workshop websites: Web resources specifically designed for early-career geoscience faculty were created by Carol Ormand of the Science Education Resource Center at Carleton College; these are part of *On the Cutting Edge* resources:

http://serc.carleton.edu/NAGTWorkshops/earlycareer/index.html

2012 Early Career Geoscience Faculty workshop website:

http://serc.carleton.edu/NAGTWorkshops/earlycareer2012/index.html

On the Cutting Edge website:

http://serc.carleton.edu/NAGTWorkshops/index.html

Program Description

R. Heather Macdonald, College of William & Mary
Rachel J. Beane, Bowdoin College
Richelle M. Allen-King, University of Buffalo
Ellen R. Iverson, Cathryn A. Manduca, and *Carol Ormand,* Science Education Resource Center at Carleton College
David W. Mogk, Montana State University
Randall M. Richardson, University of Arizona
Barbara J. Tewksbury, Hamilton College
Richard F. Yuretich, University of Massachusetts Amherst

"The best hope for improving professional practices—including teaching—lies with the cohorts of new faculty." – *Robert Boice (1992)*

2012 *On the Cutting Edge* Early Career Geoscience Faculty Workshop.

An important strategy to improve undergraduate geoscience education is to work with early-career faculty, because influencing faculty at the beginning of their careers has a career-long impact on them and on their students. Through work with early-career faculty, we can also improve the efficiency with which reform in geoscience education occurs. We offered the first national workshop for early-career geoscience faculty in 1999 and have offered one workshop each year since then. Since 2002, the workshops have been offered through *On the Cutting Edge*, a national professional development program for current and future geoscience faculty, which is sponsored by the National Association of Geoscience Teachers with support from grants from the National Science Foundation Division of Undergraduate Education. The aim of the comprehensive and discipline-wide *On the Cutting Edge* program is to develop a geoscience professoriate committed to high-quality instruction based on currency in scientific knowledge, pedagogic practice, and research on learning. The program offers an integrated series of face-to-face and virtual workshops each year and a website that supports workshop participants and extends the reach of workshop resources. The website received the Science Prize for Online Education (SPORE) in 2010 (Manduca et al., 2010).

The annual four-day early-career geoscience faculty workshop and the associated website for early-career geoscience faculty support faculty in the critical transition that occurs at the start of their careers. Our aim is to provide concrete suggestions about "what works" to better prepare early-career faculty for their teaching and research responsibilities, and to provide applicable career management strategies. Such a discipline-specific approach is complementary to the programs and support provided by institutions for graduate students (e.g., preparing for the professoriate programs) and for early-career faculty (e.g., campus teaching and learning centers).

The placement of the early-career faculty workshops in a larger professional development program provides multiple

opportunities for early-career faculty to develop as teachers and scholars. In addition to the annual workshops and the web resources for early-career faculty, *On the Cutting Edge* supports early-career faculty by offering other workshops (e.g., Innovative and Effective Course Design, Teaching Hydrogeology, Teaching Environmental Geology, Assessing Student Learning, Teaching about the Early Earth) and a variety of webinars, an online Course Design Tutorial, online resources of teaching materials including more than 1600 teaching activities contributed by the community, and various networking and sharing opportunities. The Course Design Tutorial and the extensive collection of teaching activities are particularly valuable resources for faculty developing their first courses.

Workshop goals and design

The Early Career Geoscience Faculty Workshop focuses on teaching, research, and career management. The workshop design is aligned with work on attributes of faculty who are "quick starters" (Boice, 2000). These quick starters receive higher teaching evaluations, are more productive in their research, and are happier (less stressed) in their work than other faculty at the same career stage. **The workshop goals, which guide workshop planning and evaluation, are for participants to:**

- Learn a goals-based approach to course design that incorporates active learning and assessment strategies with insights from STEM education research.
- Share ideas and approaches for teaching geoscience courses.
- Consider successful strategies for maintaining an active research program and for working with research students.
- Discuss life as an early-career faculty member and explore ways to balance teaching, research, and service responsibilities.
- Leave with examples of assignments and activities, with strategies for balancing competing demands, with a support network of other early-career geoscience faculty, and with a plan for managing an early career as an academic.

The workshop design follows from these goals and incorporates what participants tell us they want along with advances from education research and insights from other parts of the *On the Cutting Edge* program (e.g., sessions on affective domain, spatial thinking). The workshops are designed to be interactive, to emphasize participant learning, and to model effective teaching practices. As a 2012 participant wrote: "*I now more fully see the benefit of active learning and reflection—as this is what we did during the workshop ourselves. I intend to incorporate these aspects into my courses, and now feel that I have the tools to do so.*"

The workshop design includes plenary sessions, table discussions, concurrent sessions, informal discussions, individual consultations with workshop leaders, and a poster session. We provide opportunities for participants to interact (starting with kinesthetic ice breakers the first evening), to share experience and knowledge, and to reflect on and develop action plans. We focus on concrete suggestions and ask participants to consider how they might apply strategies in their teaching and research and in their professional lives. For example, for the poster session on the last day, participants present two hand-drawn posters: one about a plan for teaching developed during the workshop (e.g., classroom activity, course structure) and the other about a plan for scholarship. We aim for participants to be able to

readily apply what they learn in the workshop. As a 2012 workshop participant wrote: "*I am surprised at how much I am taking away from this workshop, not just with my own attitude and confidence, but in terms of tangible things that I can implement as soon as I get back.*"

Workshop content

Given our intent to support early-career faculty in all aspects of their career, the workshop addresses teaching, research, career management, and life balance. In the early years of the workshop, the focus was primarily on teaching and career management; feedback from participants indicated a desire to add more depth to sessions on research. Participants are particularly interested in strategies for teaching effectively and efficiently, in moving their research program forward, in balancing teaching, research, service, and personal life, and in tenure.

The workshop goals and the participants' interests are reflected in the workshop content. Day 1 begins with a session on strategic decisions, then focuses primarily on teaching. Day 2 focuses primarily on research. The session on working with research students includes examples of written guidelines; after this session participants uniformly state that they will be more explicit in sharing expectations and guidelines with their research students, either verbally or in writing. During day 3 participants develop and discuss a plan for their scholarship, discuss ways to fund their work, and prepare their posters. On day 4, participants receive feedback on their teaching and scholarship posters in the morning and in the afternoon discuss work-life balance and specific issues they face.

The 2012 workshop program, given below, illustrates the overall workshop schedule as well as types of topics and sessions that are addressed in the workshop. The 2012 workshop website provides details and links to the presentations. http://serc.carleton.edu/NAGTWorkshops/earlycareer2012/program.html

Workshop Program (2012)

(filled bullets mark plenary sessions, open bullets mark concurrent session choices)

Opening Evening: Icebreaker, dinner, introductions, workshop goals, evening program with a gallery walk activity

Day 1:

- Strategic Decisions: Elements of a Successful Career
- Course Design (Goals-Activity-Assessment approach)
- Interactive Lectures
- Teaching Strategies: Concurrent Sessions.
    - Engaging Students in Large Classes
    - Improving Students' Spatial Thinking Skills
    - Keeping Seminar Courses Lively and Engaging
    - Responding Effectively to Student Writing
    - Reducing Misconceptions through Lecture Tutorials and Concept Tests
- Lesson Design: Preparing for a Class Period
- Overview of Individual Consultations, Daily Roadcheck
- Evening Informal Session (optional) – Sharing Ideas about Specific Courses

Day 2:

- Introduction to Your Research/Scholarly Career
- Working Effectively with Research Students (Models for sharing research expectations and guidelines)
- Strategies for Research and Scholarship: Concurrent Sessions.
    - Research on Geoscience
    - Research with Undergraduates
    - Setting the Scope for M.S. Research
    - Starting New Research Projects and Building
    - Setting Up Your Lab and Obtaining High Quality Measurements
- Optional Lunch Discussions: dual academic careers, large classes, two-stage exams, teaching with mobile devices, and diverse classes.
- Finding and Being a Mentor: Listening and Giving Feedback
- Connections, Extensions, Opportunities: Concurrent Sessions
    - Publishing Your First Few Papers
    - Scenarios on Mentoring and Feedback
    - Working with Industry
    - Working with K-12 Teachers
- Individual Consultations with Leaders

Day 3:

- Developing a Strategic Plan for Research/Scholarly Activity
- Connections, Extensions, Opportunities: Concurrent Sessions
    - Assessing the Effectiveness of Our Teaching
    - Work-Life Balance
    - Effective Display of Data
- Writing Proposals and Getting Funded
- Optional Lunch Discussions: kids, online courses, international faculty, clickers, interdisciplinary research/collaborations, effective use of start-up funds, and mental health/violence issues with students
- Moving Your Research/Scholarly Activity Forward: Funding and Other Issues
    - Improving Research Proposals Through Review of Your Proposal Summaries (includes optional review of participants' research proposal summaries, submitted before workshop)
    - Reviewing Successful Proposals and Developing a Proposal Idea of One's Own
    - Issues at teaching-centered institutions
- Work on Poster, Individual Consultations

Day 4:

- Poster Session; Poster Follow-up and Reflection
- Strategic Decisions: Elements of a Satisfying Life
- Strategic Action Planning (goal-setting and action-planning session)
- Lessons Learned, Concluding Remarks, and Workshop Evaluation

Day 5:

Optional trip to the National Science Foundation that includes sessions led by NSF program officers as well as individual meetings with program officers.

Website

During the workshop, participants are introduced to the *On the Cutting Edge* website, which includes more than 4500 web pages on 47 pedagogical topics, geoscience topics and themes, and career management. The Early Career Geoscience Faculty component of the website includes sections on Making Choices: Finding Your Balance; Efficient, Effective Teaching; Developing a Thriving Research Program; Getting Tenure; International Faculty Members; Early Career Geoscience Faculty Workshops; and Workshop Leader Career Profiles. Although the examples on the website are geo-specific, the overarching principles can be applied to early-career faculty in other disciplines. The number of visits to the early career part of the website in March 2012 was more than 16,000; the *On the Cutting Edge* website had 1.2 million visitors in the last year. Using the rough estimate that 10% of visitors actually intend to look at the site, the early career site generated intentional visits by 1600 users in March 2012.

