SRI INTERNATIONAL

EVALUATION OF THE NATIONAL SCIENCE FOUNDATION'S UNDERGRADUATE FACULTY ENHANCEMENT (UFE) PROGRAM

Prepared for:

National Science Foundation
Directorate for Education and Human Resources
Division of Research, Evaluation and Communication
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Arlington, Virginia 22230

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EXECUTIVE SUMMARY

As part of its commitment to Congress to evaluate each of its programs periodically, the National Science Foundation's Directorate for Education and Human Resources (EHR) contracted with SRI for an independent evaluation of the Undergraduate Faculty Enhancement (UFE) program. This is the final report from that evaluation.

In addition to reporting descriptive information about the program, this study provides the first systematic examination of associations between various characteristics of the workshops and their impact on faculty participants' subsequent development and implementation of courses.

The UFE Program

From its inception in 1950, NSF has supported various forms of professional development for faculty who teach undergraduates. The UFE program was created to fund a broad range of faculty development workshops, short courses, seminars, and other related activities with the goals of enabling faculty members to (1) adapt and introduce new content into courses and laboratories, (2) investigate innovative teaching methods, (3) synthesize knowledge that cuts across disciplines, (4) learn new experimental techniques and evaluate their suitability for instructional use, and (5) interact intensively with experts in their field and with colleagues who are active scientists and teachers.

The UFE program operated from 1988 through 1998, when it was incorporated into a larger program of course and curriculum development and laboratory improvement. During the period covered by this study (1991-1997), the program awarded almost 500 workshop grants to Principal Investigators (PIs) at colleges and universities, professional societies, and other qualified organizations. Specific awards ranged from less than $10,000 to almost $500,000 and supported more than 750 workshops.

The Evaluation of the UFE Program

SRI's summative evaluation of the UFE program was designed to collect and interpret program-wide outcome and impact data to ascertain the extent to which UFE met the goals that NSF set out for it. In addition, as the phasing in of the Government

Performance and Results Act of 1993 (GPRA) proceeded, NSF became more interested in knowing the program's broader impacts on undergraduate education.

To ascertain such impacts, SRI worked with NSF program and evaluation staff to develop a set of desired UFE outcomes, and indicators for the outcomes. The desired outcomes are:

1. 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.
2. Undergraduate students, including those from underrepresented groups, gain proficiency in SMET, improve their attitudes toward SMET, and are prepared to apply SMET concepts to their lives.
3. Institutions offer SMET courses/labs for undergraduates that are accessible to all students, use state-of-the-art experimental techniques and technology, and are relevant to the real world.
4. SMET faculty collaborate with one another and with other experts in their fields.
5. Reforms in undergraduate SMET courses are sustained.
6. Knowledge and skills from UFE workshops are disseminated widely.

The evaluation sought to illuminate which characteristics of participants, of their institutions, and especially of the workshops themselves were associated with workshop success in terms of the changes participants made to their courses and/or laboratories. Exploring these associations was deemed particularly important because a literature search revealed no systematic information on the topic.

The principal data collection methods for the evaluation were:

- A telephone survey of 1,118 faculty.
- Site visits to eight workshops and follow-up contact with workshop PIs and participants.

Characteristics of UFE Participants and Workshops

From 1991 through 1997, more than 14,000 faculty who teach undergraduates attended UFE workshops. Approximately 30% of them were female, and approximately 16% were members of minority groups. Twenty-seven percent came from 2-year institutions, 33% from baccalaureate institutions, and 40% from comprehensive or doctoral institutions. Across institutional classifications, about 5% of participants were from Historically Black Colleges and Universities. Data were not collected on representation fro other categories of minority-serving institutions.

UFE workshops were conducted in all SMET disciplines (ranging from 1% of them in astronomy to 25% of them in mathematics), and typically focused on some combination of content (subject matter), teaching methods, and/or lab techniques or technologies. Of the workshops that included a focus on content, surveyed participants said that more than half dealt with interdisciplinary content. Most workshops were held during the summer and lasted from 3 to 10 days.

While at the workshop, the vast majority of participants worked on some type of materials for their own courses, and a substantial percentage of them completed work on their materials. After the workshop, more than half of the participants reviewed or site-tested materials or products from the workshop, often receiving technical assistance from the project PI or workshop staff. Close to half also attended formal or informal follow-up activities.

Findings from Qualitative Data for Eight UFE Workshops

During the summer of 1998, SRI researchers conducted site visits to eight UFE workshops. Within scheduling constraints, sites were selected to include various disciplines, foci, geographic regions, and types of participants targeted. Workshop PIs and selected participants were contacted again in spring and summer of 2000 to obtain updated information.

The workshops visited ranged from 5 to 21 days in length. Activities included presentations by staff and/or guest lecturers, hands-on activities (including time for participants to work on materials for their own courses), and opportunities for participants to interact with one another. All workshops visited had a real-world focus, and several included field trips. In most workshops, the activities were well balanced, and presentations and activities were of high quality, according to expert site visitors and participants interviewed. Site visitors also observed that most participants were highly engaged at all times.

Face-to-face follow-up activities proved somewhat difficult to schedule. In the two years following, none of the workshop convenors had held formal follow-up activities; however, three held informal gatherings at professional meetings. A more common type of follow-up was communication between participants and PIs or workshop staff as participants continued to work on their own materials and/or site-test those of others.

The majority of participants at the workshops visited were white males. Approximately a quarter were females, and, despite PIs' attempts to recruit individuals from underrepresented minority groups, only about 6% of participants were from such groups.

The most important characteristic about participants is that the vast majority of them were extremely eager to learn and to apply what they had learned. In a few cases, their eagerness was robust in the face of poor presentations or a less-than-optimum schedule of activities.

Findings from Survey Data

UFE's Impact on Faculty and Their Institutions

New and/or Revised Courses. Almost all UFE participants learned new content, teaching methods, laboratory techniques, and/or new technologies at UFE workshops, and approximately four-fifths applied what they learned by developing at least one new course and/or revising at least one existing course. We estimate that, as a result of UFE workshops, approximately 5,000 new courses were developed, 7,300 courses underwent major revisions, and 8,600 courses underwent moderate revisions. More than three-quarters of these new or revised courses received departmental approval.

Programs of Study for Majors. Approximately 17% of participants developed or redesigned a program of studies as a result of the UFE workshop they had attended. Even under very conservative assumptions, this translates to the development or redesign of approximately 1,200 programs of study.

Dissemination. Through a variety of formal and informal dissemination activities, participants extended the impact of the workshops beyond themselves. More than half of participant survey respondents reported that they had shared what they had learned with colleagues and that, as a consequence, at least one of their colleagues had developed a course or lab and/or modified the content of a course or lab. From these survey responses, we estimate that at least 2,700 of UFE participants' colleagues developed a new course or lab and that at least 7,200 modified the content of an existing course.

UFE's Impact on Students

Participants' professional enhancement and consequent development of new or revised courses would mean little if students did not take the courses or if the changes did not result in improved student learning. We estimate that, by 1999, more than 1,850,000 students, 1 in 22 students nationally, had completed courses that were developed or had undergone *major* revisions as a result of the UFE workshops held in 1991-1997. Approximately 965,000 additional students, 1 in 43 students nationally, had completed courses which had undergone *moderate* revisions as a result of the workshops. Slightly fewer than half of these students were female, and approximately one-quarter were from underrepresented minority groups. Twenty-eight percent of the students were in 2-year institutions, the same percentage in baccalaureate institutions, 24% in comprehensive institutions, and 20% in doctoral institutions.

Faculty reported that students in their revised or modified courses performed better along a number of dimensions than comparable students in traditional courses. In addition to improvements in content knowledge, faculty cited improvements in students' abilities to solve problems, think critically, communicate, collaborate, use technology, and understand the scientific method.

The greater the changes faculty made to their courses, the more likely they were to report substantial improvement in their students' performance. Because student performance was neither observed nor measured by third parties, the extent to which faculty may have over-reported improvements in their students' performance cannot be known; however, our data collection techniques attempted to minimize this possibility.

Factors Associated with Workshop Success

More than half of UFE participants who developed and/or revised courses encountered some type of barrier. According to survey respondents, the most common barriers concerned lack of time to work on courses because of a heavy teaching and/or administrative load, not having the necessary equipment or technology, and lack of funds. Resistance to change by other faculty was not a commonly reported problem.

We performed a multivariate analysis to examine the associations of characteristics of participants, their institutions, and the workshops with participants' probability of developing or revising a course after the workshop. Neither characteristics of participants nor those of their institutions showed any statistically significant associations. Characteristics of the workshop that were found to be positively associated with developing or revising courses were: the number of days of the workshop, the inclusion of teaching methods and/or new technology in the workshop, and activities that included work on lecture notes, handouts, problem sets, project descriptions, and/or lab exercises. Neither completing their materials at the workshop nor taking part in face-to-face follow-up activities showed significant associations with developing or revising courses. In contrast, testing materials at their home institutions and receiving technical assistance from workshop PIs or staff did show significant positive associations.

Conclusion

To judge whether the UFE program was successful, two questions must be addressed: *Did the UFE program achieve its goals? Was the UFE program an effective strategy for achieving NSF's broader goal of transforming undergraduate education generally?*

The UFE program held more than 750 workshops over a 7-year period, reaching more than 14,400 undergraduate faculty from all types of institutions. Eighty-one percent of those faculty went on to make at least moderate changes to their own courses or to develop new courses. Thus, the answer to the first question is a definite "yes."

Answering the question of whether the UFE program was an effective strategy to meet NSF's goals of transforming undergraduate education is somewhat more difficult because benchmarks are less clear, but again, we believe the answer is "yes." The 14,402 participants (total corrected for number of repeat attendees) who attended UFE workshops represent approximately 1 in 22 SMET faculty in the United States. Of these participants, we estimate that 11,666, or 1 in 27 U.S. SMET faculty, developed and/or made moderate or major changes to at least one course and attributed these actions to the UFE workshop they had attended.

The proportion of U.S. students affected by classroom changes made as a result of UFE workshops is still greater. We estimate that, between 1991 and 1999, approximately 1,850,000 students—1 in 22 undergraduate students nationally—completed courses that 1991-1997 UFE participants had developed or had revised in major ways, and another 965,000 students—1 in 43 nationally—completed courses to which UFE participants had made moderate revisions. This total of 2,815,000 students represents 1 in every 15 undergraduate students in the United States over the 8-year period covered, and the total will increase as the new and revised courses are taught again over the next few years.

Moreover, dissemination efforts of UFE participants appear to have been very fertile; slightly more than half of survey respondents reported that such sharing resulted in their colleagues' developing or revising their own courses. Even if only one colleague per participant made such changes, this would add more than 7,300 faculty, so that altogether more than 19,000 faculty revised or developed courses because of UFE. This represents 1 in 17 SMET faculty in the United States.

In addition, although the impact on students of revisions to major programs of study was not (and perhaps cannot be) measured, that impact also appears to be considerable; at a minimum, more than 1,200 major programs of study were created or redesigned.

Not only did the UFE program bring about considerable changes in undergraduate education, it did so in a cost-effective way. Between 1991 and 1997, UFE grants totaled $46,024,461. This number translates to approximately $3,900 for each participant who made at least moderate changes to his or her courses. Taking into account participants' colleagues who also made changes, the cost per faculty member who made changes due to someone's participation in UFE drops to approximately $2,400.

In terms of cost per course and per student, we can take into account only participants' courses and students (not those of participants' colleagues). Nevertheless, for courses developed by participants, the cost per course was approximately $2,200 (including new courses as well as courses that underwent major or moderate revisions). The cost per student in such courses through 1998-99 was approximately $16, and this cost will decrease as more students attend the courses.

I. INTRODUCTION

As part of its commitment to Congress to evaluate each of its programs periodically, the National Science Foundation's Directorate for Education and Human Resources (EHR) contracted with SRI for an independent evaluation of the Undergraduate Faculty Enhancement (UFE) program. This is the final report from that evaluation.

In addition to reporting descriptive information, this study provides the first systematic examination of associations between various characteristics of the workshops and their impact on faculty participants' subsequent development and implementation of courses.

Overview of the UFE Program

From its inception in 1950, NSF has supported various forms of professional development for faculty who teach undergraduates. The scope and variety of development offerings have changed over the years. By FY 1981, when funding for most of NSF's education programs was terminated by Congress at the President's request, three programs were providing direct, explicit support for faculty development. One of them, College Faculty Conferences, sponsored summer workshops over 3- to 4-week periods.[1]

During the mid-1980s, the National Science Board, Congress, and the White House all worked toward the reestablishment of NSF's education programs. Guided by a National Science Board report (1986), NSF created several new education programs and recast some former ones. Among the new programs was UFE, which was run by NSF's Division on Undergraduate Education (DUE).

UFE's goals were to support projects that enable faculty members who teach undergraduates to adapt and introduce new content into courses and laboratories, to investigate innovative teaching methods, to synthesize knowledge that cuts across disciplines, to learn new experimental techniques and evaluate their suitability for instructional use, and to interact intensively with experts in the field and with colleagues who are active scientists and teachers (National Science Foundation, 1997). UFE kept

[1] The other two were a sabbatical leave type of program and short courses of classroom instruction.

the concept of faculty enhancement through workshops from College Faculty Conferences, but shortened the time devoted to actual workshops and placed more emphasis on participants' preparation and follow-through. Projects could be regional or national in scope and could be in any field of science, mathematics, engineering, and/or technology (SMET). Many workshops used materials previously developed by Principal Investigators (PIs) under NSF Course and Curriculum Development grants.

