IV. QUANTITATIVE FINDINGS FOR FACULTY AND INSTITUTIONS

Using information from SRI's telephone survey of faculty who participated in UFE workshops during 1996 and 1997, this chapter focuses on what they learned and how they used that learning to develop or revise courses and/or programs of study, as well as the extent to which such courses were institutionalized. The chapter then examines the participants' postworkshop professional activities, the extent to which they disseminated what they had learned in the workshops, and the indirect impact of the workshops on their colleagues.

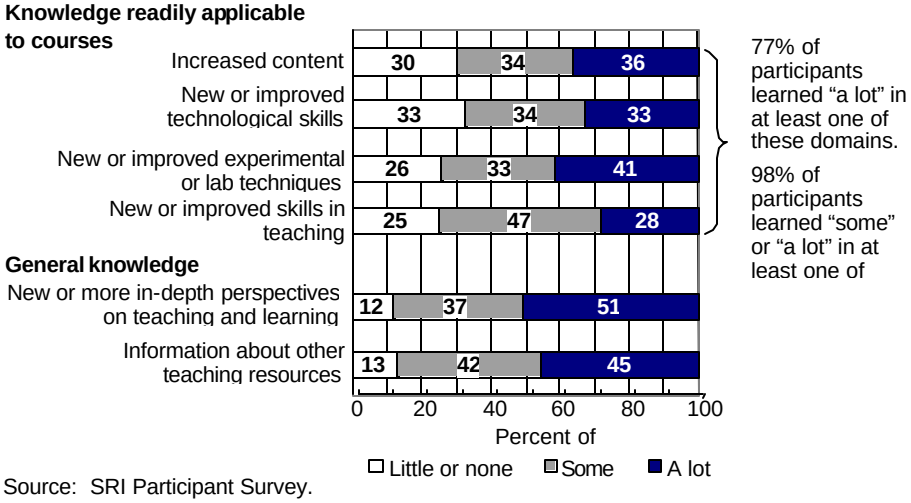
What Faculty Participants Learned

Desired outcome: Faculty incorporate current and relevant content into their teaching, use state-of-the-art experimental techniques and technology, and apply best practices in instruction.

Amount Learned

Consistent with the indicators developed for this outcome (see Appendix A), our survey asked participants how much in the way of knowledge or skills the UFE workshop had given them in six domains: four domains of knowledge that participants could use directly to develop or revise a course (content, technological skills, experimental or lab techniques, and teaching skills), and two of general knowledge (new or more in-depth perspectives on teaching and learning, and information about teaching resources). At least two-thirds of participants reported learning either "some" or "a lot" in each domain; from 28% to 51% reported learning "a lot" in each domain (Exhibit IV-1). Seventy-seven percent

Exhibit IV-1. What Participants Learned in Workshops



Source: SRI Participant Survey.

of participants reported learning "a lot" of some type of knowledge readily applicable to their courses.

"Specifically, I learned genuine applications of math that I can bring to the classroom. We don't learn that in training. To get a Ph.D. in math, you learn abstract math from day one and you simply don't know the applications to industry or practical applications of the material. In the course of these workshops, I've gotten to really understand some significant ways of how math is used in the real world. It takes a little work to study the applications, find out how it works, and figure out a way to communicate it to a certain audience. These workshops allowed me to do that—partly through the lectures, but also the time to work with people in developing materials." (A participant at the Multivariable Calculus workshop)

"Lots of faculty are teaching students antiquated content and methods, and they wonder why students aren't coming. There has to be a system where scientists can keep their instrument current. I was being pretty passive. Blinders fell away from my eyes when I got here. I want to proselytize when I get back." (A biometry professor at the Image Processing workshop)

"In 25 years of teaching, I've never ever been exposed to any type of teaching course. I didn't know about any of these things." (A participant at a workshop on teaching methods for engineering faculty)

"If I can become more effective in the classroom, I can have more influence on my students. The way I [have been teaching,] I may be losing them; I just lectured. I didn't know how to communicate in the classroom…"This is a great program…" This just doesn't exist anywhere else." (Another participant at the workshop on teaching methods for engineering faculty)

Extrapolating from these findings to the approximately 14,400 faculty who attended UFE workshops during 1991-1997, we estimate that:

The 1991-1997 UFE workshops gave substantial new knowledge* that could be used directly in their courses to approximately 11,100 faculty.[1]
Specifically, UFE workshops during this period substantially improved:

- **The content knowledge of approximately 5,200 faculty**[2]
- **The technological skills of approximately 4,800 faculty.**
- **The lab techniques of approximately 5,900 faculty; and**
- **The teaching skills of approximately 4,000 faculty;**

*Defined as knowledge or skills that participants said they had gotten "a lot" in the SRI telephone survey.