Workshop participants

The participants are primarily tenure-track faculty in their first four years of teaching. The workshop draws 40-50 participants a year, with a high of 60 in 2009. In the last decade (2003-2012), 464 faculty participated in the program, with approximately 100 more in the first four years of the program. For most participants, this was their first *On the Cutting Edge* workshop; others had participated in the *On the Cutting Edge* workshop for graduate students and post-doctoral research associates on Preparing for an Academic Career in the Geosciences or one of the topical workshops. Of the participants who provide demographic information, 48% are women, 17% are minorities, and 7% are underrepresented minorities. The percentage of women and of underrepresented minorities in the workshops is higher than in the geoscience faculty population. We encourage participation from all types of institutions across the academic spectrum, including community colleges, liberal arts colleges, comprehensive universities, and research universities. We accept all applicants who are in full-time tenure-track or similar permanent positions. When possible, we also accept applicants who are in positions in which their responsibilities are similar to those of tenure-track faculty. Participants come from across the geosciences: geology, marine science, and meteorology/atmospheric science; geographers and ecologists have also participated in the workshop.

Workshop evaluation

By both structured evaluation and less formal measures, the workshop for early-career faculty is successful. Proxy and anecdotal measures are positive. Early-career faculty members continue to come to the workshop, even as the cost to participants has increased. Some chairs "reserve" spaces in the workshop for their new hires. Participants recommend the workshop to others. Workshop alumni help publicize the workshop, providing glowing endorsements. They respond to calls for assistance in building the website (e.g., providing copies of successful grant proposals, advice on research talks for the job interview). The early-career faculty website has high use, as mentioned earlier. Workshop leaders, many of whom are workshop alumni, are willing to contribute their time to the workshop and they leave the workshop energized. More formal evaluation of the workshop is also positive. That evaluation includes participant surveys and embedded assessment at the workshop itself as well as follow-up surveys, interviews, and national surveys that are used in the overall *On the Cutting Edge* program evaluation, which looks at the impact of the program as a whole.

Participant satisfaction with the workshops is high. Surveys during the workshop include daily road-checks and an end-of-workshop survey in which participants rate specific workshop goals, provide feedback on what they have learned, describe what they plan to implement, and give an overall workshop rating. Overall satisfaction of participants in the workshops averages 9.4 on a 10-point scale. The summer 2012 workshop received an overall mean rating of 9.7. Individual comments about the influence of the workshop are positive and suggest changes in teaching and research practices, changes in thinking about teaching, and higher confidence moving forward. Participants value the practical ideas, the support network that develops, and the opportunity to interact with—and learn from—a diverse leadership team.

The posters constructed by participants for the culminating poster session serve as an embedded assessment for the workshop. A review of poster descriptions and reflections written by participants after the poster session provides information about participant teaching and scholarship plans post-workshop and how the workshop influenced these plans. An analysis of 47 teaching posters from 2010, 2011, and 2012 showed that all intended to make specific changes in their teaching based on what they learned at the workshop. Approximately two-thirds from this sample focused on teaching activities including classroom exercises with specific details for effective implementation. Other posters from this sample focused on courses as a whole, various active learning strategies, small-group discussions, and other approaches. Through the poster reflections, we have a better understanding of participants' prior knowledge, what their new knowledge is, and how they integrate the two. The poster reflection itself provides an opportunity for such integration. Even if the plan isn't implemented exactly as proposed, because participants integrated their prior knowledge with their new knowledge, the likelihood of the practices being implemented in some way is increased. This conclusion is supported by post-workshop interviews, in which participants report implementing the plan or some variation.

Evaluation of the impact of *On the Cutting Edge* shows that the majority of participants report changes in their teaching practices in the classroom and also reveals differences in reports of teaching practices between Cutting Edge

participants and nonparticipants. These results are for the program as a whole, not for individual workshops. Multiple surveys indicate that 80% of respondents report making specific changes to their teaching practices with a measurable shift toward active-learning techniques (Manduca et al, 2010). Interviewees can identify specific changes and trace them to lessons learned at a workshop or from the website. Critical to supporting these changes is a student-centered view of learning which is developed at the workshops. In addition to the impacts on individual faculty, *On the Cutting Edge* has created a culture in which faculty learn from one another and share resources to improve teaching. The workshops encourage discussions about teaching and the website allows faculty to quickly discover what others are doing (Manduca et al., 2010). Analysis of a national survey of geoscience faculty involved comparing Cutting Edge participants (website users or workshop participants who also use the website) to faculty who had not participated in Cutting Edge showed differences between the two groups. Participants were more likely to report adding group work or small group activities to their teaching (40% of participants relative to 15% of nonparticipants); and spending less time lecturing (43% of participants relative to 22% non-participants). Participants reported more frequent use of in-class questioning, small group discussion, and in-class exercises and were more likely to have changed assessment tools/strategies (McLaughlin et al., 2010).

The following three quotes present a picture of the impact of the workshop on participants

"The workshop totally changed my view of teaching from teacher-oriented to student-oriented. It's no more what I want to teach but what students need to learn or take away from the course. This is the essential point that I will keep in mind when I design course goals, syllabi, in-class activities, assignments, and exams." – End-of-workshop survey respondent

"The workshop had a powerful impact on my thoughts of teaching philosophy, highlighting the need for different approaches to get students to learn the material, including group work, and hands-on/inquiry-based approaches to subject matter that is normally covered in a (dry) lecture-based format." – Action Plan follow-up survey respondent

"I think that in the classroom is probably where it's made the biggest difference and that means I don't even do that kind of straight-up, just lecture through for an hour—it isn't even an option to me." – Follow-up survey respondent

Keys to success

We attribute the success of the Early Career Geoscience Faculty workshop in large part to the program design, the workshop leaders, the extensive preparation, and the rapport that develops among participants. Below we highlight key aspects of these four workshop components.

• *Program design*

We design sessions that model varied examples of effective pedagogy to make the workshop stimulating and interactive for the participants. Evidence-based learning principles and examples are offered at an appropriate level for beginning faculty that credits theory while emphasizing application. We use concrete geoscience examples to which participants can relate, and may later adapt or adopt. Leaders facilitate discussions and anticipate the likely outcomes of these discussions. Participants receive direct feedback from other participants and leaders on their ideas and plans

(course goal sharing, research proposal review, teaching activity review, poster review, future plans). The program schedule preserves time for casual interactions and encourages participants to reflect on what they are learning.

• Workshop leaders

Strong leaders contribute to the workshop success. Leader selection focuses on finding effective facilitators who have characteristics of a successful career whether or not they are at the top of their discipline. Leader selection considers type of institution, disciplinary expertise, diversity, geographic balance, international perspective, parent, and dual career. We include leaders from two-year colleges, four-year colleges, and research universities. Leaders range from recently tenured to more experienced, including some with administrative experience. The leader mix adds to the workshop in many ways, including opportunities for individual consultations with participants. The number of leaders allows for facilitated table discussions with six to eight participants per facilitator. The leader team includes past early-career participants who rave about their experiences in the workshop and set a positive constructive tone for the current workshop. The combination of repeat leaders and new leaders creates an ever changing team with expertise and new ideas, which leads to continual fine-tuning and improvement of the workshop.

• Extensive preparation

The workshops involve extensive preparation. Leaders adjust the program each year and discuss the implications of any changes. The relation of plenary sessions to the program and to concurrent sessions is considered. Most sessions are co-led with leaders communicating and exchanging multiple drafts of slides before the workshop. Copies of slides/notes are given to the lead convener for review and inclusion in the workshop notebook. Before developing sessions, leaders are given instructions and the conveners have discussions with new leaders about best practices for facilitating sessions. The given instructions are:

- ***Model effective pedagogy.*** Participant evaluations tell us that our most successful workshop sessions are those taught with good pedagogy in mind and that our least successful sessions are those where a presenter simply stands up and talks. As you plan your sessions, please consider incorporating active learning techniques. These will help the session to be interactive and will model effective teaching for participants.
- ***Engage participants actively during the workshop.*** Nothing is less effective than a workshop where participants do not participate. Ways of engaging participants include small and large group discussions, short problem-solving tasks, reviewing and/or trying out activities, scheduled thinking and writing time, and so forth.
- ***Plan your sessions thoroughly – maybe even minute-by-minute.*** Good sessions that appear to flow spontaneously reflect extensive planning by leaders, a clear understanding of the session and its objectives, and realistic planning for how long activities will really take. Please take care to plan time for questions at the end, and to fit into the specified time for the session.

Workshop leaders arrive early to participate in a five-hour pre-workshop meeting to review the schedule, preview sessions, and talk through any remaining questions they have. Daily breakfast meetings serve to get feedback from the previous day's participant roadcheck, review the day's program, highlight roles of table facilitators, and discuss any concerns.

• *Participant rapport*

We use a variety of approaches to build rapport and community at the workshop. We welcome participants from a range of disciplines and a range of institutions, and participants make connections with faculty they might not otherwise meet. The topics of a gallery walk exercise on the first evening help participants realize that many have similar concerns and serves to foster an early sense of "I'm not alone." Opportunities for participants to interact are planned throughout the workshop week—from paired introductions the first night to small group table discussions during workshop sessions and at lunch, to a picnic mid-way through the workshop, and more. Leaders give positive supportive guidance to participants using phrases such as "have you considered," "something I've tried," and "I know someone who has..." rather than "you shouldn't do that" or "I'm the expert and this is how it's done." Many participants pick up on this positive communication and use it in discussions and feedback. Early opportunities for feedback are lower stakes (e.g., feedback about a course goal) and build trust and support toward higher stakes feedback (e.g., research proposal review, poster session). This rapport is essential for the final session during which participants, in small groups facilitated by a leader, seek advice on a specific question or topic. Throughout the workshop we are sensitive to emotions, welcoming opportunities to smile and laugh to relieve tensions, as well as recognizing that some topics are sensitive, and that some participants have difficult situations/issues.

Conclusions

Since first offered in 1999, the workshop and associated web resources have supported early-career geoscience faculty well. Through the years, the workshop has evolved in response to participant requests, to new ideas from leaders, and to developments in geoscience education research. Some plans for the future are (1) to continue to improve the workshop to reflect new directions in STEM education research and changes in faculty's conceptions of teaching and learning; (2) to continue to recruit faculty participants broadly to reach institutions that have not had faculty participate in the past; (3) to incorporate best practices from other STEM early-career workshops; and (4) to secure funding that will offset workshop expenses and continue to support faculty who otherwise would not have the resources to attend.

Acknowledgments

This material is based upon work supported by the National Science Foundation Division of Undergraduate Education under grants DUE 9752809, 9752801, 9752819, 0127310, 0127141, 0618725, 0618482, 1022910, 1022844.

References

Boice, R. (1992). *The New Faculty Member: Supporting and Fostering Professional Development* (San Francisco: Jossey-Bass.)

Boice, R. (2000). *Advice for New Faculty Members: Nihil Nimus* (Needham Heights, MA: Allyn & Bacon).