The program operated from 1988 through 1998,[2] funding more than 1,000 workshops in all fields of SMET. In 1998, it was succeeded by a "track" within a larger program of course and curriculum development and laboratory improvement.[3] The new effort, called the National Dissemination track, focuses on disseminating exemplary course and curriculum materials and practices by providing faculty with professional development activities on a national scale. Workshops and short courses remain the primary mechanisms; the possibility of proposing to conduct distance-learning activities was explicitly added. Among NSF's stated expectations for the new track are to introduce new content into undergraduate courses and laboratories, to enable faculty members to explore effective educational practices, and to include participation by faculty who are representative of the national demographic and institutional diversity within the included field(s).

What Is Known about Workshops as a Strategy to Improve Undergraduate Education

Virtually all surveys regarding improving undergraduate teaching and learning have identified workshops as a primary strategy for this purpose. These include surveys of colleges and universities in the United States (Centra, 1978a, 1978b; Erikson, 1986; Hellyer and Boschmann, 1993), some of which focused on community colleges (Hansen, 1983; Richardson, 1987; Smith, 1981), and an international survey involving respondents in the United States, Canada, the United Kingdom, and Australasia (Wright and O'Neil, 1995).

[2] A small number of workshops were held in 1999.
[3] The Course, Curriculum, and Laboratory Improvement Program, Track 3: National Dissemination (CCLI-ND), described in NSF Program Solicitation 00-63 (May 1, 2000).

Despite the widespread use of faculty development workshops, there is relatively little empirical evidence regarding their impact other than in anecdotal form. Eison and Stevens (1995) observed:

> [C]ountless faculty development workshops are conducted on college and university campuses each year. … The majority of these are never reported in the published literature; consequently their strengths, limitations, and impact, along with any lessons learned by workshop facilitators, regrettably have not contributed to current knowledge about workshops. (p. 208)
>
> Most frequently, a participant questionnaire at the program's conclusion is the primary evidence collected to document program success. … Measures of participant satisfaction do not provide sufficient or direct evidence that a faculty development program has stimulated instructional improvement leading to enhanced student learning—an often stated goal of many programs. … One finds little evidence reported in the published literature that this type of data is collected to assess program impact. (pp. 216, 217)

As part of the current evaluation, SRI commissioned Dr. G. Roger Sell of the University of Northern Iowa to conduct a review of published literature regarding the impact of faculty enhancement (Sell, 1998). Only 12 studies regarding faculty met Sell's criteria for the review.[4] Although there were methodological differences across the studies and serious design flaws in some, the studies generally support the conventional wisdom that faculty professional development activities have positive impacts on teaching and learning, as well as on other behaviors of participants.

Teaching and instructional improvement. Participants themselves have reported improvements in their teaching because of workshops or related activities (Austin, 1992; Eble and McKeachie, 1985; Menges et al., 1988; Eison and Stevens, 1995). Students of participants also have rated faculty who participated in workshops as more effective teachers than comparable nonparticipant faculty or have indicated that participants' teaching improved after attending workshops (Annis, 1989; Boice, 1995; Hativa and Miron, 1990; Hoyt and Howard, 1978; however, see also Gibbs, Brown, and Keeley,

[4] To limit and focus the search and review process, Sell included only "research-based literature," which he defined as published studies that collected and used empirical data to assess workshop effectiveness. Purely descriptive or prescriptive reports were not included; neither were dissertations, unpublished professional meeting papers, occasional papers, project and technical reports, or ERIC documents.

1989). No studies reviewed by Sell relied on third parties' reports of the impact of workshops on faculty's subsequent teaching.[5]

Impact on student performance. The single study reviewed by Sell that examined the performance of participants' students in an objective way found a positive impact of faculty development activities. After participants attended a workshop focused on the teaching of a particular mathematics course, their students had higher rates of passing the course and higher final exam scores than students of a comparison group of faculty (Friedman and Stomper, 1983). Rates of passing the course and final exam scores also were higher than those of participants' own students before the training.

Nonclassroom activities. Several studies supported the notion that faculty development activities lead to increased productivity; Boice (1995), Eison and Stevens (1995), and Menges et al. (1988) reported positive effects of workshops on faculty research and scholarship. Collegial relationships and the involvement of faculty in departmental and institutional commitments also were found to be positively affected by workshops and related activities (Austin, 1992; Eble and McKeachie, 1985).

Findings from Westat's formative evaluation of the UFE program. A survey of UFE workshop participants conducted by Westat, Inc., in 1991 as part of a formative evaluation of the UFE program lent further credence to the positive impacts of workshops on participants' subsequent behaviors. Substantial majorities of respondents indicated that they had introduced new content into an existing undergraduate course or laboratory; acquired new equipment, materials, or computer software for undergraduate courses or laboratories; incorporated equipment, materials, or computer software into undergraduate courses or laboratories in a way they had not been used previously; modified teaching methods; and developed new undergraduate courses or laboratories (Westat, 1992).

In addition, majorities of participants indicated that, following the UFE workshop, they had participated in formal programs designed to develop curriculum or improve instruction, or had delivered a paper at a professional meeting or submitted an article to a

[5] Sell did review one study in which trained third-party observers judged the impact of an *entire semester* of training sessions on five faculty's subsequent teaching. The observers found that all five faculty implemented what they had learned during the training sessions.

professional journal; however, participants did not tend to attribute these behaviors strongly to the UFE program.

The UFE Evaluation Design and Methods

The Evaluation Design

This summative evaluation was designed to collect and interpret outcome and impact data on a programwide level to better understand the extent to which UFE as a whole met the objectives that NSF set out for the program. These objectives included the goals listed in the program announcement and in yearly directories of workshops. In addition, as the phasing in of the Government Performance and Results Act of 1993 (GPRA) became more influential in the Executive and Congressional examination of agency programs, NSF became more interested in knowing the program's broader impacts on undergraduate education.

To ascertain such impacts, SRI worked with NSF program and evaluation staff to develop a set of desired outcomes and indicators for the outcomes. Exhibit I-1 lists the outcomes (the complete set of outcomes and associated indicators is shown in Appendix A). Note that the outcomes focus on faculty behaviors, student performance, institutionalization of improved courses, etc., and are phrased in terms of desired states. Our evaluation was designed to measure movement toward those states by measuring *changes* in faculty behavior (i.e., development of new courses and/or revision of existing courses) that could be attributed to UFE.

Such changes are often measured by using a "pre-post" design or inferred from "comparison group" designs; however, neither of these was feasible for the present evaluation (see discussion below in "Limitations of the Evaluation Design"). Therefore, we observed workshops and asked participants directly in interviews and a telephone survey about changes they had made as a result of the workshops and about the consequences of these changes.

Exhibit I-1. Outcomes for the UFE Program

1. Faculty incorporate current and relevant content into their teaching, use state-of-the-art experimental techniques and technology, and apply best practices in instruction.
2. Undergraduate students, including those from underrepresented groups, gain proficiency in SMET, improve their attitudes toward SMET, and are prepared to apply SMET concepts to their lives.
3. Institutions offer 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.
4. SMET Faculty collaborate with one another and with other experts in their fields.
5. Reforms in undergraduate SMET courses are sustained.
6. Knowledge and skills from UFE workshops are disseminated widely.

The evaluation also was designed to examine the extent to which various factors were associated with participants' subsequent behaviors. Data for such analyses came from our survey, as well as from DUE's database.

The time frame covered by the quantitative data is 1991 through 1997. We began with 1991 because Westat's formative evaluation had examined workshops held in 1988-1990. We ended our coverage with 1997 because data from DUE were not available for workshops after that year, and because we chose 1996 and 1997 participants for our own survey. Qualitative data were collected in 1997 and 1998.

Limitations of the Evaluation Design

Our evaluation design has two principal limitations. The first is that it relies on participants' reports of changes in their own behavior and of their students' performance. The extent to which participants might be overly positive in their survey responses is unknown. Using third-party reports, rather than those of participants, would have been theoretically preferable; however, such a design was not feasible because it would have required visits to participants' classes before and after participants attended the UFE workshops. Because lists of participants were not available until after the UFE workshops, preworkshop observations were not possible. Second, even if lists had been obtainable, observations of a meaningful sample of participants would have been prohibitively costly.

Fortunately, two factors make reporting bias unlikely. First, participants had no vested interest in inflating the positive impact of the UFE program. In addition to the fact that the survey was anonymous, the UFE program had already been terminated by the time the survey was administered, so participants had nothing to gain. Second, some survey respondents had attended workshops run by PIs whose follow-up activities we had also visited. When we compared survey responses with interview data from participants at the same PIs' follow-up activities, we found them to be very similar regarding workshop impact.

A second limitation for the evaluation is created by the absence of a comparison group. Because of this absence, the evaluation can not tell us the extent to which nonparticipant faculty attended other types of workshops or no workshops at all, or the extent to which such faculty made the same types of changes as faculty who attended UFE workshops. However, because of a host of unmeasured factors, such as departments' push for reformed courses in particular areas and participants' motivation to attend the UFE workshops, finding a valid comparison group would have been an intractable task, and a poorly matched "comparison group" could result in misleading findings. Thus, we chose the simpler design.

Evaluation Methods

Our primary data collection methods were:

- A telephone survey of 1,118 faculty, and
- Site visits to 12 workshops or related activities and follow-up contact with PIs and/or participants at those activities.

Quantitative data collection. To allow faculty to have had sufficient time to develop and teach courses or otherwise implement new curricula, the telephone survey was administered to faculty 2 to 3 years after they had attended a UFE workshop. The survey instrument was developed to cover as many of the indicators shown in Appendix A as possible. In addition, the instrument contained questions regarding workshop activities and other variables that our preliminary qualitative data collection indicated might be associated with the outcomes. (A full discussion of survey data collection is presented in Appendix B. The survey instrument, annotated to show the linkage of each survey item to the outcome/indicator it was intended to measure, is presented in Appendix C.)

Additional quantitative data were drawn from DUE's databases of UFE awards and PIs' responses to annual surveys. These data included such items as award amounts, numbers of applicants to workshops, numbers of participants at workshops, durations of workshops, etc.

Qualitative data collection. In 1997, we conducted a preliminary round of site visits to UFE follow-up activities or workshops that were in their second or third summer to gain insight for the development of outcomes and indicators and, thus, for our survey questionnaire. In 1998, a second round of site visits to actual workshops enabled us to observe firsthand their balance of activities and their quality. In-depth interviews conducted during these visits also provided us with a richer understanding of the workshops' leadership and participants than could be obtained through a survey. In 2000, we contacted PIs and selected participants by telephone and/or e-mail to learn about participants' postworkshop experiences. (Qualitative data collection methods are described more fully in Chapter III.)

Advisors for the Evaluation Design and Methods

An advisory committee consisting of five academic specialists in science, mathematics, or engineering and two specialists in the evaluation of educational programs was appointed to provide advice regarding the evaluation's design and methods (names and affiliations are shown in Appendix D). A full-day meeting was held, during which a tentative design and methods were presented to the committee for their discussion. The final evaluation design and methods took into account their comments.

Organization of the Report

Chapter II, *Description of the Workshops*, presents an overall picture of the size, scope, and disciplinary and thematic coverage of the UFE program. This chapter includes some information from our survey of participants, as well as summary data from DUE's annual surveys of Principal Investigators. Brief descriptions of selected workshop features and quotes from survey respondents are included here and in Chapters IV, V, and VI.

Chapter III, *Qualitative Findings,* opens by discussing our qualitative data collection methods, including how various workshops were chosen for site visits. It then presents some general observations about the workshops visited.

Chapter IV, *Quantitative Findings for Faculty and Institutions* focuses on what participants learned, how they applied that learning to developing or revising courses and/or programs of study for majors, and the extent to which new and/or revised courses were institutionalized. The chapter also discusses the workshops' impact on participants' own professional activities and the "ripple" effects of their sharing workshop information with colleagues. This chapter, as well as the two subsequent chapters, uses data from SRI's survey of participants.

Chapter V, *Quantitative Findings for Students*, presents estimates of how many students completed participants' new or revised courses, as well as participants' judgment of such students' performance.

Chapter VI, *Factors Associated with Workshops' Success*, reports on barriers that participants perceived to revising and/or developing courses. It then takes a multivariate look at the associations between workshops' characteristics and participants' likelihood of revising and/or developing courses. Lastly, it discusses participants' views on the importance of various workshop characteristics.

Chapter VII, *Conclusion,* presents observations and conclusions by SRI staff, based on the earlier chapters. References and appendices follow.