[1] To estimate how many faculty who attended 1991-1997 workshops had a particular outcome, the estimated number of unduplicated faculty (14,402) is multiplied by the percentage of faculty respondents who gave a particular answer to SRI's survey. Here the calculation for "substantial knowledge" in at least one domain that could directly affect a course is 77% (from Exhibit IV-1) of 14,402 = 11,089, or approximately 11,100.

[2] Again, the total unduplicated number of participants is multiplied by the relevant percentage from Exhibit IV-1. For example 36% of 14,402 = 5,185, or approximately 5,200.

Relationship of Experience to Amount Learned

Policy-makers, participants, and evaluators of workshop programs have raised questions about who would be the most appropriate participants in faculty enhancement programs. For example, the advisory committee that reviewed the report from Westat's formative evaluation of the UFE program made a point of encouraging NSF to do more to solicit proposals involving newer faculty, because of their relative inexperience in teaching (Mills, and others, 1992). On the other hand, some people whom we interviewed thought that faculty who have been teaching longer are most in need of updating their content knowledge and teaching practices.

The SRI survey asked participants how long they had been teaching at their current institutions, as well as their date of birth. Because neither variable is a perfect proxy for total years of teaching,[3] we explored the associations of both variables with the following 15 outcomes:

What the participants gained from the workshops:

- Increased content knowledge
- New or more in-depth perspectives on teaching and learning
- New or improved skills in teaching
- New or improved experimental or lab techniques
- New or improved technological skills
- New or more in-depth knowledge of issues regarding female and minority students
- New information about other resources for use in teaching
- New contacts with colleagues from other institutions
- Increased motivation or stimulation for teaching excellence

What changes the participants made after the workshops:

- Development or revision of one or more courses
- Introduction of new content
- Increased focus on "big ideas"
- Introduction of new lab techniques
- Introduction of new equipment, materials, or computer software
- Other types of changes in teaching methods.

[3] Neither of these two variables is the perfect proxy for total years teaching because some individuals may have begun their teaching careers late in life, whereas others may have taught for many years before joining their current institution. In the first case, age would overestimate total years teaching, whereas years at current institution would be the better proxy; in the second case, years teaching would underestimate years teaching, and age would be the better proxy.

For 12 of the outcomes, there was no statistically significant difference between the less experienced and more experienced groups, which indicates that they received about the same amount of benefit in those areas. But, as might be expected, younger participants and those who had taught for fewer years were statistically significantly more likely to report having learned new and improved teaching skills ($p < .05$). On the other hand, older participants and those who had taught longer were the most likely to report having learned new or improved technological skills ($p < .05$ for relationship with age, but not significant for years on faculty) and having introduced new equipment, materials, or computer software into their courses ($p < .05$).

New or Revised Courses or Programs of Study for Majors Developed by Participants

Desired outcomes:

Faculty incorporate current and relevant content into their teaching, use state-of-the-art experimental techniques and technology, and apply best practices in instruction.

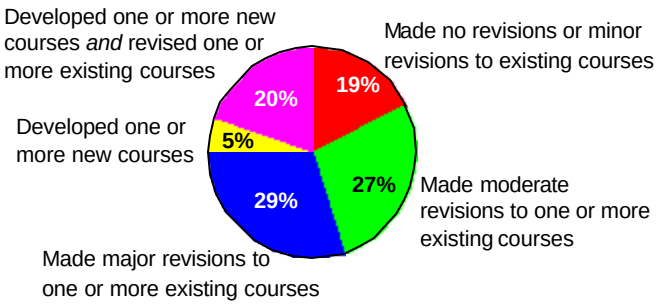
Institutions are supportive of SMET courses/labs for undergraduates that are state-of-the-art in their content and technology, incorporate best practices in their pedagogy, are accessible to all students, and are relevant to the real world.

Participants may have learned much at UFE workshops, but what is more important is how they put their learning to use. Simple personal or professional enrichment was not NSF's ultimate goal for the UFE program; rather, the goal was that participants use what they learned at the workshops to make some types of changes that would improve student outcomes, such as developing new courses, modifying existing courses, or designing a program of studies.