Manduca, C. A., Mogk, D.W., Tewksbury, B., Macdonald, R.H., Fox, S.P., Iverson, E.R., Kirk, K., McDaris, J., Ormand, C., and Bruckner, M. (2010). "SPORE: Science prize for online resources in education: On the Cutting Edge: Teaching help for geoscience faculty," *Science* **327**, 1095-1096.

McLaughlin, J., Iverson, E., Kirkendall, R., Bruckner, M., and Manduca, C.A., (2010). *Evaluation Report of On the Cutting Edge*. Available at http://serc.carleton.edu/files/NAGTWorkshops/2009_cutting_edge_evaluation_1265409435.pdf.

Project NExT
A Program of the Mathematical Association of America

Discipline: Mathematics

Workshop Leaders (PIs):

Project NExT Leadership Team, consisting of
Aparna Higgins, University of Dayton (Director)
Joe Gallian, University of Minnesota Duluth (Associate Director)
Gavin LaRose, University of Michigan (Associate Director)
Judith Covington, Louisiana State University, Shreveport (Associate Director)
Julia Barnes, Western Carolina University (Member)

Funding Source(s):

The Mary P. Dolciani Halloran Foundation
The ExxonMobil Foundation
The Educational Advancement Foundation
The American Mathematical Society
The American Statistical Association
The National Council of Teachers of Mathematics
The American Institute of Mathematics
The Association for Symbolic Logic
The W. H. Freeman Publishing Company
John Wiley & Sons
The Mathematical Association of America and several of its Sections

Cost per participant: $6000 per Project NExT Fellow.

Costs/Fees paid by the participants (or their home institutions): $3500 per Project NExT Fellow (this amount is included in the cost per Fellow mentioned above).

Target Audience: New or recent PhDs in the mathematical sciences who will hold academic jobs during the Fellowship year.

Typical Attendance: 80

Workshop Duration: Program duration is one year, which includes three consecutive national meetings of the Mathematical Association of America. At the first meeting, there is a two-and-a-half day workshop preceding the meeting. No separate workshop is held at the second meeting, although Project Next sessions are held during the national meeting. At the third meeting, there is a one-day workshop that precedes the national meeting.

When Offered: Annually. Project NExT is a year-long program.

Workshop website (url): http://archives.math.utk.edu/projnext/

Program Description

Aparna Higgins, University of Dayton

Introduction

Project NExT (**N**ew **E**xperiences in **T**eaching) is a year-long professional development program of the Mathematical Association of America (MAA) for new and recent PhDs in the mathematical sciences who are interested in improving the teaching and learning of undergraduate mathematics. The program addresses all aspects of an academic career: improving the teaching and learning of mathematics, engaging in research and scholarship, and participating in professional activities. Project NExT helps to integrate its participants (called Project NExT Fellows) quickly into the broader mathematical community. Project NExT also provides the Fellows with a network of peers and mentors as they assume the responsibilities of an academic career. The Fellows commit to attending three consecutive national meetings of the MAA, including two summer meetings (Mathfests) and the Joint Mathematics Meetings (JMM) in the winter. There is no fee for participation in Project NExT. However, the Fellows' institutions bear all meetings-related expenses for the three national meetings. More information about Project NExT can be found at its website: http://archives.math.utk.edu/projnext/.

Project NExt Fellows, 2010.

Project NExT is an exciting and established program, now in its 18th year with a total of 1324 participants. Project NExT Fellows have distinguished themselves with national research and teaching awards and awards for service. Three Project NExT Fellows have won CAREER awards (the NSF's most prestigious award for as-yet-untenured teacher/scholars) and three others have won the MAA's most prestigious national teaching award, the Deborah and Tepper Haimo Award (only three are given a year). They have influenced the mathematical profession by involving themselves in governance of professional societies at the regional and national levels, and by organizing sessions at mathematics meetings. One of the serendipitous outcomes of Project NExT has been the sense of community that has been created within each Project NExT cohort, and across cohorts.

This report includes an overview of the Project NExT fellowship year. Details of each aspect follow the overview. The report concludes with a description of recruitment, applications, and selections of Fellows, the structure of the leadership team and funding.

Project NExT fellowship year

Project NExT Fellows meet three times in their fellowship year. Each meeting is held in conjunction with a national meeting of the MAA. The first meeting is held in August, starting with a two-and-a-half day Project NExT Workshop, followed by the three-day Mathfest. The Workshop is organized by the Project NExT Leadership team. At the meetings in January and the subsequent August, the Project NExT Fellows organize six sessions. Each year's cohort is assigned a color. A dot of this color is affixed to the Fellows' meetings badges. The dot is useful at the second and third national meetings to identify those of the same cohort. Project NExT Fellows are subscribed to an electronic listserv hosted by the MAA, starting before the first meeting. The Fellows are encouraged to discuss professional issues or seek advice on this list. In the fall, the Project NExT leadership team matches each Fellow with a consultant. A consultant is an experienced faculty member who serves as a friend in the profession, outside the Fellow's department. All consultants are added to the electronic listserv and provide advice and different viewpoints.

The Project NExT Workshop

The fellowship year begins with a two-and-a-half day workshop held prior to Mathfest (the three-day summer meeting of the MAA) in August. Organized by the Project NExT leadership team, the workshop is designed to introduce the Project NExT Fellows to many different ideas about teaching, so that the Fellows can choose the ones that work for them and their students at their institutions. Project NExT Fellows participate in small group discussions and breakout sessions, attend plenary talks and panel discussions, and take a four-hour-long course (which occurs during Mathfest). The Fellows eat their meals with each other and with the presenters at the workshop. A recent Project NExT Workshop program can be found by clicking the link "sample workshop program" on the Project NExT webpage. Presenters for the Project NExT Workshop are practitioners of various methods that are used to teach undergraduate mathematics. They are asked to provide details of using this technique, including how to put it in practice, its benefits, and its limitations. The program for the Project NExT Workshop has the same basic structure each year. However, the actual topics discussed, and hence some of the presenters, vary from year to year.

Ice-breaker sessions, where Fellows meet in groups of 10 to 15, are held on the afternoon of the first day of the workshop. A presenter facilitates the discussion. The first session gets the Fellows to articulate what they most look forward to and what they are anxious about in the year to come. The second icebreaker session places Fellows in groups based on type of institution, and the Fellows discuss the kinds of teaching techniques they have found helpful to meet their goals.

There is a **plenary talk** on each day of the workshop. The first of these sets the tone for the workshop, is sensitive to the Fellows' transition from graduate students to faculty members, and welcomes the Fellows to our profession. The second plenary talk addresses aspects of an academic career that the speaker chooses to discuss. The third plenary lecture is held during the closing session. It exhorts the Fellows to find different ways of making contributions to their institutions and the mathematical community.

Three **panel discussions** are held on the first two days of the workshop. Panels are structured to have equal representation of gender whenever possible. The first panel discussion, "Joining the Mathematical Community," is held after dinner on the first day of the workshop. Four Project NExT Fellows from previous years are invited to speak on various forms of service to the mathematical community, such as holding office in the Sections of the MAA or in the national MAA, or serving on editorial boards of mathematics journals, or serving on committees of mathematical professional societies. The other two panel discussions are held on the second day of the workshop. "Choosing a Way to Teach" invites three panelists to describe a particular way of teaching or testing, such as co-operative learning or ways of getting students to read the textbook or one-minute evaluations at the end of class or implementing group exams or student journals. The panelists on "The Faculty Member as Teacher and Scholar" describe the expectations for getting tenure at various kinds of institutions. Four panelists are selected to provide a mix of research universities, branch campuses of state universities, liberal arts schools, and public and private institutions.

Breakout sessions provide Fellows the opportunity of being introduced to a topic in a small group setting. On each of the second and third days of the workshop, five simultaneous breakout sessions are held on topics that are currently important for early-career faculty in mathematics. Fellows have had the opportunity to rank the five topics (different for each day), and each Fellow is assigned to two breakout sessions per day based on those rankings. Topics include methods of teaching such as inquiry-based and cooperative learning, incorporating technology in teaching mathematics, using writing in mathematics courses, using projects to assess student learning, innovative ways of teaching specific mathematics courses such as calculus, linear algebra, abstract algebra, geometry, analysis, and courses for teacher preparation, and academic advising.

Meals at the Project NExT Workshop are communal. Fellows and presenters are guests of Project NExT at these meals and at refreshment breaks. Breaks are long and frequent to encourage informal networking, consultation, and bonding between Fellows and with the presenters. An ice cream social on the evening of the second day begins the intermingling of this year's Fellows with last year's cohort. Members of the Board of Governors of the MAA are also invited to the ice cream social.

On the **third day** of the Project NExT Workshop, two groups of Project NExT Fellows are present—the incoming group who are attending their first meeting of the fellowship year and the returning group, who are attending their final meeting of the fellowship year. The two groups have some sessions with their own cohorts. They also participate in a **joint session** on research breakouts every other year, and in alternate years, breakouts based on geography. These sessions are designed to help the Fellows get to know other Fellows in the two cohorts who are proximate in research area or location. The Project NExT leadership team selects a facilitator for each room. Fellows share with each other research questions that they are currently interested in and establish networking connections with each other. In alternate years, Project NExT Fellows meet other Fellows who are in the same geographic region (or MAA Section) to share knowledge of activities for early-career faculty and for students in that region.

Organizing session: The incoming Fellows attend a plenary session in which they begin planning for the sessions that they will organize for their second meeting of their fellowship year. In this organizing session, they propose topics and the Project NExT leadership team notes these. Further planning is done via the electronic listserv.

The **closing session** of the Project NExT Workshop is a joint session. It begins with a "graduation ceremony" for the Project NExT Fellows who have completed their fellowship year. Each returning Fellow is given a certificate, congratulating her/him on being selected as a Project NExT Fellow and completing the program. The certificates are signed by the President of the MAA and by a representative of the sponsors. Joe Gallian, of the University of Minnesota Duluth, who is known in mathematical circles for his contributions to, and prowess in, research, teaching and service, always gives the closing address, "Finding your niche in the profession." Fellows find the talk extremely inspiring.

The day concludes with the **Opening Banquet** of MAA's Mathfest, to which each Fellow from the incoming and returning groups of Fellows is given a complimentary ticket. This begins the integration and networking of the incoming Project NExT Fellows with the larger mathematical community.

On two days of Mathfest (immediately following the Project NExT Workshop), both returning and incoming Fellows (and, if space permits, Fellows from previous years and Section NExT Fellows) attend a **Project NExT course**, which has four hours of content split over two days. It allows a deeper exploration of a single topic in a small group setting. Some recent topics include: teaching introductory statistics, grant-writing and getting your research known, directing undergraduate research, mathematical biology, modeling in mathematics courses, applications of linear algebra, and teaching courses for pre-service teachers.