II. DESCRIPTION OF THE WORKSHOPS

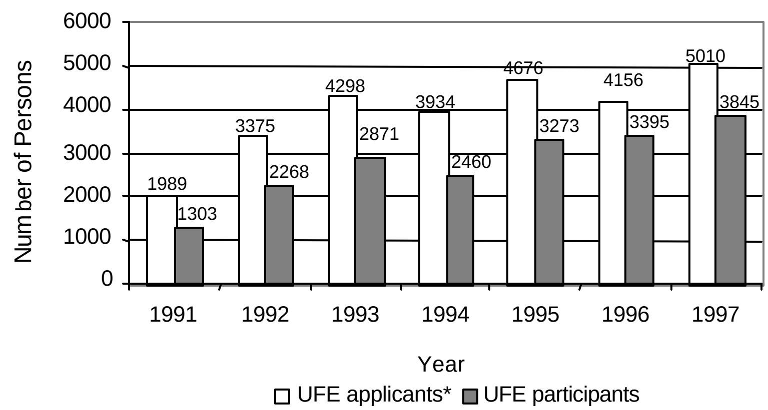
This chapter presents an overall picture of the scope, funding, and disciplinary and thematic coverage of the UFE program. Unless otherwise noted, all exhibits are based on information from the telephone survey of participants.

Awards, Participants, and Funding Levels

From 1991 through 1997, the UFE program awarded almost 500 workshop grants to PIs at colleges and universities, professional societies, and other organizations. Award amounts ranged from less than $10,000 to almost $500,000. The median amount increased from about $65,000 to $90,000.

UFE workshops were quite popular; over the years of the program, the numbers of both applicants and participants increased (see Exhibit II-1). Between 1991 and 1997, almost 27,400 applications were received by UFE Principal Investigators (PIs) from individuals who sought to participate in workshops, and some 71% of those applicants (19,400) were accepted.[1,2] The vast majority of participants -- 16,700, including repeat attendees -- received funding (typically lodging and *per diem)* through the UFE award.

Exhibit II-1. Number of UFE Applicants and Participants, 1991-1997



Note: Exhibit includes duplicated counts of faculty and nonfaculty applicants and participants, as reported by PIs in DUE's annual survey. Numbers include all workshops for each year, including those whose PIs did not respond to DUE's survey. In such cases, the mean numbers of applicants and participants for each year were imputed and included in the totals. For example, in 1991. 54 workshops were held, but PIs reported on 49 workshops comprising 1,182 participants. The mean number of participants reported for the 49 workshops was used to compute the numbers for the other five workshops. Source: DUE database.

Based on lists of participants in 1996 and 1997 workshops, we estimate that 90% of all participants were faculty who teach undergraduates (sometimes referred to in this

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[1] Numbers of applicants and participants are not available for workshops held in 1998 and 1999; however, approximately 90 UFE workshops were held in 1998, and fewer were held in 1999.

[2] The data reported in the text and in Exhibit II-2 include duplicated counts of participants within years (those who applied to and/or attended more than one workshop in a given year) and across years (those

report as "undergraduate faculty"). The remaining 10% included secondary school teachers, pre-service teachers, and observers from institutions outside the United States. Exhibit II-2 shows the estimated numbers of faculty who attended in each year from 1991-1997, excluding repeat attendees.[3] Annual PI surveys conducted by the DUE showed that 30% of participants were female, and 16% were members of a minority group (including Asians; see note to exhibit). Twenty-seven percent of the faculty participants were from 2-year institutions, 33% from baccalaureate institutions, and 40% from comprehensive or doctoral institutions. Across those categories, five percent were from Historically Black Colleges and Universities. Data were not collected on representation from other categories of minority-serving institutions.

Exhibit II-2. Unduplicated Number of Undergraduate Faculty at UFE Workshops, Percentages of Female and Minority Participants, and Percentages of Undergraduate Faculty Participants from Various Types of Institutions, by Year

Year	Number of Undergraduate Faculty Participants	Percent Female*	Percent Minority*	Participant's Institutions: Percent 2-Year	Percent Baccal.	Percent Comp./Doc.	Percent HBCU***
1991	1,090	21	15	19	38	43	5
1992	1,898	26	15	29	30	41	3
1993	2,403	23	12	24	30	46	4
1994	2,059	31	21	32	29	39	6
1995	2,739	32	18	29	30	41	6
1996	2,842	32	13	23	37	40	4
1997	3,218	36	16	29	38	33	6
Unduplicated total	****14,401**	N/A	N/A	N/A	N/A	N/A	N/A
Percent of total	**100**	**30**	**16**	**27**	**33**	**40**	**5**

*Percent female and percent minority are percentages of all participants as reported by PIs in DUE's yearly surveys. Separate percentages for undergraduate faculty were not available. Percent minority includes all Hispanics and nonwhites. DUE's database did not differentiate between "underrepresented minorities" (which NSF defines as African Americans/Blacks, Hispanics, American Indians, Alaska Natives, and Pacific Islanders) and other minorities.
**Does not equal sum of numbers in column because of duplicate counts of participants across years.
***Historically Black Colleges and Universities.
Source: DUE database.

Generalizing from SRI's survey respondents, we estimate that slightly fewer than one-fifth of faculty participants were not on tenure track (many because there was no tenure track at their institution), approximately one-quarter were on tenure track but not tenured, and more than half of participants were tenured. Approximately 22% of participants were assistant professors, 27% associate professors, and 33% full professors.

who applied to and/or attended more than one workshop in various years). See Appendix E for further information regarding calculation.

[3] See Appendix E for calculation.

Exhibit II-3. Academic Rank and Tenure Status of UFE Undergraduate Faculty Participants*

	Percentage of Respondents
Tenure status	
N/A (e.g., no tenure track at institution)	8
Not on tenure track	9
Not tenured	24
Tenured	59
Academic rank	
N/A	7
Instructor/lecturer	11
Assistant professor	22
Associate professor	27
Full professor	33

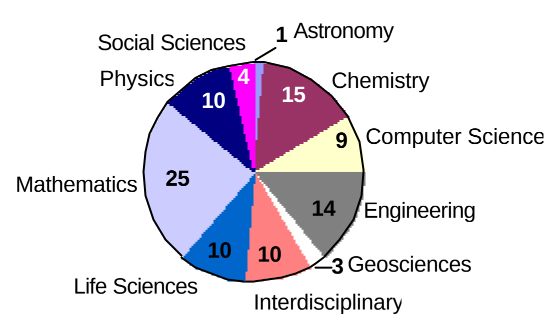
*Based on SRI survey respondents.

Workshop Duration and Coverage

Most UFE workshops were conducted during the summer. They typically were intensive experiences—full-day and sometimes residential. Although workshops ranged in duration from 1 day to 30 days, most were 3 days (15%), 5 or 6 days (35%), or 10 days (14%).

Over the years, UFE supported workshops in all SMET disciplines. The largest single percentage of workshops was in mathematics (25%) and the smallest in astronomy (1%) (see Exhibit II-4). The disciplines of the workshops funded varied slightly from year to year; however, there were no marked trends.

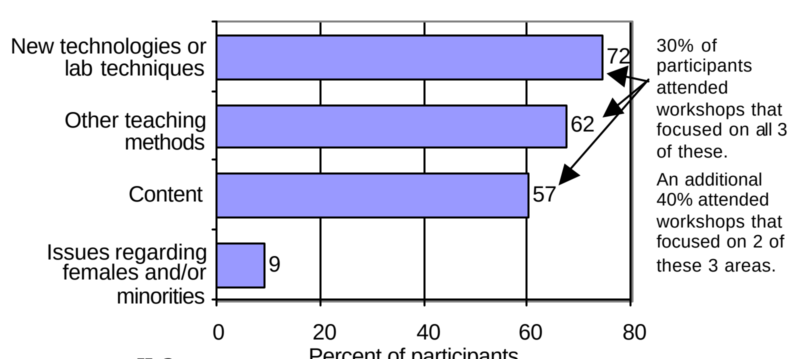
Exhibit II-4. Percentages of UFE Workshops in Various Discipline Groups, 1991-1997



Source: DUE database.

Workshops also varied in their focus on content, teaching methods, and/or lab techniques or technologies. Approximately three-fourths of participants attended

Exhibit II-5. Percentages of Participants Attending Workshops with Various Foci



Source: SRI Participant Survey.

workshops that included a focus on the introduction of new technologies or lab techniques, close to two-thirds of participants attended workshops that included a focus on teaching methods other than technologies or lab techniques, and more than half attended workshops that included a focus on content (more than half such workshops dealt with interdisciplinary content) (see Exhibit II-5).[4] In contrast, about one-tenth of participants attended workshops that dealt with issues regarding females and/or minorities.

Some workshops focused on only one of these areas; however, combining foci was more common. Thirty percent of participants attended workshops that focused on content, teaching methods, *and* lab techniques and/or new technologies, and an additional 40% attended workshops that focused on two of the three areas. All workshops had a real-world focus.

In the "Image Processing Applied to Classroom Teaching" workshop, participants learned to work with remote sensing and image processing technologies. Instructors taught each technology using real-world content in sessions such as "Features of the Seafloor: Evidence of Plate Tectonics" and "Relationships Between Trees: Molecular Taxonomy." Participants then worked on developing their own course units. The purpose of the workshop was to enable participants to incorporate inquiry-based learning using real-world problems into their own courses.

The "Art and Science of Mathematical Modeling" workshop taught applied mathematics content and relevant computer software. In addition, participants learned about what was being modeled—namely, environmental phenomena such as endangered species, forest fires, and water conservation. Sessions on how to incorporate modeling into participants' classrooms focused on both content and teaching methods. The workshop stressed how mathematics could be made relevant for all students.

[4] For most workshops, there was disagreement among SRI survey respondents as to whether the workshop they had attended included each focus shown in the survey, with some participants responding "yes" and others responding "no." Such disagreements are likely to have arisen because of participants' own backgrounds and experiences at the workshops (e.g., a respondent to whom the content presented at the workshop was unfamiliar may have indicated that the workshop focused on new content, but a respondent who was previously familiar with the content may have indicated that the workshop did not focus on new content). Thus, workshop focus is a somewhat subjective area. Therefore, in this paragraph, we present the percentages of *respondents* that reported about each area of workshop focus, not the percentages of *workshops*.

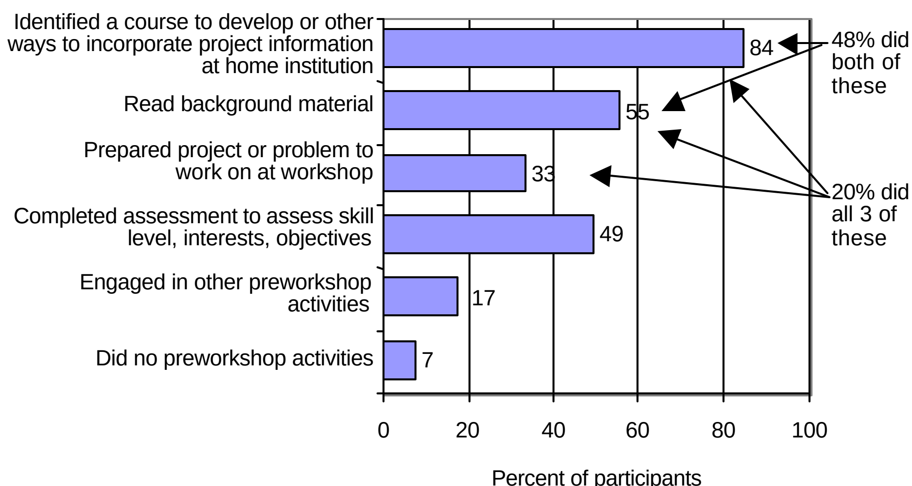
Because of similar cross-participant differences in the rest of the variables in this chapter, all analyses are presented as percentages of participants.

Workshop-Related Activities

Before the Workshops

More than 90% of faculty participants engaged in some type of preparation before attending a workshop (see Exhibit II-6). To increase the probability that participants would actually use what they learned in the workshop to change their own courses, the most common preparation was for participants to identify a course they wanted to develop or some other way in which they would incorporate what they learned at the workshop at their home institutions. Eighty-four percent of participants did this. Fifty-five percent of them read some type of background material, textbooks, or lab manuals; and 33% prepared a project or problem to work on at the workshop. Twenty percent of participants took part in all three types of preworkshop activities.

Exhibit II-6. UFE Participants' Preworkshop Activities



Source: SRI Participant Survey.

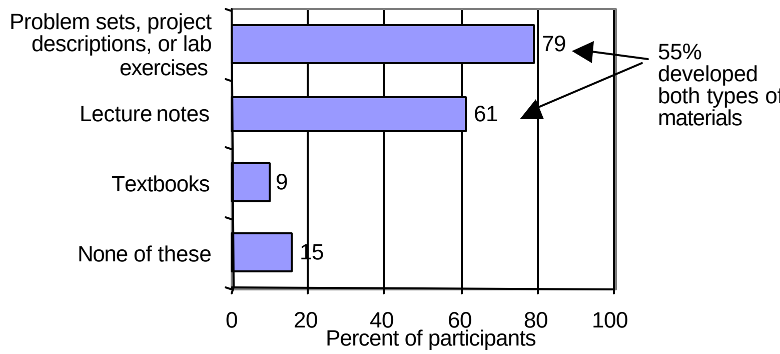
In addition to reading background materials, preparing projects or problem sets, and/or identifying ways to incorporate what they hoped to learn at the workshop, participants often were asked to complete questionnaires to assess their skill level, interests, teaching responsibilities, or objectives to assist PIs in targeting the workshop appropriately. Almost half of participants completed such questionnaires before attending workshops. Close to one-fifth of participants engaged in some other type of preworkshop activity, such as preparing a presentation or proposal, holding meetings or discussions, etc.

During the Workshops

Participants took part in a variety of activities at the workshops. Although many workshops included a lecture component, all workshops included hands-on activities (which were a criterion for being funded), and almost all included development of some types of materials.