Development and Revision of Courses

In the first 2 to 3 years after attending a UFE workshop, 81% of participants developed new courses or made major or moderate revisions to existing courses as a result. As shown in Exhibit IV-2, 20% of them developed one or more new courses *and* revised one or more existing courses. An additional 5% developed at least one new

Exhibit IV-2. Percentages of Participants Who Developed and/or Revised Courses



Source: SRI Participant Survey

course but did not revise an existing course. Twenty-nine percent made major revisions to one or more existing courses, and 27% made moderate revisions to one or more existing courses.

On average, respondents reported that they had developed and/or revised approximately two courses as a result of participating in a UFE workshop (mean = 2.04). Using the numbers mentioned above, we estimate conservatively that:

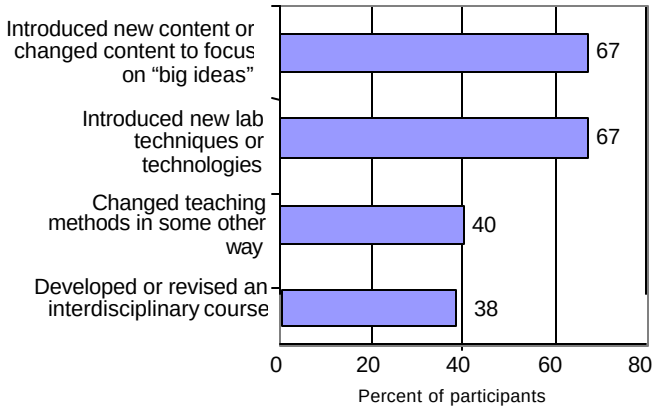
The 1991-1997 UFE workshops resulted in at least moderate revisions to approximately 20,800 courses, [4] as follows:

- **5,000 new courses were developed.**
- **7,300 courses underwent major revisions.**
- **8,600 courses underwent moderate revisions.**

Specific Changes to Courses

The two types of changes most often made to courses concerned the introduction of new content or of new technologies or laboratory methods; two-thirds of respondents made major or moderate changes in each of these areas (see Exhibit IV-3). More than half of participants who made changes in content moved toward a focus on "big ideas" (not shown in exhibit). Changes to teaching methods (other than changes in lab methods or technologies) were somewhat less common, but still were undertaken by a substantial percentage (40%) of participants.

Exhibit IV-3. Specific Types of Changes UFE Participants Made in their Courses



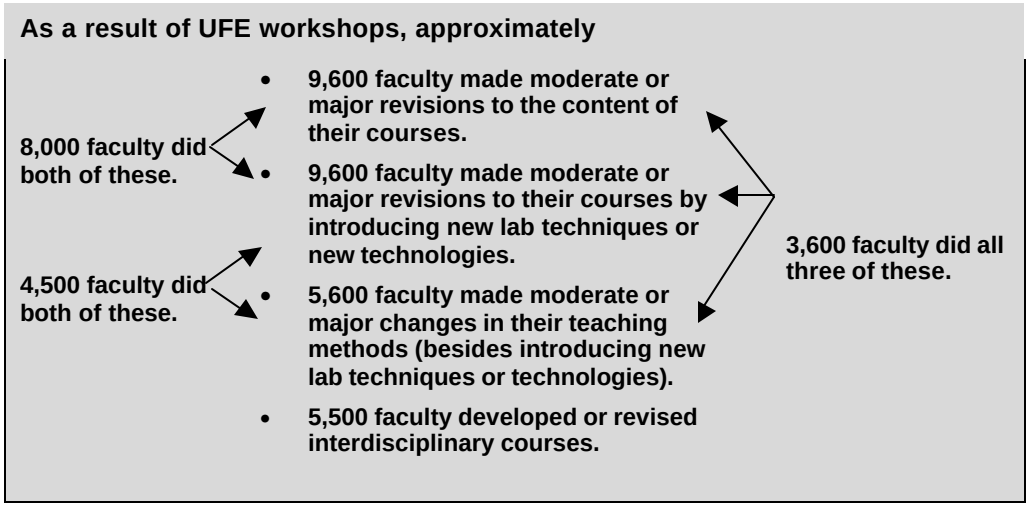
Source: SRI Participant Survey

Many of the UFE workshops focused on more than one of these domains, for example, by using new technologies to bring about more inquiry-based teaching. The workshops appear to have been quite successful in this regard. More than half of the respondents (56%) made major or moderate revisions to their courses in terms of

[4] See Appendix E for calculation.

laboratory techniques and/or technologies *and* content, and 31% made major or moderate revisions in terms of lab techniques and/or technologies *and* other teaching methods. Twenty-five percent of survey respondents made major or moderate changes in all three domains, and 38% of respondents developed and/or revised interdisciplinary courses.