The second and third meetings of the Project NExT fellowship year

The second of the three national meetings that Project NExT Fellows are committed to attending occurs in January, in conjunction with the Joint Mathematics Meetings (JMM), an event sponsored by many of the professional societies in mathematics. The current Project NExT Fellows and their consultants (see description elsewhere in this document) are invited to be guests of Project NExT at a dinner the night before the start of the JMM. The dinner provides an opportunity for the Fellows to re-connect with each other, connect with consultants, and start planning their own sessions for the third meeting of the fellowship year, which occurs in August. The Fellows attend six sessions which they have organized under the guidance of the Project NExT leadership team. At the first and second meetings of the fellowship year, the Fellows propose topics on which they would like to have sessions during the following meeting. Two coordinators (selected by the Project NExT leadership team) organize the Fellows to vote for the topics, six of which are chosen to be presented. Fellows volunteer to form organizing teams. Four organizers per session plan the session, write an abstract, select panelists to represent diverse points of view on the topic, invite the panelists, and moderate the session at the meeting. Recent topics included capstone courses, inquiry-based learning, refereeing and publishing, and writing in mathematics.

At the Joint Mathematics Meetings in January, the current Fellows also organize and staff the **Project NExT booth** – the Fellows are, indeed, the best ambassadors of the program.

At the last meeting of the fellowship year, in August, in addition to their own sessions, the Fellows attend some joint sessions with the incoming Fellows, thereby networking with the next group of Fellows (see description of the Project NExT Workshop above).

The application process

Applications to Project NExT are available in February of each year and are due mid-April. The application materials include an application form, a one-page resume, a short research statement, a two-page personal statement, and a letter of support from the chair of the department at which the applicant will be employed in the fall. Support from the institution requires assurances that the applicant will be free to implement techniques from the program and that financial support for the applicant to attend three consecutive national meetings has been procured. Applications are recruited by sending letters to all member departments of the MAA, and additional letters to all mathematics departments at PhD-granting universities and minority-serving institutions; by postings on the Project NExT electronic discussion lists; and by announcements in newsletters and websites of various mathematical professional societies, including the MAA's newsletter FOCUS.

Selection of applicants

Applicants must meet eligibility requirements (the fellowship year being the first or second year of a full-time position teaching mathematics after earning the PhD degree) and must be fully financially supported by their institutions. There is no registration fee for Project NExT. The institutional support is entirely for the Fellow's meetings-related expenses (including registration fees, travel, board, and lodging) and is estimated at $3500 per Fellow. Each application is read by at least two readers. Readers include all members of the Project NExT leadership team and, by invitation, a few experienced faculty members. Readers seek out applicants who can contribute to the program, yet can grow by learning from the program and from the other Fellows, and who are thoughtful and reflective of teaching experiences. Eventual selections are made based on gender balance; diversity of ethnicity, race, geographical area and type of institution; and sponsor requirements. Each year, about 80 Fellows are selected from 120-140 applications.

Leadership team

The leadership team of Project NExT consists of a Director and four Associate Directors (four-year terms) and a member (two-year term). All five positions offer some compensation in the form of course release or stipend. After 16 years of directing Project NExT, co-founder T. Christine Stevens, of Saint Louis University, stepped aside in 2009, leading to the first change in personnel in Project NExT in over a decade. Members of the leadership team now have fixed-length terms with searches held for replacements. The first search was conducted in 2011-12.

Funding

Funding for Project NExT initially was provided in full by the Exxon Education Foundation (later, the ExxonMobil Foundation). When the ExxonMobil Foundation cut back its funding, Project NExT sought additional donors, giving "naming rights" to individuals or corporations for an amount of $2500 per Fellow per year. Despite the recent cessation of funding from the ExxonMobil Foundation, Project NExT has been able to continue selecting about the same number of Fellows each year, with funding provided by professional societies (including The American Mathematical Society, The American Statistical Association, The Association for Symbolic Logic, The American Institute of Mathematics, The National Council for Teachers of Mathematics and The Association for Mathematics Teacher Educators), foundations (such as The Mary P. Dolciani Halloran Foundation, The Educational Advancement Foundation), publishing companies (such as The W. H. Freeman Publishing Company, John Wiley & Sons), mathematical computing and software companies (such as Maplesoft and Texas Instruments). Some of the 29 Sections of the MAA provide funds for a Project NExT Fellow each year. A few endowed Fellowships and bequests have provided funding for many Fellows. The aggregation of smaller donations by individuals is used to name Fellows after Project NExT's other co-founder, the late James R.C. Leitzel. The amount of $2500 per Fellow per year is used for expenses associated with the Project NExT Workshop and at the JMM (including space rental, audio-visual equipment, catering for meals, refreshment breaks, receptions, travel expenses and honoraria for the presenters), expenses for the Project NExT leadership team (such as travel expenses to two national meetings a year, and compensation), MAA staff time, supplies, duplication, materials for folder inserts for the Project NExT Workshop, postage, telephone.

Key features of Project NExT

a) Selection of qualified Project NExT Fellows guided by deliberate diversity considerations.

b) Facilitating the integration of the Fellows into the mathematical community by forming the habit of attending national meetings.

c) Assigning a consultant to each Fellow.

d) The electronic discussion lists. These are used during the Fellowship year and beyond. A voluntary list across all years on issues regarding the preparation of teachers is also available.

e) Section NExTs, which are programs conducted by MAA Sections that use many ideas of the national program. The Section NExTs have their own eligibility requirements.

f) The sense of community formed serendipitously in the early years of Project NExT, but now touted as one of the features that applicants find appealing, and that Fellows rely on.

g) **The dot!** Used originally on badges to help Project NExT Fellows identify each other (by cohort) at large national meetings, it has now become a symbol of a group of energetic, thoughtful new faculty who are influencing the learning and teaching of undergraduate mathematics by organizing and contributing to scientific sessions at mathematics meetings and by participating in the governance of professional mathematics organizations.

Annual American Society for Microbiology Conference for Undergraduate Educators

Discipline: Microbiological and Biological Sciences

Workshop Leaders (PIs): 2012 – **Chair,** Jacqueline Washington, Nyack College, Nyack, NY; **Vice Chair**, Todd Primm, Sam Houston State University, Huntsville, TX

Funding Source(s): Registration, exhibitors, sponsorship and ASM speaker fund subsidy

Cost per participant: ~$600/participant

Costs/Fees paid by the participants (or their home institutions): Registration fee: ASM members – $699.00; Non-members– $799.00

Target Audience: Microbiology and biology educators from colleges, universities and international institutions.

Typical Attendance: 350

Workshop Duration: Four days

When Offered: annually in May or June

Workshop website: www.asmcue.org

Program Description

Jacqueline Washington, Nyack College

Todd Primm, Sam Houston State University

Introduction

The American Society for Microbiology (ASM) is the largest life science professional organization with nearly 39,000 members. The Society has held an annual general meeting every year since 1899. In 1988, recognizing the unique needs of educator members to gather and share best practices, two education sessions at the general meeting were introduced. By 1993, ASM educators wanted even more opportunities for in-depth discussions, and a group met separately in order to discuss and design guidelines for the undergraduate microbiology curriculum. A core group of approximately 100 microbiologists gathered for consensus-building discussions prior to the ASM General Meetings of 1994 to 1996. These discussions culminated in the first version of the ASM Recommended Curriculum Guidelines for Microbiology (American Society for Microbiology, 2002). The meeting, held annually since then, is now known as the American Society for Microbiology Conference for Undergraduate Educators (ASMCUE).

ASMCUE participants model active learning.

Now in its 19th year, ASMCUE (www.asmcue.org) gathers over 325 microbiology and biology educators from around the world for an interactive four-day conference. The meeting is typically held in May or June alternating between East and West Coast locales. Attendees gather to improve their teaching techniques, engage in teaching as a scholarly endeavor, and identify with a community. Topics include teaching, learning and assessment, classroom and independent student research, student advising and mentoring, graduate training and professional skills development, K-12 outreach, and community service.

Conference attendees represent diverse types of institutions, from community colleges, universities, undergraduate, graduate, and international institutions. In general, half of the attendees have been teaching for less than 10 years. Courses taught range from Introductory Microbiology and Biology/Biotechnology to Upper Division Microbiology/ Biology and Human Anatomy and Physiology, and other courses. The typical students taught by the attendees are biology, microbiology or allied health/nursing majors, biology nonmajors, and students in doctoral or medical microbiology programs.

ASMCUE educators gather to learn and share the latest information in both the biological sciences and education research. The conference program includes plenary, concurrent, poster, and exhibit sessions. Participants engage in formal and informal small group discussions between colleagues all focused on the same goal: to improve teaching and learning in the biological sciences.

ASMCUE Program Format

Plenary lectures

The ASMCUE theme, "Blending Science and Education," seeks to blur the dividing line between science and education research. Four plenary lectures given by well-known, distinguished speakers, anchor each day of the four-day conference. Two of the lectures are on cutting-edge science and the other two focus on the latest research in science education.

Concurrent sessions

Attendees can choose to attend any one of three types of concurrent sessions: scientific, pedagogical, and resource. The sessions are one hour long and in general, each topic is offered twice throughout the four day conference.

Concurrent Scientific Sessions enhance participant knowledge of current topics in biology and science education through lectures given by the leaders in these areas. Presenters are encouraged to engage participants actively in their

presentations. Concurrent Pedagogy Sessions present practices and pedagogies that have been assessed for classroom effectiveness. Presenters provide background information and their approach to the strategy, leaving time for participants to practice and reflect upon how the new practice or approach can be implemented into their classrooms. Concurrent Resource Sessions provide attendees with topics and information to enhance their professional skill sets and scholarship. Presenters provide background information to tools, resources, and references for advancing in the profession. Speakers for these sessions may be invited by the conference committee, or selected from submitted abstracts. Effort is made not only to diversify the types of topics presented, but also to reflect the suggestions of attendees of previous conferences.

Microbrew symposia

Participants may also submit abstracts detailing their best teaching practices or laboratory activities to be considered for 15-minute "chalk talk" oral presentations. Abstracts submitted to these "Microbrew" sessions do not require assessment of student learning. These are very informal presentations, and serve as a forum for sharing ideas, best strategies or thoughts pertaining biology or microbiology education. An additional period of five minutes is allowed for discussion. Thus, Microbrews serve not only as a learning opportunity for attendees; the presenter can also obtain valuable feedback from the audience.

Poster sessions

Abstracts describing innovative teaching approaches or the specific activities conducted by the students that indicate how those changes affected student learning are accepted for poster presentations. The accepted abstracts cover microbiology and biology education research, and must fully demonstrate a scientific problem, including hypothesis, methodology, results, and conclusion. A decision was made in 2010 to publish abstracts selected for the poster sessions in the *Journal of Microbiology & Biology Education*.