Development of materials. The most common type of materials developed at workshops were problem sets, project descriptions, or lab exercises, with 79% of participants working on such materials (see Exhibit II-7). This focus is hardly surprising, given most workshops' goal of helping participants move to more inquiry-based teaching. Also common was development of lecture notes or other handouts, with 61% of respondents developing these. More than half of participants (55%) worked on both types of materials. Working on textbooks was much less common; 9% of participants did so. Again, this finding is not surprising, given the problem- and project-based orientation of the workshops.

Exhibit II-7. Types of Materials Developed by Participants at UFE Workshops



Source: SRI Participant Survey

Despite the fact that most workshops lasted only 10 days or less, a substantial percentage of participants (approximately 40%) left workshops with at least one type of material completed and ready for use in their courses.

The "Geometry of Multivariable Calculus" workshop provided participants with ways to help their students gain mathematical intuition through visualizing concepts. It had a strong real-world component, with several guest speakers from industry. Through previous experience, the workshop's PI knew that many math professors don't teach real-world applications because they lack the time to develop new modules for their courses. Consequently, approximately half of the time of this 1-week workshop was devoted to work on modules. At the end of the workshop, most participants had completed one module. Many modules were shared, not only within participant groups but also across groups.

At the Image Processing workshop, participants began work on instructional modules that encompassed data and images produced by remote sensing and image processing technologies. Although some participants completed their units, most—particularly those with little background before the workshop—had more work to do after the workshop to complete the units.

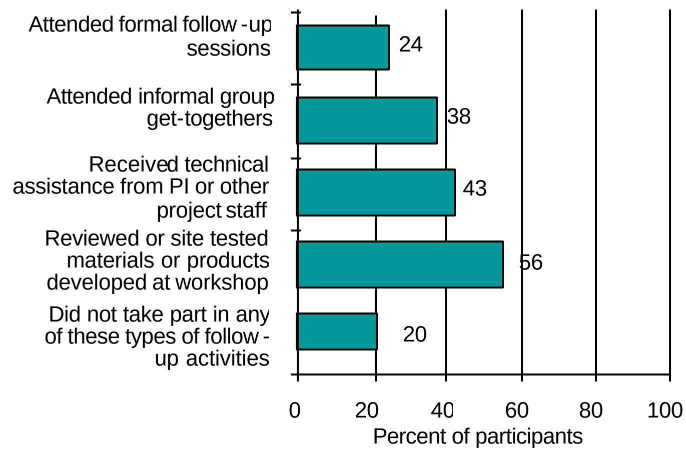
Presentations. Approximately three-quarters of workshops included presentations by participants so that they could experience how their new projects or teaching techniques would actually play out in the classroom. Typically, presentations were a relatively minor part of the activities, with some participants giving no presentations at all. However, in a few workshops, presentations were a major activity, as evidenced by the fact that 5% of participants gave at least three presentations at the workshops they attended.

"Teaching Teachers to Teach Engineering" was a workshop dedicated exclusively to the improvement of teaching methods in large lecture-class situations. Instructors conducted model whole-class sessions in which they demonstrated best practices in organization, black- or white-board techniques, questioning of students, and continual monitoring of student engagement. A great deal of the workshop was dedicated to participants' conducting practice classroom sessions and receiving feedback from a small group consisting of an instructor, a mentor, and four participants. Over the course of the workshop, all participants delivered at least three practice sessions to their team. In addition, each participant observed and participated in critical discussions of at least 12 practice sessions of his or her team members.

After the Workshop

The UFE PIs appear to have been excellent at following up with participants; the great majority of participants at UFE workshops (80%) took part in some type of follow-up activity, as shown in Exhibit II-8.

Exhibit II-8. UFE Participants' Follow-up Activities



Source: SRI Participant Survey.

Follow-up sessions. Many workshops were designed to include formal follow-up sessions to provide participants an opportunity to discuss how they had implemented what they had learned, report their successes and challenges, work further on their materials, and, in some cases, learn more advanced content or techniques. However, relatively few of the original participants (about one-fourth) attended formal follow-ups. According to PIs, nonattendance often was due to competing demands on participants' time.

Informal follow-up get-togethers were somewhat more common, with 38% of participants attending them. Like formal follow-up sessions, such reunions (which often took place at professional meetings) also offered participants opportunities to share their postworkshop experiences. Altogether, 46% of participants attended formal and/or informal follow-up activities.

Technical assistance. Even when workshops did not feature follow-up sessions, the workshop PI or staff still were fairly likely to provide technical assistance after the workshop. Forty-three percent of all participants (including approximately one-third of those who did not attend either formal or informal follow-up activities) received technical assistance from the workshop PI or staff after the workshop.

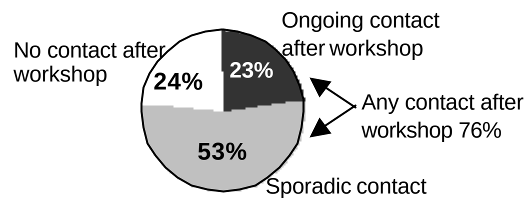
Site testing and review of materials. The most common type of postworkshop activity, engaged in by more than half the participants, was site testing or review of materials that they or others had developed at or after the workshop. This type of activity kept participants actively engaged in the substance and focus of the workshop.

A 1-day follow-up session was held a year after the workshop "A Cognitive Based Approach to Curriculum Development as Applied to Introductory Courses." The purpose of the session, attended by 7 of the original 21 participants, was to share successes and challenges. Topics included how to apply what was learned in the workshop in a variety of courses, how to measure student performance, and how to overcome institutional resistance.

"Workshop Biology" disseminated a biology course for nonmajors that had been developed with grants from NSF's Course and Curriculum Development (CCD) program and the Department of Education's Fund for the Improvement of Postsecondary Education (FIPSE). The project maintained a Web site on which participants posted their course descriptions and materials. In the third year of its UFE award, the project hosted a 3-day follow-up session for selected participants and facilitators from the previous years' workshops. Each was asked to provide a reflective statement about his or her own experiences in implementing Workshop Biology. These papers then were used as the starting point for a series of discussions and brainstorming sessions about student learning, organizational change, and strategies for the future.

Postworkshop communication. Typically, site testing and/or reviewing materials also involved electronic exchanges of information. In fact, approximately three-quarters of participants had electronic communication with workshop PIs and/or other participants following the workshops. This communication tended to be sporadic, rather than ongoing, as would be suggested by a cycle of site testing and communication. However, it is noteworthy that almost one-quarter of participants engaged in *ongoing* communication with PIs or participants after the workshop.

Exhibit II-9. Percentage of Participants in Contact with UFE PIs or Participants after the Workshop



Source: SRI Participant Survey.

Summary

The number of UFE awards and workshops grew sharply from the first fiscal year examined (1991) until they stabilized in fiscal years 1993 through 1997. During that period, the number of faculty applications continued to increase steadily, from about 2,000 to 5,000 annually. Altogether, some 27,400 persons applied, about 90% of whom were undergraduate faculty. Approximately 71% of applicants participated in workshops.

PIs were very creative in designing the required hands-on component of the workshops. All workshops focused on "real-world" phenomena—some in the context of new content, others in the context of laboratory methods and/or new technology. Although very few workshops focused on teaching methods alone, most included teaching methods along with their primary focus.

The vast majority of participants worked on some type of materials for their own courses, and a substantial percentage of participants completed work on their materials at the workshop. After the workshop, more than half of participants reviewed or site tested materials or products developed by themselves or others at the workshop, often receiving technical assistance from the project PI or workshop staff. Close to half also attended formal or informal follow-up activities.

The importance of the various foci of workshops, the types of materials worked on, and follow-up activities to participants' subsequent behaviors will be discussed in Chapter VI.

III. QUALITATIVE FINDINGS

Selecting Workshops to Visit

During the summers of 1997 and 1998, SRI researchers visited four and eight UFE workshops (and related activities), respectively. Three of the 1997 visits were to follow-up activities to prior workshops, and one was to the second year of a workshop that met during three summers. Using information from the preliminary visits as a guide, a round of visits to workshops in progress was conducted during the summer of 1998. These visits focused on gaining in-depth qualitative knowledge about: (1) the workshops *per se,* including their intensity, types of activities, and quality (for which a content expert accompanied the SRI site visitor; see list of experts and their affiliations in Appendix D); (2) the participants, including their motivations for attending and their reactions to workshop activities; and (3) the workshop's leadership, including what the leaders hoped to accomplish and how and why they had arrived at the particular format and activities they were using.

Within scheduling constraints, sites were selected to vary in terms of disciplines, foci, geographic regions, and types of participants targeted. We also sought to include workshops of various lengths. Exhibit III-1 shows the workshops visited in 1998.

Exhibit III-1. UFE Workshops Visited in 1998

Name of Workshop	Focus of Workshop	PI's Institution	Length	Targeted Participants
The Art and Science of Model Building: A Workshop for College Mathematics Teachers	Content and teaching methods	University of Montana, Missoula	2 weeks	Mathematics faculty
Teaching Teachers to Teach Engineering (T^4E)	Teaching methods	United States Military Academy, West Point	1 week	Engineering faculty
Undergraduate Faculty Workshop in Computer Networks	Content	Michigan State University	2 weeks	Computer science, especially from HBCUs*
Undergraduate Faculty Program of the Institute for Advanced Study/Park City Mathematics Institute	Content, teaching methods, technology	Institute for Advanced Study, Princeton University	3 weeks	Mathematics faculty
Molecular Genetic Analysis Applied to Evolution, Ecology, and Systematic Biology	Content, laboratory techniques, technology, teaching methods	San Francisco State University	2 weeks	Biology faculty without expertise in molecular biology
Using Mathcad in Teaching Physical Chemistry	Content, technology, teaching methods	University of South Alabama, Mobile	1 week	Physical chemistry faculty
Innovative Physics Experiments for Beginning College Faculty	Laboratory methods, technology, teaching methods	Winston-Salem University	1 week	Physics faculty from HBCUs or Hispanic-serving institutions, nationally or from small colleges in the South
Image Processing Applied to Classroom Teaching	Technology	Foothill College, Los Altos, CA	1 week	Faculty from any discipline, especially community college faculty

* Historically Black Colleges and Universities.

In the spring and summer of 2000, we contacted the eight workshop PIs and many participants by telephone and/or e-mail to learn about participants' postworkshop experiences. Appendix F presents summary reports of the eight workshops visited in 1998 and information we learned from our follow-up contacts.

In the remainder of this chapter, we present summary observations from the eight workshop visits.

Workshop Focus

Consistent with findings based on quantitative data presented in Chapter II, the qualitative data indicate that most of the eight workshops dealt with transforming the classroom in more than one dimension. Seven of the eight were designed for faculty to change the content, lab techniques, and/or technology of their courses. Five of those seven also had a heavy focus on teaching methods; the eighth was dedicated almost entirely to teaching methods.

Workshop Length and Intensity

The durations of the workshops ranged from 5 days to 21 days. The appropriate length for a given workshop depended principally on its learning objectives and also, to an important degree, on the availability of speakers, specialized equipment, field sites, and classroom space. At least as important as those factors was participants' ability to fit the workshop into their schedules.

Almost all PIs whom we visited stated that they would prefer to hold longer workshops so that they could cover subject matter more indepth, engage in more hands-on learning activities, and/or have more time for participants to develop materials and plans for their own courses. However, PIs also indicated that they were aware that faculty's time was scarce and that most faculty had many other responsibilities during the summer. PIs who had experimented with various lengths of workshops indicated that if a workshop was too long, many potential participants were unlikely to apply.

Most workshop programs were of high intensity, with some evening sessions and/or demands for participants to fulfill in the evenings. Though in many cases tired by the end of their workshops, participants appreciated the high-intensity experience. The one nonresidential workshop we visited had considerably shorter hours than the residential workshops, to allow for long commutes.

Balance of Workshop Activities

In most workshops observed, the types of activities were well balanced, and participants were highly engaged at all times. The optimal balance included some lectures or presentations involving interaction with participants, programmed hands-on work, sufficient time for participants to work on materials for their own courses, and time for social interaction among participants. Where one of these elements was missing or short-changed, it was challenging for participants to get as much out of the workshop. However, clearly, balancing the various types of activities was easier for longer workshops.

Most workshops did not include many traditional lectures. There was one exception, in which, when faced with the decision of balancing various types of workshop activities versus covering more content in lectures, the PI decided to sacrifice modeling good teaching methods in favor of packing the workshop with the maximum content information. Although participants who were interviewed appreciated the breadth and depth of content, they indicated that their attention waned somewhat during some of the lectures.

In some cases, because of time limitations and/or workshop structure, the amount of time allowed for participants to work on their own projects was inadequate. In several of the shorter workshops, only about 5 hours was scheduled for this sort of work. Clearly, how long a workshop should allocate for participants' work depends on the difficulty of their tasks. For example, less time is needed to develop a simple experiment based on principles that participants already know, whereas more time is needed to employ complex new content and/or technology to develop an entire new module.

Workshops also varied in the amount of time they allowed for free-flowing interaction among participants. Such opportunities ranged from breaks between classroom or laboratory sessions to dinners to field trips with a mix of educational experiences and social interaction. Participants indicated that such interaction was very beneficial, stating that casual conversations often turned to topics that they had not previously considered but that were important to them.