With these findings, we estimate that:



One participant presents material from the Multivariable Calculus workshop in his linear algebra class. He was teaching standard abstract math before the workshop, which he described as "quite divorced from reality." Now he uses the applications he learned in the workshop and says, "Students walk away impressed with the power of mathematics."

Another participant at the same workshop stated, "Calculus reform didn't work at my school. It was an institutional thing, and it failed. But in my own classes where I have control, I've been able to use what I've learned in the UFE workshops. It's really made a difference. For instance, in abstract algebra, I teach in a completely different manner than before—collaborative and computer based. I include materials from this workshop in my Linear Algebra and Multivariable Calculus classes.

A faculty member who had attended a Molecular Biology workshop indicated in the telephone survey of participants, "I created a new bio-systematics course. It allowed us to form a bridge academically between the molecular biology track and the environmental science track. As a result of the workshop, here at the university, we study environmental problems using molecular techniques."

After attending a workshop called "Biology in Action: New Approaches to Teaching and Learning," a Life Sciences faculty member indicated in the telephone survey, "I introduced the stories behind the scientific approach. [I] introduced more assignments and made the students analyze their own data and make up their own experiments. I also introduced interdisciplinary teaching, a combination of science, English, and history."

New or Revised Programs of Study

Desired outcome: Institutions are supportive of SMET courses/labs for undergraduates that are state-of-the-art in their content and technology, incorporate best practices in their pedagogy, are accessible to all students, and are relevant to the real world.

Seventeen percent of UFE participants developed or redesigned a program of studies for a major after the workshop. For example:

- A department chair at a state university who attended the Environmental Modeling workshop was in the process of redesigning the mathematics major. Currently, few students major in math, but the chair hopes that once the major has been revised to include more real-world math, the number of students will increase.
- Another participant at the same workshop was designing an upper-division program for her small college, which is converting from a 2-year to a 4-year institution. She thinks the workshop has given her good ideas for a modeling course for the program and has also pointed her to valuable resources.

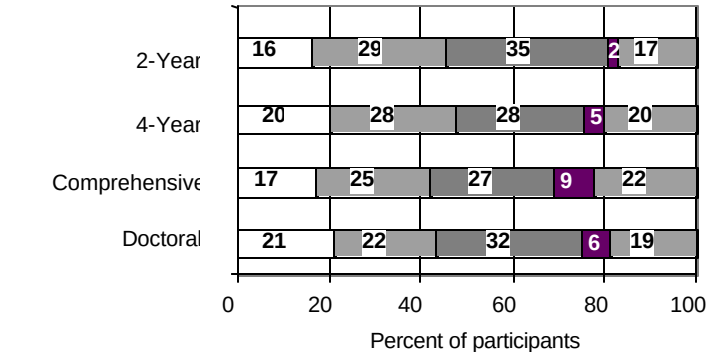
Some of these participants may have been working together, but even if only *half* of the 17% of the estimated number of "nonrepeating" undergraduate faculty participants (14,402) who reported designing major programs of study did so, it would mean that:

The 1991-1997 UFE workshops resulted in the development or redesign of more than 1,200 programs of studies for majors.

Types of Institutions Where Changes Took Place

The new courses, revised courses, and new programs of study were made in all types of institutions, with at least 79% of participants from institutions in each of four Carnegie (1994) classifications making at least moderate revisions to an existing course or developing at least one new course. As Exhibit IV-4 shows, participants from all types of institutions were more likely to revise existing courses than to develop new ones. This was particularly true for participants from 2-year institutions.

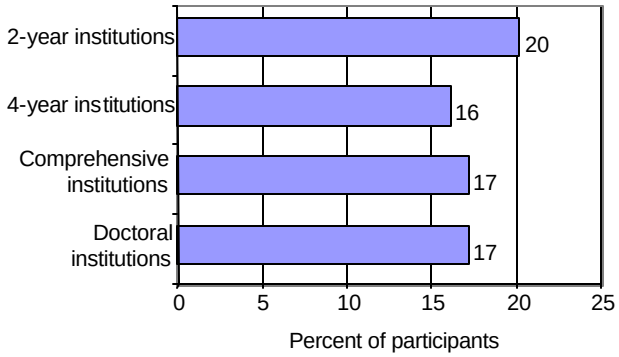
Exhibit IV-4. Percentages of UFE Participants Who Developed and/or Revised Courses, by Participants' Institution Type



Source: SRI Participant Survey.