Exhibit program

Typically, exhibitors at ASMCUE are textbook publishers and others offering services to educators. An interesting statistic that holds true every year for ASMCUE is that 40-50% of participants are first-time attendees of the conference. Exhibitors are delighted to have new customers every year and it also means that there is always "new blood" being added to this supportive community of educators to which exhibitors can demonstrate their products.

Peer review and networking/topical meal sessions

Attendees have many opportunities for networking. All meals during the conference except one are taken together. Attendees may sit together to join in discussion on topics of areas of common interest. The topics selected are gleaned from listserv discussions. Lunch sessions serve as opportunities where conference attendees may participate in any of several important initiatives.

Participants have the opportunity each year to provide input on several standard microbiology protocols during a lunch session. To date, 38 protocols have been reviewed by the community. The protocols are comprehensive and include purpose, theory, history, recipes, and best practices. Protocols are revised after the conference and then are published in MicrobeLibrary (www.microbelibrary.org) where participants are listed as contributors (American Society for Microbiology, 2012).

In the last several years, attendees have also contributed to the reform of microbiology education and laboratory practices. In 2011, ASM Undergraduate Microbiology Curriculum Guidelines were vetted by the ASMCUE community. The guidelines were aligned with the Vision and Change core concepts and competencies found in *Vision and Change in Undergraduate Biology: A Call to Action* (AAAS, 2011). After several opportunities for the community to comment on and review the guidelines, the vetted guidelines and the process for consensus were published in 2012 (Chang, 2011).

In 2012, attendees were asked to comment on newly written Guidelines for Laboratory Safety in Teaching Laboratories. The effort, led by ASM and in conjunction with the Centers for Disease Control (CDC), was initiated after the 2010-11 salmonella outbreak. The ASM Laboratory Biosafety Committee developed a draft set of biosafety guidelines for instructors using microorganisms in undergraduate or K-12 laboratories and presented them to ASMCUE 2012 attendees for comment and discussion. The guidelines are expected to be published in 2013.

ASMCUE and professional development

Post-conference surveys suggest that 80% of the attendees indicate ASMCUE as their primary source for professional development. Attendees have the opportunity to contribute to an onsite conference wrap-up session in which they can offer feedback on the current conference and ideas for the future. In addition, each year conference participants receive a post-conference survey. Results and comments are considered by conference planning committee and enhancements are made to future conferences, if possible.

In 2004, a comprehensive survey was sent to 759 participants who had attended at least one conference in the preceding 10 years. The response rate was 25% and respondents reported that they developed professionally in the following ways:

- 82% changed their courses or programs on the basis of information gained at the conference.
- 61% shared information learning with colleagues.
- 57% attended to safety issues more regularly.
- 51% introduced more group learning and writing assignments.
- 49% added new course materials from MicrobeLibrary.
- 48% conducted more extensive research about ASM curriculum guidelines.
- 41% contacted or visited another participant after the conference.
- 35% introduced case-based assignments.
- 30% revamped entire courses.
- 25% served on a national committee (including ASM) as a reviewer, advisor, planner, or consultant.
- 16% published peer-review article(s) for publication in undergraduate education.
- 14% established collaborations with other participants.

- 14% submitted an educational improvement or faculty development proposal (e.g. NSF, FISPE, HHMI, ASM, Carnegie, etc.).
- 10% invited someone to their campus to speak.

Results of the survey and the success of ASMCUE were highlighted in *Vision and Change* (AAAS, 2011). The report acknowledges ASM's contributions to undergraduate education, particularly citing on pp. 60-61 the Annual ASM Conference for Undergraduate Educators as a venue that advances the scholarship of teaching and learning in biology. The report also notes the 2010 decision to publish ASMCUE abstracts in ASM's *Journal of Microbiology & Biology Education* in order to provide authors a citation for their work in the field. Finally, this "In Practice" highlight section of the report concludes with "It is expected that ASMCUE participants will contribute new knowledge and understanding in biology education as they develop professionally and that they will be recognized and rewarded for these efforts, leading to genuine reform in undergraduate biology education (AAAS, 2011)."

The ripple effect of ASMCUE

Several additional ASM-sponsored professional development programs have their origins in ASMCUE and the needs voiced by educators at the conference. ASM developed a series of faculty institutes focusing on training educators in specific areas such as education research or scientific areas such as bioinformatics and functional genomics.

The ASMCUE has adopted a "residency" model for these institutes where attendees meet face-to-face for several days of intensive training and then work online "virtually" as a cohort throughout their year in residency. All educators must apply to attend a faculty institute and are vetted by the organizers of each training institute. Once accepted to a residency, attendees begin a series of pre-assignments before arriving face-to-face. The assignments are primers and meant to level the knowledge field and allow attendees to reflect before coming together onsite. Once they have completed an institute, attendees continue to receive post-institute assignments throughout the year until they meet again for a capstone experience. ASM has found this model to be very effective in building long-lasting faculty communities in which attendees also become leaders in education reform.

One example of these programs is the ASM/NSF Biology Scholars Program. In 2005, in response to educators who were interested in determining the effects of their teaching on student learning, the ASM began a "Scholars" program in which microbiologists were trained in the development of classroom research projects. In 2007, the ASM received funding from the National Science Foundation (NSF) to expand the program into all areas of biological sciences. To date, the Biology Scholars Program (www.biologyscholars.org) has trained over 150 educators and the network continues to grow (NSF Biology Scholars, 2011). The program's goals are to:

- **Empower biologists** to be leaders in science education reform.
- **Expand and support a highly interactive community of biology scholars** committed to scholarly teaching.
- **Catalyze deep networks** among life science professional societies to collectively engage in sustained undergraduate education reform.

Biologists in the program move from individual investigations to participation in a collaborative community where work is grounded in a collective understanding about undergraduate education in the life sciences. They move from individual scholarship in student learning to serving as role models and mentors in their departments, institutions, and professional societies. Life science professional societies are provided with models that advance scholarly teaching in the discipline.

Since its establishment, the program has evolved from a small-scale faculty development program to one that has developed a core group of biologists committed to improving student learning through ongoing self-evaluation of their teaching practices.

19th Annual ASM Conference for Undergraduate Educators

June 14-17, 2012

San Mateo Marriott – San Mateo, California

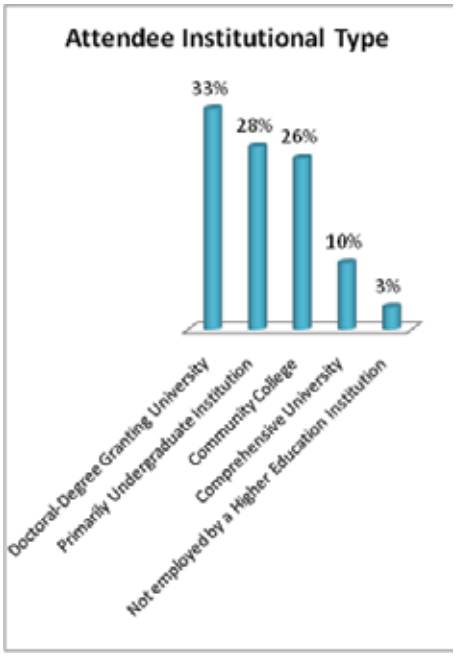
2012 Attendee Demographics – 337 registered participants)

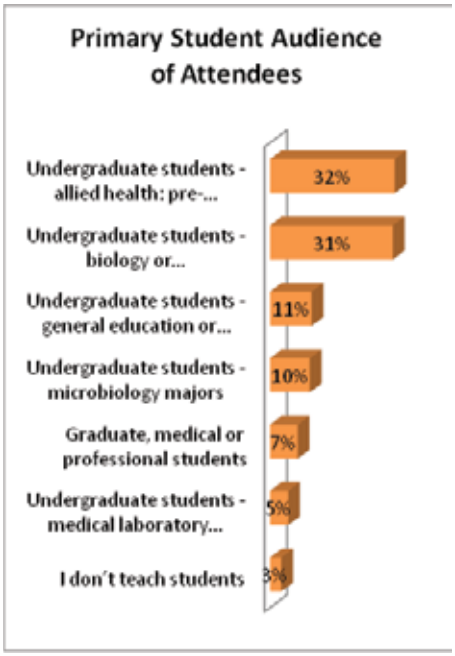
Of those registered, there are:

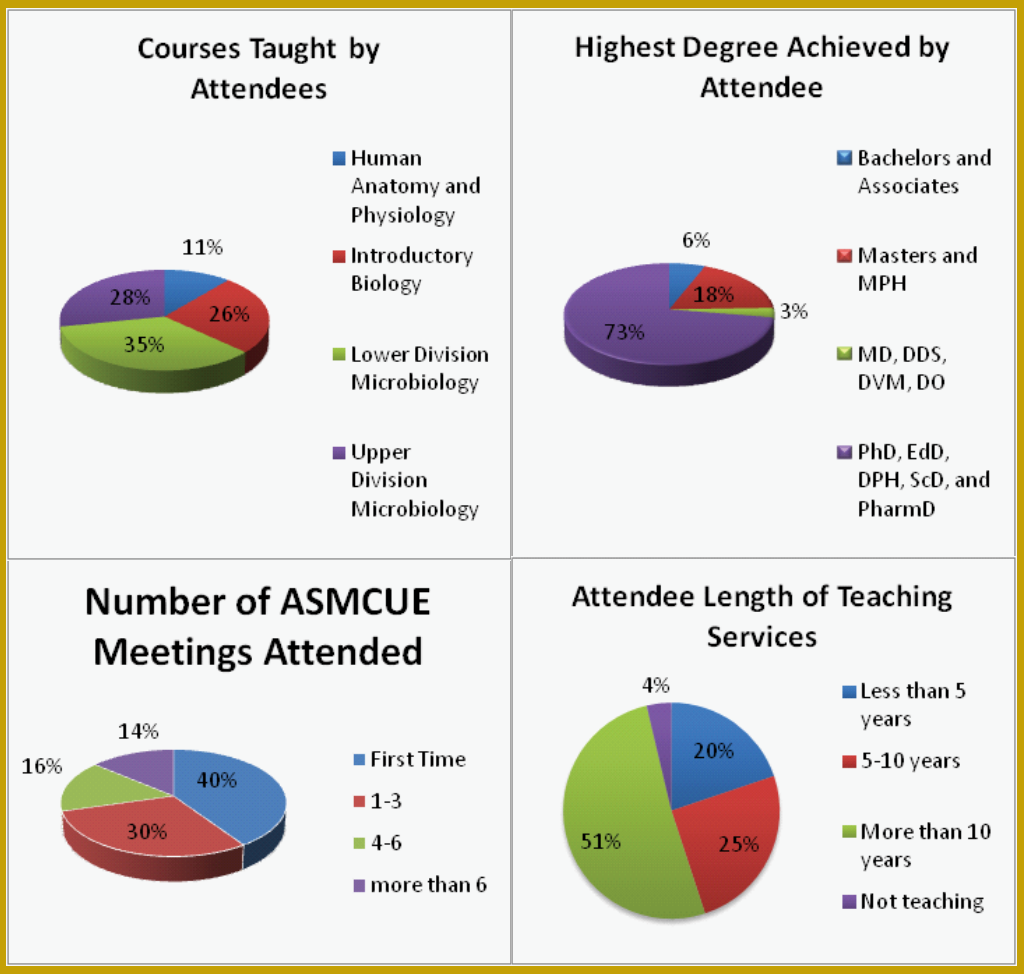
- 297 conference attendees and 40 exhibitors
- 252 ASM Members and 45 nonmembers (among the faculty participants)
- 16 international attendees representing 9 countries

Conclusion

ASM continues to build and enhance faculty development programs for its members and beyond. The Society has been a leader in the field and collaborates effectively with other life science societies to build a community of educators who are effective and continue to find ways to improve student learning.