Recruitment and Selection Strategies

Recruitment strategies included mailing information packets to department chairs and deans across the country, sending special brochures to selected audiences such as faculty at Historically Black Colleges and Universities (HBCUs), making personal contact with institutions in a state or region, placing notices or advertisements in professional association publications, and posting announcements on Web pages and Internet discussion lists. Participants also reported hearing about a workshop from earlier participants, receiving a special invitation from the PI, or being "tapped" by their deans or department chairs.

Participants often were required to submit a resume, letters of support or recommendation, a statement of reasons for wanting to attend, and, in some cases, a proposal for their workshop project. Although it is difficult to generalize from the few cases observed, it appears that the participants' stated reasons for wanting to attend were very important to the selection process.

Participant Demographics

Four workshops had from 13 to 15 participants, and the other four had from 21 to 28. The proportions of women ranged from 13% to 32%, with an average of 25% across all eight workshops (in contrast to 30% for all UFE workshops from 1991 to 1997, as reported by PIs).

Despite many PIs' attempts to recruit participants from underrepresented minority groups, few such faculty attended the workshops (NSF's definition of "underrepresented minority groups" includes African Americans/Blacks, Hispanics/Latinos, American Indians, Alaska Natives, and Pacific Islanders but *not* Asian Americans or Asians). Three workshops had no participants from underrepresented minority groups, and the rest had no more than three such participants. Of the 156 participants in all the workshops visited, 11 (7%) were from underrepresented minority groups.

When asked why so few faculty from underrepresented minority groups attended workshops, PIs indicated that they were unsure but offered the possible explanations that (1) there were relatively few such faculty to draw from; and (2) minority faculty tended to be relatively junior, so that, possibly, many were unable to attend workshops because of heavy responsibilities of other types, such as taking on extra work to pay off student loans or responsibilities concerning new families with young children.

In most workshops visited, participants began with similar levels of prior knowledge, according to PIs and site visitors' interviews with participants. Where prior knowledge levels were too different, some participants were not able to take advantage of part or most of the workshop. This was a particular problem at single-discipline workshops that included individuals not steeped in the discipline (e.g., K-12 teachers) and at multidisciplinary (not interdisciplinary) workshops, in which case participants tended to understand presentations that related to their own field but got relatively little out of presentations related to other fields.

The most important point that can be made about participants is that the vast majority of them were extremely eager to learn and to apply what they learned. In a few cases, their eagerness was robust in the face of some poor presentations or a less-than-optimum workshop schedules.

Presenters and Staff

Most of the time, presentation methods and materials were of very high quality. In a few cases, however, presenters (typically content experts) were not sufficiently skilled to tailor their presentations appropriately. For example, toward the beginning of a presentation by a research scientist, some participants indicated that they did not understand his use of several technical terms. When it became apparent that reaching an understanding would take some time, the scientist decided to continue with the rest of the presentation rather than resolve the definitions. As a result, about half the participants could not follow the rest of the presentation.

In several workshops, computer lab demonstrations were led by staff who were experts at the software but not skilled at handling an interactive demonstration. These sessions were somewhat chaotic at times, with some participants paying little attention to the presenter and others trying hard to follow.

Important factors in workshop success were the number and quality of staff providing assistance for participants as they worked on assignments or their own projects. In the best cases, there were sufficient staff who acted as mentors and were in constant contact with their participants throughout hands-on activities. In the worst case, one or two staff walked around the room, answering questions only when asked, rather than actively checking how participants were doing and assisting them. In one case, a site visitor sat with a participant who was supposed to be working on a project but who was completely lost, not asking for help, and not receiving any.

Follow-up Activities

PIs and participants were active in creating and pursuing follow-up activities. Examples originated by PIs included later sessions specifically to ensure that products were completed, critiqued, and disseminated; offer of a small matching grant for equipment purchases; continuing technical assistance by e-mail; and placement of completed exercises on a Web site. Scheduling formal follow-up activities could be somewhat difficult, however; one PI had to cancel his planned follow-up activity because no dates could be found during which a critical mass of participants could attend.

Summary

The eight workshops visited ranged from 5 to 21 days. PIs attempted to find a length for their workshops that would be sufficient for participants to learn the material and do hands-on work, but not so long as to be burdensome for participants. All of the eight workshops included presentations by staff and/or guest lecturers, hands-on activities (including time for participants to work on materials for their own courses), and opportunities for participants to interact with each other. Several workshops also included field trips.

Most workshop presenters did an excellent job, according to expert site visitors and participants interviewed. In general, the few exceptions to this rule were content experts who either gave formal lectures or were not able to adapt their presentations to the participants' level of knowledge. These situations typically were the only cases in which participants were not highly engaged.

A majority of the participants at the workshops visited were white males; across all eight workshops, about a quarter of participants were women. Participants from underrepresented minority groups constituted only 7% of all participants in workshops visited, despite PIs' attempts to recruit them.

Face-to-face follow-up activities proved somewhat difficult to schedule. Of the eight workshops visited, only one intended to schedule a formal follow-up activity, but it was cancelled. Informal gatherings at meetings were a more successful strategy and were held by three workshops. The most common type of follow-up was for participants and workshop staff to continue to communicate with each other during the year after the workshop, as participants continued to work on their materials.

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.

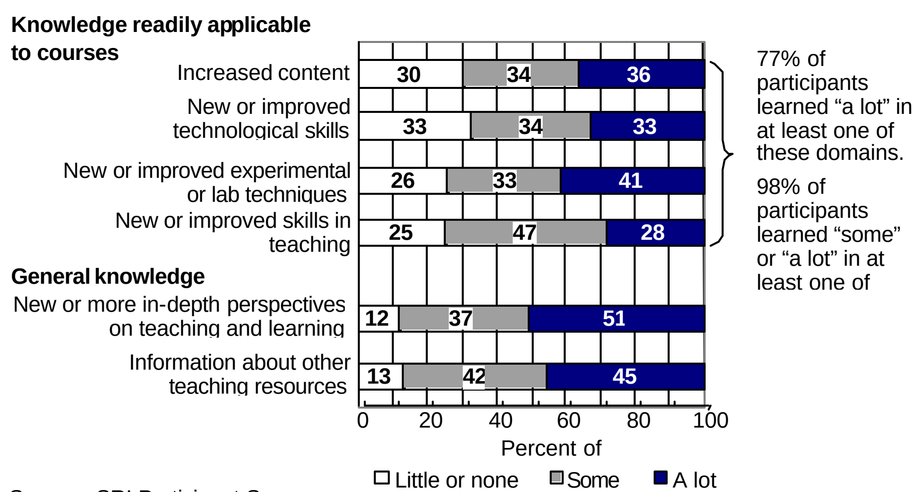
What Faculty Participants Learned

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.

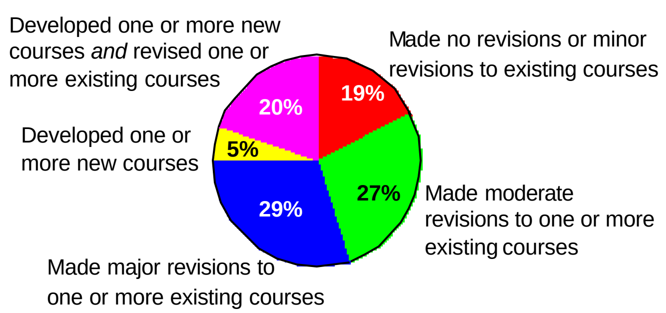
Institutions are supportive of SMET courses/labs for undergraduates that are state-of-the-art in their content and technology, incorporate best practices in their pedagogy, are accessible to all students, and are relevant to the real world.

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:

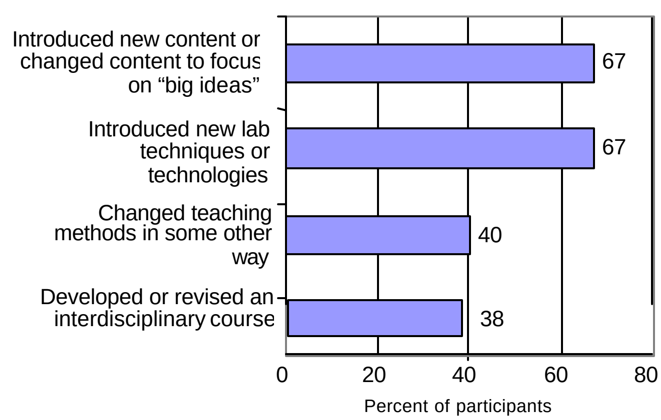
The 1991-1997 UFE workshops resulted in at least moderate revisions to approximately 20,800 courses,[4] as follows:

- **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:

As a result of UFE workshops, approximately

- **9,600 faculty made moderate or major revisions to the content of their courses.**
- **9,600 faculty made moderate or major revisions to their courses by introducing new lab techniques or new technologies.**
- **5,600 faculty made moderate or major changes in their teaching methods (besides introducing new lab techniques or technologies).**
- **5,500 faculty developed or revised interdisciplinary courses.**

8,000 faculty did both of these. (first and second items)

4,500 faculty did both of these. (second and third items)

3,600 faculty did all three of these.

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:

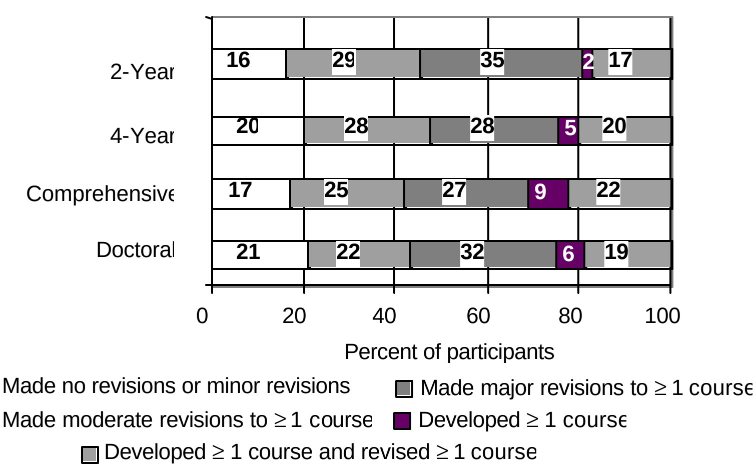
- A department chair at a state university who attended the Environmental Modeling workshop was in the process of redesigning the mathematics major. Currently, few students major in math, but the chair hopes that once the major has been revised to include more real-world math, the number of students 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

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

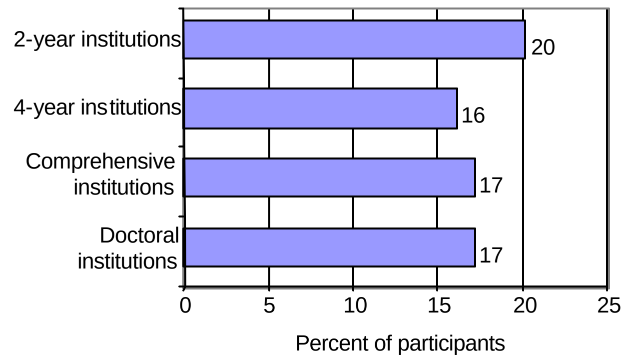


Source: SRI Participant Survey.

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.

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

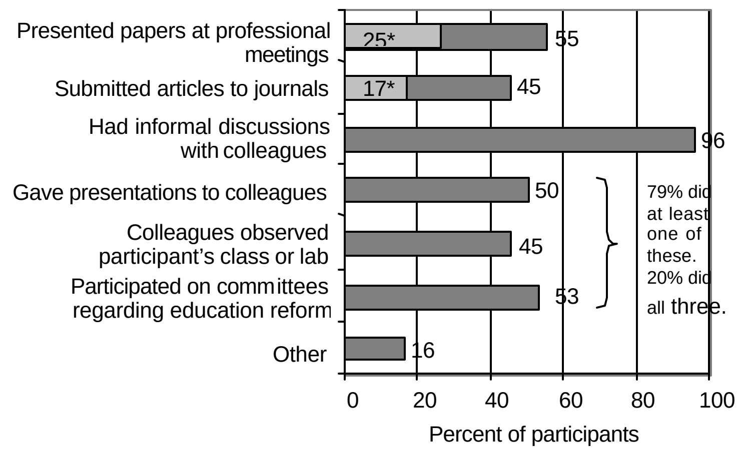
Desired outcomes:

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.

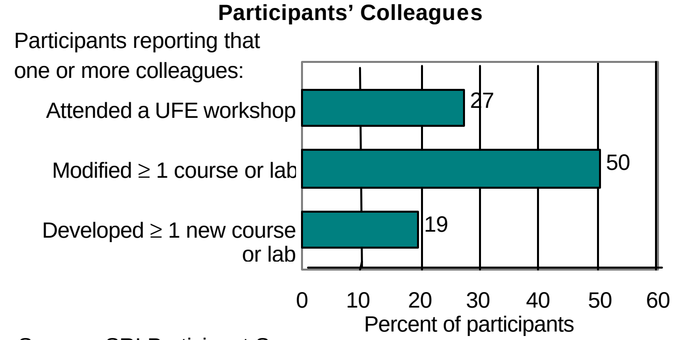
Exhibit IV-9. UFE Participants' Dissemination Activities



*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.