New programs of study for majors were also developed or revised by participants from all four types of institutions. As shown in Exhibit IV-5, participants from 2-year institutions were slightly more likely than participants from other institutions to develop new majors, yet even in the other types of institutions, 16% to 17% of participants developed new programs of study for majors.

Exhibit IV-5. Percentages of Participants Developing or Revising Majors, by Institution Type



Source: SRI Participant Survey.

Extrapolating from these findings (and keeping the conservative assumption that for each two participants reporting work on a new or revised major, only one program of study was developed) would mean that[5]:

In 2-year institutions, approximately:	• **1,100 new courses were developed.** • **2,100 courses underwent major revisions.** • **2,300 courses underwent moderate revisions.** • **400 new or revised programs for majors were developed.**
In 4-year institutions, approximately:	• **1,700 new courses were developed.** • **2,100 courses underwent major revisions.** • **2,700 courses underwent moderate revisions.** • **400 new or revised programs for majors were developed.**
In comprehensive institutions, approximately:	• **1,400 new courses were developed.** • **1,500 courses underwent major revisions.** • **1,800 courses underwent moderate revisions.** • **300 new or revised programs for majors were developed.**
In doctoral institutions, approximately:	• **700 new courses were developed.** • **1,000 courses underwent major revisions.** • **1,000 courses underwent moderate revisions.** • **200 new or revised programs for majors were developed.**

Institutionalization of Changes

Desired outcome: Reforms in undergraduate SMET courses are sustained.

[5] See Appendix E for calculation.

Sustaining education reform requires that changes become institutionalized. UFE workshops' impact was strong in this regard. Most new or revised courses became institutionalized; 78% of respondents who developed or revised one or more courses reported that their courses received formal departmental approval (or that no such approval was applicable), and another 4% reported that some courses they had developed or revised had received such approval while others had not (as of the time of the survey).

Virtually all respondents to SRI's survey (99%) reported that the courses they had developed or revised were still being offered. Most (77%) taught their new or revised courses more than once during the 2 to 3 years following the workshop. In general, each time participants taught a course, they tended to *increase* the extent of their changes. When changes involved teaching methods, participants tended to become more adept and comfortable at the new methods over time and to increase their use of them. Thus, for example, over the first few opportunities to teach the course, they increased the percentage of time devoted to problem solving and hands-on learning activities and decreased the time spent on lectures. Likewise, when changes concerned the introduction of new content or technology into an existing course, participants often increased the percentage of their course(s) that dealt with the new content or used the new technology.

Participants' Professional Activities

Desired outcomes:

Faculty incorporate current and relevant content into their teaching, use state-of-the-art experimental techniques and technology, and apply best practices in instruction.

Faculty collaborate with one another other and with other experts in their fields.

Although impact in the classroom, and ultimately on students, is the principal goal of a program such as UFE, this type of program can also have other types of impacts. The simplest type involves motivating workshop participants to pursue ways of making their teaching more consistent with best practice. Another by-product can be increased collaboration among faculty. Finally, since activities funded by NSF cannot possibly reach all faculty in the nation directly, it is important that those who are directly reached disseminate their new knowledge and skills to others.

Faculty Professional Development

Within 2 or 3 years of attending the UFE workshop, about three-fourths of participants went on to attend further professional development activities designed to change the content of their courses or improve their instruction. For almost two-thirds of those who did so (that is, for almost half of all participants), UFE workshops provided great or at least moderate motivation to attend. About two-fifths of UFE workshop participants indicated that their postworkshop communication with experts in one or more SMET disciplines was motivated greatly or moderately by the UFE workshop they had attended.

Faculty Collaboration and Communication

Forty-four percent of participants collaborated with colleagues when developing new courses or revising existing courses, and 15% team-taught courses they had developed or revised. Some of these collaborations predated the workshops; however, in the first few years after attending a workshop, 37% of participants established *new* research or teaching collaborations that they attributed in great part or moderately to the UFE workshop.