References

AAAS. (2011). *Vision and Change in Undergraduate Biology Education: A Call to Action* (Washington, D.C.: American Association for the Advancement of Science). Available from: www.visionandchange.org.

American Society for Microbiology. (2012). MicrobeLibrary. http://www.microbelibrary.org/.

American Society for Microbiology. (2002). ASM Curriculum Resources and Publications. http://forms.asm.org/Education/index.asp?bid=1241.

American Society for Microbiology. (2005). ASM Biology Scholars Program. http://www.biologyscholars.org/.

Chang, A. (2011). "A retrospective look at 20 years of ASM education programs (1990-2010) and a prospective look at the next 20 years (2011-2030)," *J. Microbiol. & Biol. Educ.* **12**(1). doi:10.1128/jmbe.v12i1.253.

Merkel, S. & ASM Task Force on Curriculum Guidelines for Undergraduate Microbiology. (2012). "The development of curricular guidelines for introductory microbiology that focus on understanding," *J. Microbiol. & Biol. Educ.* **13**(1). doi:10.1128/jmbe.v13i1.363.

NSF Biology Scholars Program Annual Report. (2011). http://www.biologyscholars.org/wp-content/uploads/2011/07/Annual-Report-2011-Biology-Scholars-Program-v31.pdf.

Workshops for New Faculty in Physics and Astronomy

Discipline: Physics and Astronomy

Workshop Leaders (PIs): *Robert Hilborn*, American Association of Physics Teachers, co-PIs: *Ted Hodapp,* American Physical Society, *Kevin Marvel*, American Astronomical Society.

Funding Source(s): National Science Foundation, Research Corporation for Science Advancement.

Cost per participant: $900

Costs/Fees paid by the participants (or their home institutions): Transportation to workshop site (College Park, MD).

Target Audience: Newly hired physics and astronomy faculty at four-year colleges and universities in first one-three years of initial tenure-track appointment.

Typical Attendance: 80

Workshop Duration: Three and one-half days.

When Offered: Originally once per year; since 2008 twice per year.

Workshop website: http://www.aapt.org/Conferences/newfaculty/nfw.cfm.

Program Description

Kenneth S. Krane, Oregon State University

The problem

The New Faculty Workshop in Physics and Astronomy (NFW) was developed in the mid-1990s during the appearance of a disturbing trend: from 1990 to 1996 the number of baccalaureate physics degrees awarded in the U.S. declined by about 25% (American Institute of Physics, 2008), while the number of baccalaureate degrees in the other STEM disciplines was increasing by 10%. During this period, physics fell from awarding one out of 200 U.S. baccalaureate degrees to one out of 300.

The NFW was created under the assumption that poor physics 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 (Seymour and Hewitt, 1997), who interviewed hundreds of students at seven 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 SME (science, mathematics, engineering) 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."

Participants at the 2006 Physics and Astronomy New Faculty Workshop.

Further evidence of the problems with undergraduate teaching was revealed 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" (Boyer Commission, 1998). Among their 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 deliver set lectures from yellowed notes, making no effort to engage the bored minds of the students in front of them….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." Although the commission did not deal specifically with science classes, the overlap with the Seymour and Hewitt results is persuasive.

The proposal

In the late 1980s and early 1990s, physics education research produced a number of successful models for effective physics teaching. A common theme of many of these projects was the need for 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 reported by users of these techniques was a doubling of learning gains relative to more traditional teaching methods (Hake, 1998).

Unfortunately, graduate students in physics PhD programs are often unaware of these pedagogic developments, and so newly hired faculty often rely on traditional (and less effective) teaching methods. It was clear that this problem was sufficiently widespread and common that it called for a national program to mentor newly hired physics faculty.

In 1995 a steering committee was established under the auspices of the American Association of Physics Teachers (AAPT), and a proposal was submitted to the National Science Foundation (NSF) for a national workshop for new

physics faculty that would focus on a small number of well-tested pedagogic developments that could be implemented by the participants at their home institutions with minimal additional time commitment and risk. 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 MS or a PhD in physics), which account for 70% of tenured physics faculty, provide 70% of introductory physics instruction, and produce a majority of majors. The NSF funded the project initially for three years to hold an annual workshop for 50 attendees, and the first program was held in the fall of 1996.

NFW logistics

The target audience for the original NFW series was faculty at research universities in the first one to three years of their initial tenure-track appointment. Letters were sent to department heads inviting them to nominate their newly hired faculty to attend. The workshops were scheduled for late October or early November, a time that avoided conflict with most major physics research conferences in the U.S. Because each workshop presents more-or-less the same program, repeat attendance is not permitted.

The NSF grant pays all expenses for the workshop, except for transportation of the participants to the workshop site, which is the responsibility of each participant's home institution. No registration fee is charged. Participants all stay at the same hotel, which adds to the bonding effect in forming a cohort group.

The workshops are held 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, support staff are available onsite to assist with logistics, and personnel from the other societies can observe the workshops. Moreover, the participants gain a sense of "ownership" by attending the workshop in a facility that they support with their professional society dues, and there are fewer distractions as compared with a workshop held in a hotel.

The NSF grant included a budget for follow-up activities, which were planned to be of two types: (1) reunion meetings held in conjunction with selected national meetings of the various physics and astronomy professional societies, and (2) sessions directed at concerns of new faculty at the annual national meetings of the AAPT.

By year four of the grant we had decided that any future program under renewed NSF support should also include full participation by the four-year colleges (those that do not award graduate degrees in physics), so we opened up the program and attendance swelled to 73. In year five there were only limited funds remaining in the original budget, so we held a small workshop for only 40 participants.

In 2002 the NSF renewed funding for the program for an additional five years, expanding the capacity 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. In 2008 we expanded the program by holding two workshops per year, one in June and one in November, and we were awarded another five-year renewal of the NSF grant. In 2007 we held the first reunion workshop, in which we brought former participants back to ACP for discussions of teaching practices at a more advanced level; the third reunion

workshop was held in November 2012. Other smaller reunions have been held in conjunction with national meetings of AAPT, APS, and AAS, with participants' travel partly funded by the NSF grant.

Table I 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 almost 20% in recent years when invitations have also been issued to departments of astronomy. Women have constituted a nearly constant 24% of the participants, which exceeds their 18% representation among U.S. physics PhD recipients and perhaps reflects the larger fraction of women who are awarded PhD degrees in astronomy (40%).

YEAR	Highest physics degree of participant's institution				Total	% Astro	% 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 June	4	33	9	43	89	19.1	19.1
2008 Nov	5	44	4	42	95	16.8	25.3
2009 June	1	38	7	34	80	17.5	28.8
2009 Nov	2	25	8	37	72	15.3	27.8
2010	1	42	9	27	79	21.5	27.8
2011 June	3	29	9	36	77	16.9	33.8
2011 Nov	0	27	2	29	58	25.9	25.9
TOTAL	**36**	**553**	**93**	**716**	**1398**	**17.7**	**24.2**

The NFW Program

The NFW has three formal goals: (1) to involve a significant fraction of the newly hired physics and astronomy faculty; (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.

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. Because delivery of information is a significant goal of the NFW, much of the program is lecture-oriented in plenary sessions. (However, even the plenary sessions model good teaching practices by having the participants often break up into small discussion groups.) The "workshop" nature of the program is achieved through frequent small "breakout" groups of 20 to 30 participants, which enable interactions of participants with one another and with the discussion leaders. Here they obtain practical experience with the techniques introduced at the plenary sessions or discuss other topics of interest, including digital libraries, tenure, time management, and teaching specific courses such as introductory physics, upper-level physics, or astronomy. Prior to the opening of the Workshop, participants have the opportunity to meet with program officers of NSF and Research Corporation to discuss grant writing and funding opportunities. A sample NFW program is shown below.