V. QUANTITATIVE FINDINGS FOR STUDENTS

Participants' professional enhancement and consequent development of new or revised courses means little if students do not take the courses or if the changes do not result in improved student learning. In this chapter, we examine how many students took participants' new or revised courses, and participants' estimation of students' performance in such courses.

Numbers of Students in Participants' New and/or Revised Courses

> Desired outcome: Institutions offer 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.

Telephone survey respondents who had made major revisions to existing courses or had developed new courses reported that, on average, 71 students completed such courses each year,[1] and respondents who had made at most moderate revisions to existing courses reported that, on average, 81 students completed their courses each year.

Respondents' estimates of the characteristics of students completing the new or revised courses are shown in Exhibit V-1. According to survey respondents who developed new courses or made major or moderate revisions to existing courses, approximately 46% of their students were female and 25% were from underrepresented minority groups. This percentage of females is slightly lower than the percentage of females among all undergraduate students in the United States in 1996 (52%), but the percentage of students from underrepresented minority groups is approximately the same as the national percentage (22%). (National Science Board, 2000, Appendix Table 4-32.)

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[1] Respondents were asked, "In all, approximately how many students have completed this course/these courses?" From the responses, we calculated yearly means.

Exhibit V-1. Gender, Race/Ethnicity, and Institutions of Students Affected by Changes

	New and/or Substantially Revised Courses (Percent)
Gender	
Male	54
Female	46
Race/Ethnicity	
Not underrepresented minority	75
Underrepresented minority	25
Institutional type	
Two-year colleges	29
Four-year colleges	28
Comprehensive universities	24
Doctoral institutions	19
HBCUs	4
Tribal colleges	<1

Source: SRI Participant Survey.

From these reports, conservative estimates of the numbers of students in UFE-affected courses are as follows:

By the end of 1999, approximately 1,850,000 students had completed courses that were developed or had undergone *major* revisions as a result of the 1991-1997 UFE workshops.[2] These included approximately:

- **857,000 females**
- **527,000 from underrepresented minority groups**
- **546,000 in 2-year colleges**
- **495,000 in 4-year colleges**
- **521,000 in comprehensive institutions**
- **288,000 in doctoral institutions.**

Approximately 965,000 additional students had completed courses that had undergone *moderate* revisions as a result of the 1991-1997 UFE workshops. These included approximately:

- **455,000 females**
- **232,000 from underrepresented minority groups**
- **279,000 in 2-year colleges**
- **287,000 in 4-year colleges**
- **147,000 in comprehensive institutions**
- **252,000 in doctoral institutions**.

[2] See Appendix E for calculations.

Impact of New and/or Revised Courses on Students

> Desired outcome:
>
> Undergraduate students, including those from underrepresented groups, gain proficiency in SMET, improve their attitudes toward SMET, and are prepared to apply SMET concepts to their lives.

Knowing that large numbers of students were in UFE participants' courses does not tell us *how* the changes that participants made in their courses affected students. Clearly, one of the participants' desired goals was that students improve their subject matter knowledge. But at least as important is that students acquire the skills and abilities they need in the modern world and workplace. Thus, in addition to knowledge of subject matter, our indicators of positive outcomes for students also included a positive change in students'

- ability to apply new knowledge
- problem-solving skills
- critical thinking skills
- ability to collaborate with others
- communication skills
- ability to use advanced technology
- understanding of the scientific method.

For each of these outcomes, we asked telephone survey respondents to compare the average level of knowledge and skills of students who completed the courses they had developed or modified as a result of participating in a UFE workshop with the knowledge and skills of students who completed similar courses they had taught previously. (If there was no valid basis for comparison, respondents were asked to so indicate.) According to faculty reports, students have benefited in a number of ways from the new or revised courses. Approximately four-fifths of respondents who developed new courses or made major or moderate revisions to existing courses reported that students who completed those courses had more in-depth knowledge of the subject area, better critical-thinking skills, better problem-solving skills, and better ability to apply new knowledge than students in similar courses the respondent had previously taught. From 17% to 20% of respondents rated their students' knowledge and skills along these dimensions as "*substantially* better."

Exhibit V-2 shows the associations of particular changes that participants made with particular student outcomes.[3,4] Every dimension of students' knowledge and/or performance was affected in some way by participants' changes. The larger the changes made by participants, the more likely they were to report improvements in students' outcomes. Respondents who made no changes or small changes were the most likely to report that there was no difference in their students' performance and the least likely to report that their students did substantially better. Conversely, participants who made major changes were the least likely to report that there was no difference and the most likely to report that their students did substantially better.

In terms of students' knowledge of subject matter, more than 80% of survey respondents who made major changes to content reported that their students did somewhat or substantially better after the changes. Forty-three percent of those who introduced new content and 34% of those who increased their focus on "big ideas" reported that their students did substantially better.

[3] The selection of the particular types of changes made by participants for Exhibit V-2 was made *a priori* on a theoretical basis, not on the basis of statistical significance.
[4] Participants who indicated that there was no valid basis for comparison (e.g., because they developed a course they had never taught before) are not represented in Exhibit V-2.

Exhibit V-2. Impact of Participants' Changes on Students' Knowledge and Skills*

Category of Students' Knowledge or Skills	Level of Participants' Changes in Courses	Percentage of Participants Reporting that Students' Performance** Was: Worse or the Same	Somewhat Better	Substantially Better
Knowledge of subject matter				
Participant introduced new content to courses ($p < .001$)	No or small changes	36	54	10
	Moderate changes	21	67	12
	Major changes	12	45	43
Participant increased focus on "big ideas" ($p < .001$)	No or small changes	29	60	11
	Moderate changes	24	60	16
	Major changes	16	50	34
Ability to apply knowledge				
Introduction of new content ($p < .001$)	No or small changes	26	64	11
	Moderate changes	22	60	17
	Major changes	13	54	33
Increased focus on "big ideas" ($p < .001$)	No or small changes	30	59	11
	Moderate changes	16	67	18
	Major changes	14	54	32
General changes in teaching methods ($p < .001$)	No or small changes	26	59	15
	Moderate changes	21	66	13
	Major changes	11	56	33
Problem-solving skills				
Increased focus on "big ideas" ($p < .001$)	No or small changes	32	57	11
	Moderate changes	18	66	16
	Major changes	15	58	27
Introduction of new lab techniques ($p < .001$)	No or small changes	32	56	12
	Moderate changes	23	66	11
	Major changes	16	58	25
Introduction of new technologies ($p < .001$)	No or small changes	29	57	14
	Moderate changes	23	64	13
	Major changes	16	60	24
General changes in teaching methods ($p < .001$)	No or small changes	30	58	13
	Moderate changes	20	69	11
	Major changes	14	56	30
Critical-thinking skills				
Increased focus on "big ideas" ($p < .001$)	No or small changes	31	59	10
	Moderate changes	19	65	16
	Major changes	12	54	34
Introduction of new lab techniques ($p < .001$)	No or small changes	30	56	14
	Moderate changes	18	66	16
	Major changes	9	60	31
Ability to collaborate with others				
Introduction of new lab techniques ($p < .001$)	No or small changes	36	45	19
	Moderate changes	31	49	20
	Major changes	17	39	43

Exhibit V-2. Impact of Participants' Changes on Students' Knowledge and Skills* (concluded)

Category of Students' Knowledge or Skills	Level of Participants' Changes in Courses	Percentage of Participants Reporting that Students' Performance** Was: Worse or the Same	Somewhat Better	Substantially Better
Ability to collaborate with others (continued)				
Introduction of new technologies ($p < .001$)	No or small changes	30	44	25
	Moderate changes	33	49	19
	Major changes	19	39	41
General changes in teaching methods ($p <.001$)	No or small changes	38	42	20
	Moderate changes	24	52	24
	Major changes	10	41	49
Communication skills				
Increased focus on "big ideas" ($p < .001$)	No or small changes	50	35	14
	Moderate changes	37	46	17
	Major changes	34	43	23
General changes in teaching methods ($p < .001$)	No or small changes	54	33	13
	Moderate changes	36	50	14
	Major changes	21	48	30
Ability to use advanced technology				
Introduction of new lab techniques ($p < .001$)	No or small changes	34	43	23
	Moderate changes	15	53	32
	Major changes	13	31	56
Introduction of new technologies ($p < .001$)	No or small changes	39	39	21
	Moderate changes	12	57	31
	Major changes	6	30	64
Understanding of the scientific method* **				
Introduction of new content ($p < .001$)	No or small changes	39	41	20
	Moderate changes	43	46	11
	Major changes	29	43	28
Increased focus on "big ideas" ($p < .001$)	No or small changes	48	40	11
	Moderate changes	33	52	15
	Major changes	29	41	31
Introduction of new lab techniques ($p < .001$)	No or small changes	47	40	13
	Moderate changes	41	44	15
	Major changes	27	46	26
General changes in teaching methods ($p < .001$)	No or small changes	43	46	11
	Moderate changes	43	42	15
	Major changes	25	40	35

*As reported by survey respondents.

**Students' performance after respondents made changes to their courses that they attributed the workshop, compared with the performance of students in similar courses respondents had taught before the workshop. Participants who indicated that there was no valid comparison group of students are not included.

***Does not include participants at mathematics w orkshops.

Participants who made some types of changes in their courses also reported that their students' skills and abilities improved in other dimensions. Approximately a third of respondents who made major changes by introducing new content, increasing focus on "big ideas," or generally changing teaching methods reported that their students' ability to apply new knowledge was improved substantially. From 24% to 30% of respondents who made major changes of these types or introduced new lab techniques or new technologies also reported a substantial improvement in their students' problem-solving skills.

Improvements in students' critical-thinking skills and communication skills were similarly associated with faculty's increased focus on "big ideas" and changes in their teaching methods. In addition, from 41% to 49% of respondents who made major changes in lab techniques, advanced technologies, or general teaching methods reported that their students' ability to collaborate was substantially improved. Not surprisingly, a majority of respondents who updated their lab techniques in major ways (56%) or introduced more advanced technology (64%) in their courses reported that their students' ability to use advanced technology was improved.

Lastly, students' understanding of the scientific method was improved by participants' introduction of new content, increased focus on "big ideas," introduction of new lab techniques, and general changes in teaching methods. Introduction of new technology into the classroom was not significantly associated with the percentage of participants reporting improvement in student performance in this category.

Respondents were asked to describe in their own words the changes in their students' performance. Typical answers were:

"My students are aware of concepts they weren't aware of, like evolution at a molecular level. They've become good at new technologies…. They now are able to see they can solve field problems using molecular techniques. They can ask academic questions they previously wouldn't have thought of. They are better prepared for the job market and grad school in molecular biology."

"The students are more interested in what they are doing. They are working together as a team and seem to be understanding and getting concepts that other students prior to changing the class could not understand."

"They do more in-depth thinking about the problem—understanding the solution and how it answers the question."

"They understand differential equations for what they mean, rather than what they look like. They also better understand subject matter from previously taught courses. [The changes I made] integrated their previous knowledge so they can better grasp concepts."

"My students' application of calculus to real-world problems became second nature to them."

"Students were able to learn new techniques and work with new instrumentation, which gives them a background that they can use in their future research."

"They're better prepared for technology they're likely to encounter in the professional world."

"They communicate and cooperate with each other better. They're more familiar with computers."

"The attendance is much better, and they do better on the communication aspect of statistics."

"[The changes I made] gave them the opportunity to develop projects that applied their learning. They had to report their products in writing and orally, which improved communication skills and overall skills."

Could faculty have overreported the extent of the impacts on their students? We cannot discount that possibility. We attempted to minimize positive exaggerations by separating questions about student performance from questions about changes faculty had made (and, because the interview was conducted by telephone, respondents could not go back to check what they had answered to previous questions). However, it is possible that faculty who have put substantial work into developing or revising courses may be more likely than others to believe that their work has paid off in terms of student performance. Assessing the validity of faculty's beliefs about student performance was not within the scope of this study.

Summary

We estimate that, by 1999, more than 1,850,000 students had completed courses that were developed or had undergone major revisions as a result of the UFE workshops held in 1991-1997. Approximately 965,000 additional students had completed courses that had undergone *moderate* revisions as a result of the workshops. Slightly fewer than half of these students were female, and approximately one-quarter were from underrepresented minority groups. About the same percentages of students (28%) were in 2-year, 4-year, and comprehensive institutions, and about 11% were in doctoral institutions.

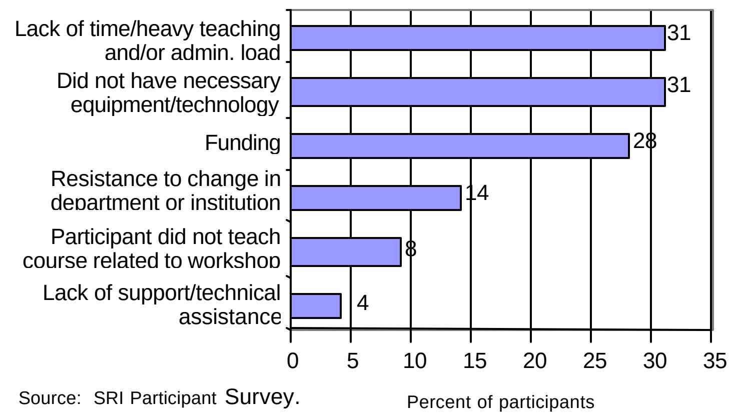
Faculty reported that students in their revised or modified courses performed better along of number of dimensions than comparable students in traditional courses. In addition to improvements in content knowledge, faculty cited improvements in students' abilities to solve problems, think critically, communicate, collaborate, use technology, and understand the scientific method. The greater the changes faculty made to their courses, the more likely they were to report substantial improvement in their students' performance. Because student performance was not observed or measured by third parties, the extent to which faculty may have overreported the improvements in their students' performance is not known.