Dissemination and Indirect Impacts

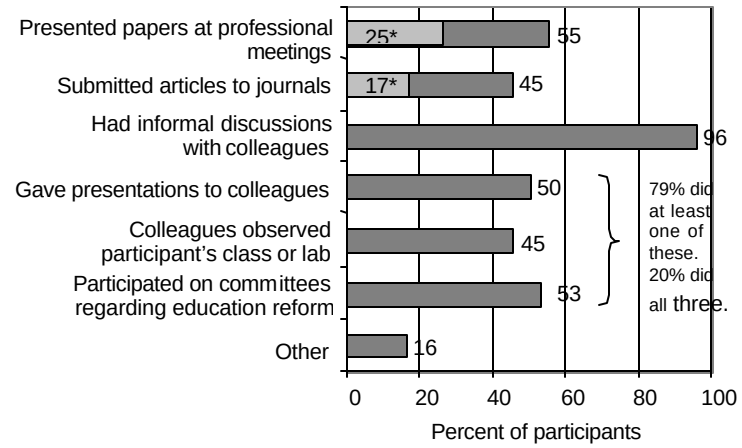
Desired outcomes:

SMET faculty incorporate current and relevant content into their teaching, use state-of-the-art experimental techniques and technology, and apply best practices in instruction.

Knowledge and skills from UFE workshops are disseminated widely.

We asked participants whether they had submitted articles to journals or delivered papers at professional meetings in the first few years after attending a UFE workshop. These were fairly common activities, as shown in Exhibit IV-9. Approximately half of participants engaged in each activity, and close to 40% did both. About 38% of those who presented papers and 45% of those who submitted journal articles said that the UFE workshop was influential in their doing so.

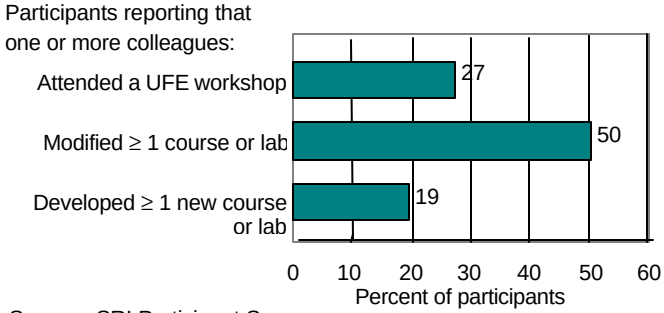
Exhibit IV-9. UFE Participants' Dissemination Activities



*Engaged in activity, but did not attribute it to the UFE workshop.
Source: SRI Participant Survey.

Closer to home, in the 2 to 3 years after attending a UFE workshop, almost all participants (96%) shared information informally with their colleagues (either at their own institutions or at other institutions), half gave formal presentations to their colleagues, and almost half (45%) had colleagues observe one or more of their classes or laboratories. UFE participants also were quite likely to participate in department or campus committees regarding curricular change and reform, and more than half (53%) shared information they had learned at UFE workshops through their participation on such committees. Almost four-fifths of participants either gave formal presentations, had colleagues observe their courses or labs, and/or participated on committees regarding education reform.

Exhibit IV-10. Indirect Impacts of UFE Workshops on Participants' Colleagues



Source: SRI Participant Survey.

Because of this sharing of information, the impact of the workshops did not stop with the participants. Approximately one-fourth of participant respondents reported that, because of their influence, at least one of their colleagues had attended a UFE workshop. Even more strikingly, half of participant survey respondents reported that one or more of their colleagues had modified the content of at least one course or lab because of information the participant had shared. Furthermore, almost one-fifth of participant respondents reported that one or more of their colleagues had developed at least one new course or lab because of the information the participant had shared (see Exhibit IV-10).

The survey did not ask these participants how many of their colleagues had modified or developed courses or laboratories; however, even if only *one* colleague per participant had done so, the percentages in Exhibit IV-10 would mean that, because of what participants learned at UFE workshops, at least:

- **7,200 of UFE participants' colleagues modified the content of at least one course or laboratory.**
- **2,700 of UFE participants' colleagues developed at least one new course or laboratory.**

Summary

Almost all participants learned new content, teaching methods, laboratory techniques, and/or new technologies at UFE workshops, and about three-quarters went on to attend other activities designed to improve their teaching. Most of the participants applied their knowledge: approximately four-fifths revised at least one existing course and/or developed a new course as a result of the workshops. Institutions were largely supportive of faculty's curricular reforms; at the time of the survey, more than three-quarters of participants reported receiving explicit departmental approval for their new or revised courses. Another 18% reported that their courses had not been approved by that time, but it is likely that some have been approved since then. We did not ask whether explicit approval was always required by their institution.

Through a range of formal and informal dissemination activities, the impact of the workshops on the participants' institutions (and colleagues in other institutions) extended beyond the participants themselves. More than half of participant survey respondents reported that what they had learned at the UFE workshop and shared with others had influenced one or more of their colleagues to develop or revise a course or lab.