Day 1:

1:30 - 3:00 pm	Optional Workshop on Grant Opportunities with Research Corporation
3:00 - 4:30 pm	Optional Workshop on Grant Opportunities with NSF Program Directors
4:30 - 5:00 pm	Break
5:00 - 5:15 pm	Welcome and Introductions
5:15 - 6:15 pm	Eric Mazur: Introduction to Peer Instruction (Plenary)
6:15 - 7:30 pm	Dinner
7:30 - 8:30 pm	Peer Instruction Workshop

Day 2:

8:30 - 10:00 am	Lillian McDermott: Research in Physics Education as a Guide to Student Learning (Plenary)
10:00 - 10:15 am	Break
10:15 - 11:15 am	Ed Prather: Learner-Centered Teaching in Physics and Astronomy (Plenary)
11:15 - 12:00 pm	Breakouts: PhET, Digital Libraries, Lecture Tutorials
12:00 - 1:00 pm	Lunch
1:00 - 1:45 pm	Breakouts: PhET, Digital Libraries, Lecture Tutorials

1:45 - 2:30 pm	Breakouts: PhET, Digital Libraries, Lecture Tutorials
2:30 - 3:00 pm	Break
3:00 - 4:00 pm	Andy Gavrin: How to Get Your Students to Prepare for Every Class (Plenary)
4:00 - 5:00 pm	Small Group Discussions - Various Topics
5:00 - 6:00 pm	Noah Finkelstein: Evaluation and Assessment (Plenary)
6:00 - 7:00 pm	Dinner
7:00 - 8:00 pm	Dick Berg: The Physics IQ Test

Day 3:

8:15 - 9:15 am	David Sokoloff and Ron Thornton: Interactive Lecture Demonstrations (Plenary)
9:15 - 10:00 am	Breakouts: Intro Physics, RTP/ILD, Upper-level Physics
10:00 - 10:30 am	Break
10:30 - 11:15 am	Breakouts: Intro Physics, RTP/ILD, Upper-level Physics
11:15 - noon	Breakouts: Intro Physics, RTP/ILD, Upper-level Physics
noon - 1:00 pm	Lunch
1:00 - 2:00 pm	Breakouts: PUI, Ph.D. and Research Master's
2:00 - 3:00 pm	Ken Heller: Help Your Students Develop Expertise in Problem Solving (Plenary)
2:45 - 3:30 pm	Breakouts: Physlets/OSP/Ejs, Tenure Matters, Problem Solving
3:30 - 4:00 pm	Break
4:00 - 4:45 pm	Breakouts: Physlets/OSP/Ejs, Tenure Matters, Problem Solving
4:45 - 5:30 pm	Breakouts: Physlets/OSP/Ejs, Tenure Matters, Problem Solving
5:30 - 6:15 pm	Reception
6:15 - 7:30 pm	Dinner

Day 4:

8:15 - 9:00 am	Tim Slater: Case Studies Discussion of Student Behavior (Plenary)
9:00 - 10:00 am	Diola Bagayoko: Mentoring for Retention (Plenary)
10:00 - 10:15 am	Break
10:15 - 11:00 am	Tim Slater: Time Management (Plenary)
11:00 - 11:30 am	Final Words, Evaluation Procedures and Adjourn

Assessment of NFW program

How well are we meeting our goals? The first goal was to involve a significant fraction of the newly hired faculty. Table 2 shows that nearly 1/4 of the (approximately 350 yearly) new U.S. physics hires have attended the workshop, with more than half attending in 2008. More than 75% of the Ph.D.-granting institutions have sent at least one faculty member. Sixteen Ph.D.-granting institutions have sent 10 or more faculty. Participation by the 510 baccalaureate departments is more difficult to assess, for these institutions average only 4 physics faculty and thus have new hires only rarely. Nevertheless the data show that we have typically attracted 1/3 of the hires at baccalaureate institutions, with nearly 2/3 attending in 2008. We feel that we are succeeding admirably at our goal of attracting a broad representation of the new hires in physics and astronomy.

Table II. NFW participants as a fraction of new U.S. physics hires.

YEAR	Highest physics degree of participant's 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%
2008	64.2%	43.3%	42.5%	52.6%

The extent to which the NFW program meets its second and third goals (acquainting the participants with new pedagogies and effecting improvements in teaching) can be assessed only through surveys of participants and their department chairs. For a detailed report on this evaluation, see the article by Charles Henderson in these proceedings. In summary, surveys of NFW participants reveal 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 are better learners in classes taught by NFW participants.

Anecdotal evidence of the success of the program comes from statements by participants and their department chairs.

A Research I participant (now tenured) reports:

"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."

A faculty member from a highly selective four-year liberal arts college states:

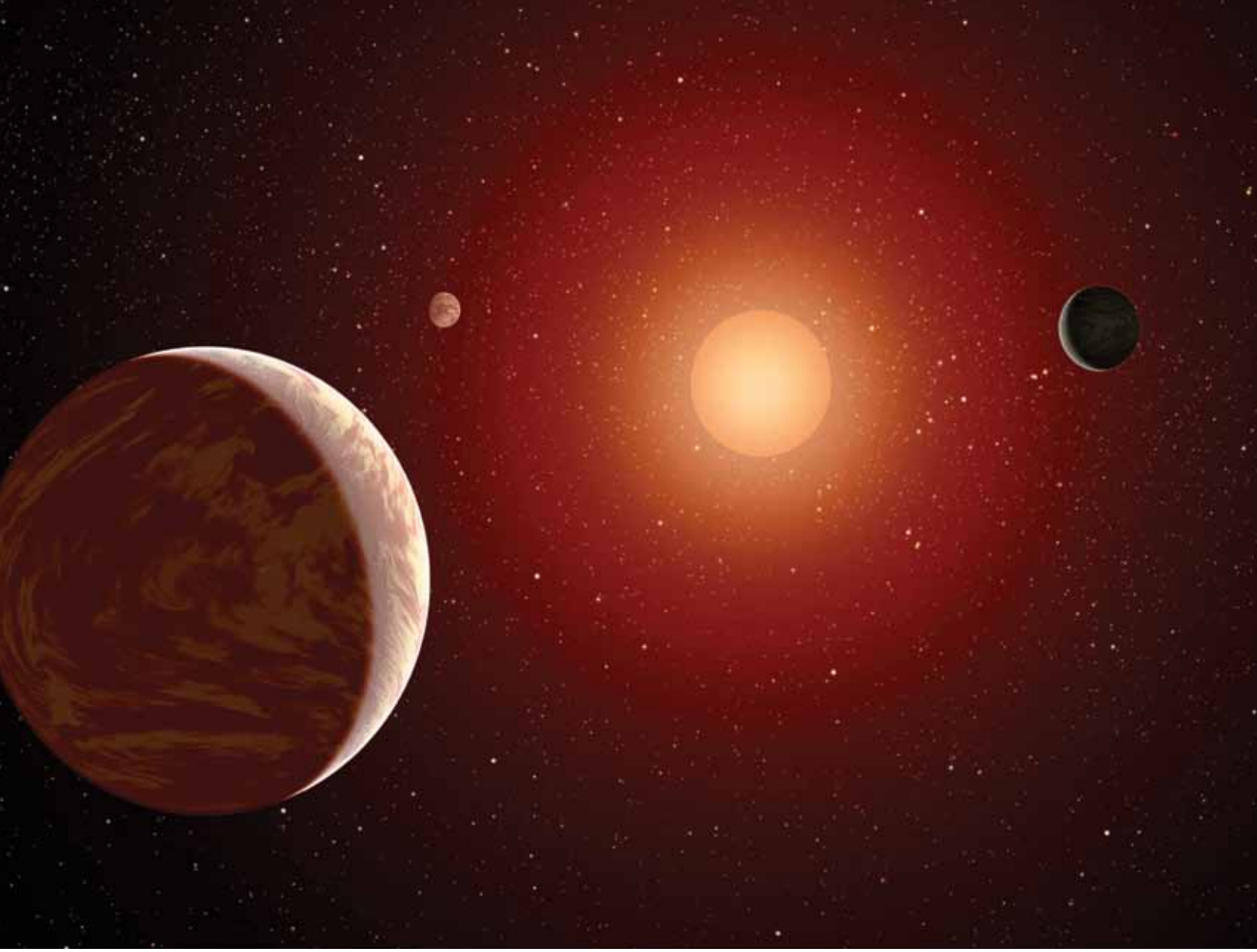
"I consider this workshop to have been an invaluable contribution to my development as an effective physics educator. The workshop introduced me to a variety of cutting-edge techniques in physics pedagogy, enabled me to develop a nationwide network of connections among new faculty members in physics, 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 Research I department chair (more than ¼ of whose faculty have attended the NFW):

"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. I offer, as an indication of the progress which a dedicated cadre of faculty can achieve, the statistic that the number of physics majors graduated last spring was the largest in at least two decades. The improvement is not a statistical fluctuation, and represents a thorough reversal of the depressing decline in the number of majors through the 80's and 90's."

What are the characteristics of the physics-astronomy community that contribute to 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 that is taken by virtually all majors in basic and applied science and engineering and that 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 many 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 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 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 PhD-granting institutions, many of which do not normally participate to a significant extent in AAPT programs.



Acknowledgments

These workshops have been made possible through National Science Foundation grants DUE-9554738, 0121384, and 0813481 and grants from Research Corporation for Science Advancement.

References

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

Boyer Commission. (1998). *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/).

Hake, R.R. (1998). "Interactive-engagement versus traditional methods: A six-thousand-student survey of mechanics test data for introductory physics courses," *American Journal of Physics* **66**, 64-74.

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

Evaluation of the Physics and Astronomy New Faculty Workshops

Charles Henderson, Western Michigan University

Abstract

Four distinct data sets suggest that the Physics and Astronomy New Faculty Workshop (NFW) is very successful at increasing participant knowledge about research-based instructional strategies and motivating participants to try incorporating these strategies in their teaching. However, it also appears that many of the participants struggle to successfully implement these research-based instructional strategies and some discontinue use or modify strategies in ways that likely diminish their effectiveness. Additional post-NFW support may improve the success rate of participants in the customization and implementation process.

Overview of successful dissemination strategies

The presentation was framed by the results of a literature review of change strategies in higher education (Henderson, Beach, & Finkelstein, 2011). Based on an analysis of 191 journal articles, successful disseminating strategies involve more than one of the following: (1) coordinated and focused efforts lasting over an extended period of time—usually a semester or academic year, (2) use of performance evaluation and feedback, (3) deliberate focus on changing faculty conceptions. In contrast, the Physics and Astronomy New Faculty Workshop is a short (four-day) one-time intervention, does not include performance evaluation or feedback, and is focused primarily on providing information and motivation.

Data Set 1: Evaluation surveys directly after each NFW

The author has been involved in post-workshop evaluation surveys for the 10 NFWs offered since 2006. A short web-based evaluation survey is due approximately two weeks after each workshop. Response rates are typically high (>80%). In both forced-choice and open-ended questions, participants are asked to rate their satisfaction with the workshop as a whole as well as the individual sessions and make suggestions for improving the workshop. Participants are overwhelmingly happy with the workshop and nearly all (>95%) express the intention to use specific instructional materials or ideas from the NFW in their teaching. The most common criticism of the workshop (typically expressed by 10-20% of respondents in open-ended comments) is the packed conference schedule.

Data Set 2: Evaluation survey of all NFW participants (Henderson, 2008)

During spring 2007, a web survey was sent to all former NFW participants who were still in academia and could be located. A response rate of 76% resulted in 527 usable responses. Results indicate that the NFW increases participant knowledge about and attitudes toward research-based instructional strategies and results in changes in teaching behavior. A separate survey of department chairs corroborates the participant self-reports (see Fig. 1).