VI. BARRIERS TO AND REASONS FOR WORKSHOPS' SUCCESS

Barriers Encountered When Developing Courses or Majors

The road to developing or revising courses or majors was not always smooth. More than half (56%) of participants who did so had to surmount some type of barrier. As shown in Exhibit VI-1, the most common barriers included lack of time (often due to heavy teaching or administrative loads), lack of equipment or technology, and lack of funding. Nevertheless, the vast majority of participants overcame whatever barriers they faced and went on to develop or revise courses or develop programs or study.

Exhibit VI-1. Barriers Encountered by Participants



Source: SRI Participant Survey.

Reasons for UFE Workshops' Success

Despite the presence of barriers for so many participants, approximately 80% of participants made at least moderate changes to their courses or developed new courses. What accounts for this high success rate of the UFE workshops? We addressed this question in two ways. First, we used multivariate analyses to investigate the associations between a positive outcome and various factors. Second, we examined participants' own answers concerning why they attended the workshops and the features of workshops that they felt contributed the most to what they got out of the workshop.

Statistical Associations between Workshop Characteristics and Success

Our indicator of a "successful workshop" was participants' making at least moderate changes to their existing courses and/or developing one or more new courses. We examined the association of workshop characteristics with this outcome, controlling for characteristics of participants and characteristics of their institutions. Exhibit VI-2 shows the variables included in various models we estimated.

Exhibit VI-2. Variables Included in Models

Characteristics of Workshops	**Participants' Characteristics (Control)**	**Participants' Institutions (Control)**
Length of workshop (days) Workshop focus • Included content • Included teaching methods • Included lab techniques • Included new technology Materials worked on at workshop • Textbooks • Lecture notes/handouts • Problem sets, project descriptions, or lab exercises Completion of materials at workshop Participant gave presentations Type of follow-up • Formal session • Informal gathering • Participant site tested materials Participant received technical assistance from workshop PIs and/or staff	Years on faculty at institution Academic rank Tenure status Discipline Motivation for attending workshop • To develop or revise a course • To modify teaching methods • To become a better teacher • To increase the use of labs/improve labs • To learn to use new technology • To develop a program of studies • To keep current in subject area • For personal enrichment Participant's discipline • Astronomy • Chemistry • Computer Science • Engineering • Geosciences • Life Sciences • Mathematics • Physics • Social Sciences • Non-SMET • Other	Institutional type • 2-year • 4-year • Comprehensive • Doctoral • HBCU

Ultimately, after learning that none of the control variables had statistically significant associations with revising or developing courses, we estimated a model containing only the workshop characteristics.[1] Exhibit VI-3 presents the association of each variable with a participant's probability of revising an existing course and/or developing a new course. Variables with statistically significant associations are

[1] We used logistic regression to estimate a participant's likelihood of developing one or more new courses or making at least moderate changes to existing courses. Workshop characteristics were chosen for their theoretical interest and left in the model regardless of their statistical significance. We estimated the model with the workshop characteristics and sets of control variables. Regardless of the model's specification, none of the control variables were significantly associated with the dependent variable, and the associations of the workshop characteristics remained substantially the same.

We also estimated models of participants' likelihood of making *major* changes to one or more existing courses and/or developing one or more new courses. The results were substantially the same as those reported in the text.

presented first in each group of variables, and the level of significance is indicated by one or two asterisks.

As shown in the exhibit, participants who attended workshops that included a focus on teaching methods and/or new technology were considerably more likely to revise and/or develop one or more courses after the workshop. The former variable increased participants' probability of revising and/or developing one or more courses by 15 percentage points, and the latter variable increased the probability by 13 percentage points.[2]

Exhibit VI-3. Associations of Variables with Participants' Probability of Revising/Developing at Least One Course

	Change in Probability of Revising/Developing at Least One Course
Length of workshop (in days)	0.014*
Focus of workshop	
Included teaching methods	0.151**
Included new technology	0.131**
Included new content	0.005
Included lab techniques	-0.047
At workshop, participant:	
Worked on lecture notes/handouts	0.145**
Worked on problem sets, project descriptions, or lab exercises	0.153**
Worked on textbooks	-0.024
Gave presentation at workshop	-0.055
Completed materials at workshop	0.029
Participant's follow-up activities	
Site testing materials at own campus	0.062**
Received technical assistance from PI or workshop staff	0.050**
Formal follow-up session(s)	0.011
Informal gathering(s)	0.015

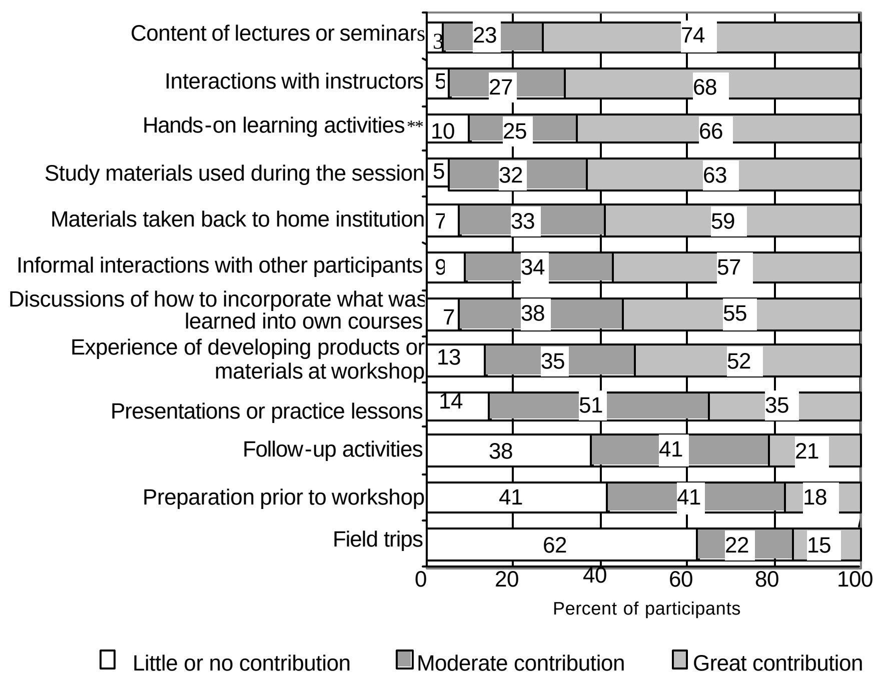
*$p < .05$
**$p < .005$

Working on lecture notes and/or course handouts at the workshop and working on problem sets, project descriptions, or lab exercises also were associated with participants' increased probability of revising or developing one or more courses, with an increase of approximately 15 percentage points for each variable. Completing the materials at the workshop was not important, but it was important that participants *continued* to work on materials at their own campuses and that they received the technical assistance they needed. Site testing workshop materials at their own campuses was associated with an increase of 6 percentage points in participants' probability of revising or developing at least one course, and receiving technical assistance from the workshop PI or staff was associated with an increase of 5 percentage points. Contrary to the conventional wisdom, neither formal follow-up sessions nor informal follow-ups showed associations with participants' probability of revising or developing courses.

Participants' Perceptions of Importance of Workshop Features

As stated earlier, we also asked participants themselves what features of workshops

Exhibit VI-4. Participants* Perceptions of Workshop Features That Contributed to the Usefulness of the Workshop



* Includes only participants who developed ≥ 1 or made major revisions to ≥ 1 course.
**Other than developing products or materials. Source: SRI Participant Survey

[2] Unfortunately, the changes in probability presented in the exhibit are *not* additive. However, we present coefficients that can be used to calculate the changes in probability associated with several variables at a time and a formula for calculating such changes in Appendix E.

they felt had contributed most to what they got out of the workshop (see Exhibit VI-4). Among participants who made *major* changes to existing courses and/or developed new courses, the three most highly valued features of the workshops (cited as making a "great contribution" by 66% or more of respondents) were the content of the lectures or seminars, the interactions with instructors, and the hands-on learning activities. Five other features were cited as having made a great contribution by more than half of respondents (see Exhibit VI-4). Consistent with the findings of our multivariate analysis, relatively low ratings were given to presentations and follow-up activities. Similarly, most participants did not feel that preworkshop preparation or field trips were important features.

Participants' Motivation as a Factor in Workshops' Success

In interpreting these findings, it is important to bear in mind that the UFE participants were not a random sample of all U.S.SMET faculty. In general, they were a highly motivated group. In fact, when asked in an open-ended question why they attended the workshops, 80% of respondents who were queried gave reasons that related to changes they wanted to make in their courses. Thus, these findings may not apply to all SMET faculty professional development.

Why some survey respondents attended UFE workshops:

"I was looking for ideas to revise the course and looking for ideas and materials to start revising."

"To get information that I needed to develop a new course and also information that would help me prepare my students for grad school."

"To broaden my knowledge and to learn new things in my research and to incorporate materials and revise some courses."

"***To develop some active-learning strategies and to add realistic content to my classes."***

Summary

More than half of UFE participants who developed or revised courses overcame some type of barrier to do so. The most commonly reported barriers concerned lack of time to work on courses because of a heavy teaching and/or administrative load, not having the necessary equipment or technology, and lack of funds. Other faculty's resistance to change was not a commonly reported problem.

Neither characteristics of participants nor those of their institutions were associated with their likelihood of revising or developing a course after a UFE workshop. Characteristics of the workshop that were found to be important were: its duration, the inclusion of teaching methods and/or new technology, and activities that included work on lecture notes, handouts, problem sets, project descriptions, and/or lab exercises. It was not important whether participants completed their materials at the workshop. Neither was it important whether participants took part in face-to face follow-up activities. In contrast, site testing materials at their home institutions and receiving technical assistance from the workshop PI or staff were associated with an increased probability of developing and/or revising courses after the workshop.

VII. CONCLUSION

The ultimate purpose of a summative evaluation is to judge whether a program was a success or a failure. However, before a judgment can be made, clear criteria for success must be set. Earlier in this report, we enumerated two sets of criteria by which UFE could be judged: (1) the goals that the UFE program set for itself, as described in program announcements; and (2) the broader NSF goals, the criteria for which were established by using the indicators for the outcomes developed by SRI (see Introduction and Appendix A). The former focused principally on whether workshops were held in all fields, how many participants were served, and what participants learned at the workshops. Those outcomes, although necessary, are intermediate ones. The latter criteria focus on more final outcomes, such as whether participants developed new courses or changed their existing courses after the workshops, the extent to which the new or revised courses had received formal approval, and the impact of participants' course changes on their students' performance.

All the criteria for success discussed in the preceding paragraph can be subsumed by two questions of equal importance: *Did the UFE program achieve its goals? Was the UFE program an effective strategy for achieving NSF's broader goal of transforming undergraduate education generally?*

The first question can be answered easily with a firm "yes." The UFE program held more than 750 workshops over a 7-year period, reaching more than 14,400 undergraduate faculty from all types of institutions. Eighty-one percent of them went on to make at least moderate changes to their own courses or to develop new courses. Two-thirds of participants introduced new content to their courses and/or changed the content to focus on "big ideas," (i.e., unifying concepts). Two-thirds introduced new laboratory techniques or new technologies, and two-fifths changed their teaching methods in some other way. Most changed their teaching in some combination of the three ways. Most also felt that the changes they had made resulted in improvement in their students' academic performance, as well as in general skills needed for the modern world, such as problem solving, critical thinking, communication, collaboration, and ability to use technology.

Judging whether the UFE program was an effective strategy to meet NSF's goals of transforming undergraduate education is somewhat more difficult because benchmarks are less clear, but again, we believe the answer is "yes." The 14,402 participants who attended UFE workshops represent approximately 1 in 22 SMET faculty in the United States.[1] Of these faculty, 11,666 participants made moderate or major changes to at least one course and/or developed at least one course, *and attributed the revisions or changes to the UFE workshop.* Such participants represent 1 in 27 SMET faculty in the United States. More specific changes were as follows:

Area of change	Number of faculty	Ratio to faculty in the United States
Content	9,600	1 in 33
Technology or lab techniques	9,600	1 in 33
Other changes in teaching methods	5,600	1 in 56

The proportion of U.S. students affected by classroom changes made because of UFE is still greater. Between 1991-92 and 1998-99, approximately 1,850,000 students—1 in 22 students nationally—completed courses that 1991-1997 UFE participants had developed or had revised in *major* ways, and another 965,000 students—1 in 43 nationally—completed courses to which UFE participants had made *moderate* revisions. This total of approximately 2,815,000 students represents 1 in every 15 students in the United States over the 8-year period covered.[2] According to faculty reports, approximately 46% of these students were female, and 25% were from underrepresented minority groups.

The UFE program also provides some evidence that workshops can affect undergraduate education beyond the participants' own courses. First, it is noteworthy that 17% of participant survey respondents indicated that, because of the workshop, they had gone on to develop or redesign a new program of study for a major. As stated in Chapter IV, if we estimate very conservatively that many of those faculty were working together and calculate that only one program was developed or revised for each two participants working on a program of study, it would still mean that 1,200 programs of

[1] According to National Science Board (2000), Appendix Table 4-46, there were 315,500 SME&T faculty in the United States in 1997.