In addition to having an impact on the participants directly, in many cases the NFW also impacts the departmental

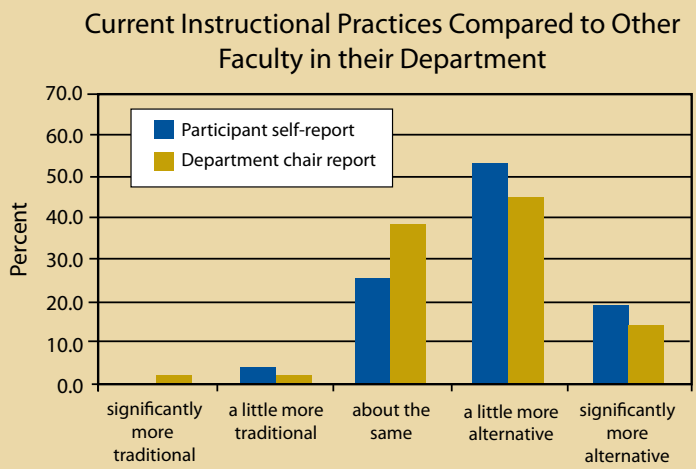


Fig. 1. Participant and department chair ratings of NFW participant's instructional styles.

colleagues of participants. Most participants (87%) report sharing NFW ideas with their colleagues. Common mechanisms mentioned were informal conversations, formal colloquia or faculty meetings, as well as discussions following pre-tenure teaching observations by colleagues. Many participants (40%) and many department chairs (51%) believe that the NFW participants have had an influence on faculty in the department who have not attended the NFW.

Data Set 3: National web survey of randomly selected physics faculty (with M. Dancy)

During fall 2008, as part of a separate NSF-funded project (NSF #0715698), a web survey was distributed to a randomly-selected sample of U.S. physics faculty (Dancy and Henderson, 2010. Henderson and Dancy, 2009. Henderson, Dancy, and Niewiadomska-Bugai, 2012). A response rate of 50% resulted in 722 usable responses. Thirteen percent of the respondents had attended the NFW. NFW attendees were significantly more likely to know about and try research-based instructional strategies than non-attendees. For example, as shown in Fig. 2, 99% of NFW attendees (compared to 85% of non-attendees) indicated knowledge of one or more of the 24 research-based instructional strategies (RBIS) asked about in the survey and 96% of NFW attendees (compared to 67% of non-attendees) indicated that they had tried at least one. Of the 20 personal and situational variables asked about in the survey, the NFW had the largest correlation with knowledge about and trial of at least one research-based instructional strategy.

However, attendance at the NFW was not significantly associated with current use vs. discontinued use or being a high vs. a low RBIS user. Of the NFW participants who initially try one or more RBIS, 27% indicate that they no longer use any RBIS. This is not significantly different from the 33% of non-NFW attendees who have tried one or more RBIS and no

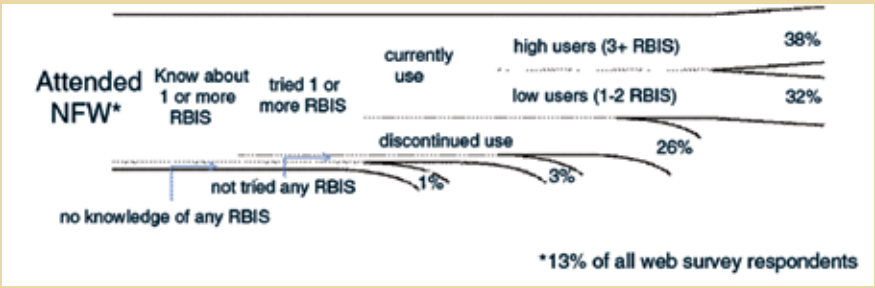


Fig. 2. Where do New Faculty Workshop participants leave the innovation-decision process?

longer use any RBIS. Current users are also approximately evenly split between high users and low users for both NFW attendees and non-attendees.

Data Set 4: Longitudinal study of NFW participants (with M. Dancy)

Beginning in fall 2010, as part of a separate NSF-funded project (NSF #1022186 and #1065714) 15NFW participants were followed for five semesters after the workshop. Data collected each semester includes: pre- and post-semester interviews, teaching artifacts, student course evaluations, student learning outcomes as measured by national-normed conceptual inventories, and time spent on teaching. Consistent with web survey results, all participants reported enjoying the NFW, reported increased knowledge and attitudes toward research-based teaching methods, and reported making changes in their instruction. Preliminary analysis of year 1 data suggests that all faculty ran into implementation difficulties and all made modifications to their planned instruction. In some cases this meant a decrease in the use of research-based methods.

What makes the New Faculty Workshop successful?

It was hypothesized that there are four main reasons that the NFW is successful at increasing participants' knowledge about and motivation to try research-based instructional strategies. (1) It is sponsored and run by three major disciplinary organizations. Research has shown that disciplinary cultures can play an important role in faculty behavior (Fairweather, 1996). (2) It introduces participants to a wide variety of research-based instructional strategies and materials. Research has shown that faculty members are often skeptical of workshops that "sell" one particular strategy (Henderson & Dancy, 2008). (3) Presentations are made by the leading curriculum developers in physics education research. Research has shown that the reputation of the reformer and/or their institution impact how a reform message is received (Foertsch, Millar, Squire, & Gunter, 1997). (4) It targets new faculty. Research has shown that new faculty are already struggling with their teaching responsibilities (Boice, 1991).

Improving the New Faculty Workshop

Based on the four data sets discussed above, it is possible to make the strong conclusion that the Physics and Astronomy New Faculty Workshop is highly successful at informing new physics and astronomy faculty about research-based instructional strategies and at motivating participants to try using these strategies in their teaching. The evidence also suggests, however, that most of the participants struggle to successfully implement these research-based instructional strategies. Some of the participants are eventually successful in their use of these instructional strategies, but others end up modifying the strategies in ways that likely diminish their effectiveness or giving up use of these strategies entirely. It is recommended that appropriately developed post-NFW support be added to improve the success rate of participants in the customization and implementation process.

References

Note: Slides from presentation at CSSP meeting can be found at: http://homepages.wmich.edu/~chenders/Publications/2012HendersonCSSPPresentation.pdf.

Boice, R. (1991). "New faculty as teachers," *Journal of Higher Education* **62**, 150-173.

Dancy, M. & Henderson, C. (2010). "Pedagogical practices and instructional change of physics faculty," *American Journal of Physics* **78** (10), 1056-1063.

Fairweather, J. S. (1996). *Faculty Work and Public Trust: Restoring the Value of Teaching and Public Service in American Academic Life* (Boston: Allyn and Bacon).

Foertsch, J., Millar, S. B., Squire, L., & Gunter, R. (1997). *Persuading Professors: A Study of the Dissemination of Educational Reform in Research Institutions* (Madison, WI: University of Wisconsin-Madison, LEAD Center).

Henderson, C. (2008). "Promoting instructional change in new faculty: An evaluation of the physics and astronomy new faculty workshop," *American Journal of Physics* **76** (2), 179-187.

Henderson, C. & Dancy, M. (2008). "Physics faculty and educational researchers: Divergent expectations as barriers to the diffusion of innovations," *American Journal of Physics* (*Physics Education Research Section*), **76** (1), 79-91.

Henderson, C. & Dancy, M. (2009). "The impact of physics education research on the teaching of introductory quantitative physics in the United States," *Physical Review Special Topics: Physics Education Research*, **5** (2), 020107.

Henderson, C., Beach, A. & Finkelstein, N. (2011). "Facilitating change in undergraduate STEM instructional practices: An analytic review of the literature," *Journal of Research in Science Teaching* **48**(8), 952-984.

Henderson, C., Dancy, M. & Niewiadomska-Bugaj, M. (2012). "The use of research-based instructional strategies in introductory physics: Where do faculty leave the innovation-decision process?" *Physical Review Special Topics: Physics Education Research* **8** (2), 020104.

APPENDIX

The Role of Scientific Societies in STEM Faculty Workshops

May 3, 2012
Marvel Hall, 1155 16th Street
Washington, D.C.

Noon **Lunch** (optional – get ticket for take-out lunch from CSSP Staff)

1:15 pm **Welcome and Introductions** – Expected Outcomes of this Workshop
Marty Apple (Council of Scientific Society Presidents)
Carl Wieman (Office of Science and Technology Policy)
Don Millard (National Science Foundation)
Bob Hilborn (American Association of Physics Teachers)

1:30 pm **Workshop Case Study 1** (20 minute presentation, 10 minutes discussion)
National Academy Summer Institutes – Biology
Jay Labov, NRC-NAS

2:00 pm **Professional development of faculty: how do we know it is effective?**
Diane Ebert-May, Michigan State University

2:30 pm **Small group discussion:** How should we determine the effectiveness of STEM faculty workshops?

- How might we measure the impact of faculty participation in teaching workshops on student learning?
- What constitutes sufficient, even if incomplete, evidence for the effectiveness of the workshops?
- How do we determine, on a large-scale, what changes in teaching are implemented as a result of these workshops?
- Does your discipline have nationally-normed exams for introductory courses?
- What instruments might be developed to gauge changes in student learning as a result of having faculty attend teaching workshops? Who should pay for this development? Who should pay for the administration of these instruments and the analysis of the data?
- What role, if any, should scientific societies play in measuring the effectiveness of these workshops?

3:00 pm **Workshop Case Study 2**
Physics and Astronomy New Faculty Workshop
Ken Krane, Oregon State University

3:30 pm **Evaluation of the Physics and Astronomy New Faculty Workshops**
Charles Henderson, Western Michigan University

4:00 pm Break

4:15 pm **Keynote Speaker** – "Improving Undergraduate STEM Education,"
Carl Wieman, Associate Director for Science, White House Office of Science and Technology Policy

5:00 pm **Workshop Case Study 3**
Mathematics Project NExT
Aparna Higgins, University of Dayton

5:30 pm **Workshop Case Study 4**

Microbiology

Jacqueline Washington, Nyack College

6:00 pm **Workshop Case Study 5**

Geosciences

*On the Cutting Edge W*orkshops and Web Resources for Early Career Geoscience Faculty: Teaching, Research, and Career Management

Heather Macdonald, William and Mary

6:30 pm **Working Dinner –** General Action Plans to Expand STEM Faculty Workshops

- How can STEM faculty workshops reach a larger number of STEM faculty members?
- How can we convince "reluctant" faculty members to attend these workshops?
- How can the workshops be sustained beyond the initial funding? Who should pay for these workshops?
- Could a single workshop serve faculty from several disciplines effectively?

7:00 pm **Workshop Case Study 6**

Engineering

Jeffrey Froyd, Texas A&M

7:30 pm **Workshop Case Study 7**

Chemistry

Andrew Feig, Wayne State University

7:45 pm **Full Group Discussion** – Next steps and recommendations for the meeting report

- What can be done to assist scientific societies in implementing or extending the reach of STEM faculty workshops?
- What should be part of the report on this meeting and for whom should the report be written?
- To whom should the report be distributed?
- Other ideas and suggestions

8:15 pm **Adjourn**