[2] From National Science Board (2000), we estimate that there were approximately 41,442,000 undergraduate students enrolled in the United States from 1991-92 through 1998-99. See calculation in Appendix E.

study were developed or revised. Additional evidence that the change brought about by the UFE was broader than simply modifications of individual courses is the fact that 38% of survey respondents—approximately 5,500 faculty between 1991 and 1997—worked on *interdisciplinary* courses. More than three-quarters of all courses developed by participants became institutionalized, having received formal approval (if needed) from the department, school, or college by the time of the survey. Thus, the UFE program, which did not target systemic reform as such, resulted in considerable systemic change.

Second, UFE participants' dissemination efforts appear to have been very fertile; slightly more than half of survey respondents reported that such sharing resulted in their colleagues' developing or revising their own courses. Even if only one colleague of each of these participants made such changes, this would add more than 7,300 faculty, so that altogether more than 19,000 faculty revised or developed courses because of UFE. This represents 1 in 17 SMET faculty in the United States. We doubt that many, if any, other programs targeted at undergraduate education can make a similar claim.

Not only did the UFE program bring about considerable changes in undergraduate education, it did so in a cost-effective way. Between 1991 and 1997, awards totaled $60,963, 917. This number translates to approximately $5,200 for each of the 11,666 participants who made at least moderate changes to his or her courses. Taking into account the estimated 7,300 colleagues who also made changes, the cost per faculty member drops to approximately $3,200.

In terms of cost per student, we can take into account only those who attended *participants'* courses (not those of participants' colleagues). Nevertheless, for courses developed or revised by participants, the cost per student through 1998-99 was $22, and this cost will decrease as more students attend the courses.

In our judgment, the UFE program was successful in accomplishing its own goals, as well as helping to accomplish NSF's undergraduate education goals, at a relatively low cost. What we have learned about UFE does not stop with this conclusion, however. This evaluation also was able to document some barriers to change as well as factors associated with workshop success.

Heavy teaching and/or administrative loads, lack of funding, and lack of equipment and technology were the most often cited barriers to developing or revising courses or labs. These factors have been mentioned as barriers to change elsewhere. For example, the former two were mentioned by more than half of Institution-wide Reform (IR) PIs surveyed as part of an evaluation of that program.[3] In contrast to a finding of the IR evaluation, few UFE participants indicated that faculty or institutional resistance was a barrier to change for them. This result points to an advantage of the UFE strategy: participants were able to work on their own courses, over which they had control, and win their colleagues over by discussing or demonstrating their own successes.

Every principal investigator wants to design his or her workshop to maximize its success, but to date there has been no hard evidence of what factors are associated with success. This evaluation found that participants' likelihood of designing or revising courses after a workshop increases when a workshop includes a focus on teaching methods and when participants work on materials for their own courses or labs at the workshop. The probability of designing or revising courses is not increased by completing materials at the workshop; however, it is increased when participants continue to work on the materials after the workshop, as well as when they receive continuing technical assistance from workshop staff. Thus, NSF might want to suggest that Principal Investigators include these features in their future development activities.

We acknowledge that our findings are based on analyses of data that include almost exclusively faculty who were willing and eager to reform their courses. They may not apply to faculty who are content with their existing courses or are resistant to change. Nevertheless, the vast majority of undergraduate faculty who attend professional development activities of any kind—not just UFE activities—do so of their own volition. Therefore, we believe the findings apply broadly to faculty development activities.

[3] In SRI's evaluation of NSF's Institution-wide Reform Initiative (in final preparation for NSF publication).

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Appendix A

EVALUATION OF THE UNDERGRADUATE FACULTY ENHANCEMENT PROGRAM

DESIRED OUTCOMES AND INDICATORS

The numbers in parentheses are used to cross-reference the indicators with items in the survey (see Appendix C).

A. Desired Outcomes for Faculty

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. Indicators are:

Proportion of participants:

- Developing/revising courses with content that is current and relevant to the real world. (A1)
- Developing/revising courses that incorporate best practices (e.g., providing opportunities for students to engage in open-ended problem solving, developing hypotheses, designing and carrying out experiments to test hypotheses). (A2)
- Developing/revising courses to incorporate new experimental techniques. (A3)
- Developing/revising courses to incorporate state-of-the-art technology. (A4)
- Developing/revising interdisciplinary courses. (A5)
- Developing new majors or plans of study. (A6)
- Teaching courses that were developed/revised. (A-7)
- Collaborating with other faculty to develop or revise their courses. (A8)
- Attending subsequent workshops/seminars. (A9)
- Communicating with experts in their field and other scientists subsequent to UFE workshops. (A10)
- Engaged in professional development activities that promote best practices or increase knowledge of content, technology, or experimental techniques (e.g., workshops, institutes, conferences). (A11)
- From underrepresented groups. (A12)

Extent to which participants report:

- learning new content, teaching methods, technologies, and/or experimental techniques. (A13)
- implementing concepts and skills learned in UFE activities. (A14)
- attendance at subsequent professional development activities was influenced by their UFE participation. (A15)
- implementing concepts and skills learned at professional development activities subsequent to UFE workshop. (A16)
- Participants from underrepresented groups report that UFE workshops are relevant to their needs. (A17)

B. Desired Outcomes for Students

Students, including those from underrepresented groups, gain proficiency in SMET, improve their attitudes toward SMET, and are prepared to apply SMET concepts to their lives. Indicators are:

Numbers of students completing courses that were developed/revised as a result of UFE and that:

- Reflect best practices (e.g., providing opportunities for students to engage in open-ended problem solving, developing hypotheses, designing and carrying out experiments to test hypotheses). (B1)
- Incorporate content that is current and relevant to the real world. (B2)
- Incorporate advanced technologies. (B3
- Incorporate state-of-the-art experimental/lab techniques. (B4)

Extent to which students completing the new/revised courses:

- Achieve high grades in such courses. (B5)
- Take follow-on courses. (B6)
- Report that such courses are relevant and motivating. (B7
- Report having confidence in applying SMET concepts. (B8)

Extent to which faculty report that students in new/revised courses showed improvements in:

- SMET knowledge among students enrolled in new/revised courses. (B9)
- Problem-solving skills among students enrolled in new/revised courses. (B10)
- Communication skills among students enrolled in new/revised courses. (B11)
- Ability to apply new knowledge among students enrolled in new/revised courses. (B12)
- Critical-thinking skills among students enrolled in new/revised courses. (B13)
- Ability to collaborate among students enrolled in new/revised courses. (B14)
- Ability to use advanced technology among students enrolled in new/revised courses. (B15)
- Understanding of the scientific method among students enrolled in new/revised courses. (B16)

C. Desired Outcome for Learning Infrastructure

Institutions offer 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. Indicators are:

Number of SMET courses that were developed/revised as a result of UFE workshops and that:

- Incorporate current, relevant content. (D1)
- Integrate advanced technology. (D2)
- Incorporate best practices. (D3)
- Integrate inquiry-based labs. (D4)
- Experts judge that new/revised courses/labs reflect state-of-the-art SMET content and technology and best practice in pedagogy. (D5)

- Faculty and administrators report that, compared with previous courses, new/revised lower-level courses offer better preparation for upper-level courses in all SMET areas. (D6)
- Faculty and administrators report that, compared with previous courses, new/revised courses are more relevant to the current labor market. (D7)
- Students rate new/revised courses/labs as more interesting, less intimidating, and more relevant to the real world (compared with previous students' ratings of commensurate traditional courses/labs). (D8)
- Underrepresented students report that new/revised courses take their needs into account. (D9)

D. Desired Outcome for Collaboration

SMET Faculty collaborate with one another and with other experts in their fields. Indicators are:

Extent to which UFE workshops have been collaborative efforts between various types of institutions. (E1)

Extent to which participants:

- Establish new research or teaching collaborations with colleagues. (E2)
- Communicate with other participants or workshop PIs following UFE workshops regarding content, teaching practices, or technology. (E3)
- Communicate with experts in SMET fields. (E4)
- Report that communications they have engaged in as a result of UFE workshops have had value for their careers. (E5)
- Report team teaching courses that were developed/revised as a result of UFE workshops. (E-6)
- Extent to which courses/labs developed as a result of UFE workshops are interdisciplinary. (E7)

E. Institutionalization of Reform

Reforms in undergraduate SMET courses are sustained. Indicators are:

Extent to which courses developed/revised as a result of UFE workshops:

- Have had formal departmental and program approval. (F1)
- Continue to be offered to date. (F2)

Institutions plan to continue to offer new/revised courses/labs. (F3)

F. Desired Outcome for the Broader Academic Community

Knowledge and skills from UFE workshops are disseminated widely. Indicators are:

Extent to which participants disseminate what they learned in UFE workshops by:

- Publishing in professional journals and/or making presentations at conferences, seminars, or workshops. (G1)
- Communicating informally with colleagues. (G2)
- Demonstrating or modeling new teaching strategies or technology for colleagues. (G3)
- Participating in department and/or campus committees on curricular change and/or reform. (G4)

Extent to which nonparticipant faculty have developed new courses or revised old courses and attribute changes to participants' influence. (G5)

Extent to which nonparticipant faculty have attended UFE workshops because of participants' influence. (G6)

Appendix B

SURVEY METHODOLOGY

The Universe

The universe consisted of participants from 1991 to 1997. The following table shows the numbers of workshops in each year, the numbers of workshops that reported data to NSF, and the numbers of participants they reported. The final column shows the estimated total number of participants.

Exhibit B-1. Numbers of UFE Workshop Participants, by Year

Year	Number of Workshops Funded	Number of Workshops Reporting Data	Number of Participants Reported by PIs	Mean Number of Participants per Workshop Reported by PIs	Estimated Number of Participants for all Workshops, Adjusted for Missing Data*
1991	54	49	1,182	24	1,303
1992	89	88	2,243	25	2,268
1993	112	74	1,897	26	2,871
1994	113	106	2,308	22	2,460
1995	140	129	3,016	23	3,273
1996	124	118	3,231	27	3,395
1997	125	118	3,630	31	3,845
Total			17,507		19,416

*Imputed by using the mean number of participants as reported by PIs for that year.

To check the extent to which the participants reported by PIs for all years contained duplicate counts and/or participants who were not undergraduate faculty, we examined all participant lists that NSF furnished for 1996 and 1997. We found that:

- Approximately 10% of the participants reported by the PIs were not undergraduate faculty (many were high school teachers; some were preservice teachers; others were from industry; etc.).
- 6.22% of the participants reported in 1996 and 6.39% of the participants reported in 1997 were duplicated names (for an average of 6.3% across the two years).
- 6.10% of the 1997 participants had also participated in at least one workshop in 1996.

Using these figures, we estimated the number of unique faculty participants for each year and across all years as shown in Exhibit B-2:

Exhibit B-2. Nonduplicated Faculty Participants, by Year								
	1991	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**Total**
Total participants (using adjusted figures from Exhibit B-1)	**1,303**	**2,268**	**2,871**	**2,460**	**3,273**	**3,395**	**3,845**	**19,416**
Nonfaculty at 10.01%	130	227	287	246	328	340	385	1,944
Within-year duplicates at 6.30%	82	143	181	155	206	214	242	1,223
Eligible, nonduplicates within each year	**1,090**	**1,898**	**2,403**	**2,059**	**2,739**	**2,842**	**3,218**	**16,250**
Cross-year repeats*								
Repeats from previous year		66	116	147	126	167	173	795
Repeats from 2 years previous			53	93	117	100	134	497
Repeats from 3 years previous				43	74	94	80	291
Repeats from 4 years previous					34	59	75	168
Repeats from 5 years previous						27	47	75
Repeats from 6 years previous							22	22
Eligible and nonduplicated faculty	**1,090**	**1,832**	**2,234**	**1,777**	**2,388**	**2,394**	**2,686**	**14,402**

*We assumed that the probability that workshop participants will participate in another workshop in the following year is 6.1%, and then decreases by 20% per year.

Exhibit B-3 shows demographic characteristics of 1991-1997 UFE participants as reported by PIs to NSF, and the percentages attending workshops in various disciplines.

Exhibit B-3. Characteristics of UFE 1991-1997 Participants	
	Percent of 1991-1997 Participants
Gender	
Male	70
Female	30
Race/ethnicity	
Nonminority	84
Minority	16
Type of institution	
2-year	23
Baccalaureate	28
Comprehensive or Doctoral	33
(of the above categories, Historically Black)	5
Other (nonuniversity)	15
Discipline of workshop	
Astronomy	1
Chemistry	10
Computer Science	7
Engineering	13
Geosciences	3
Interdisciplinary	14
Life Sciences	8
Mathematics	28
Physics	10
Social Sciences	5

The Sample

As reported in Chapter I, we included only individuals who had attended UFE workshops during 1996 or 1997. NSF awards supported 124 and 125 workshops in 1996 and 1997, respectively, and we estimate that a total of 5,887 faculty[1] attended them. NSF supplied us with hard-copy lists of participant names for 76 workshops from 1996 and for 72 workshops from 1997. These lists contained 1,429 and 1,501 names, respectively, for a total of 2,930 names.

From these lists, we randomly selected 1,786 names and began telephone interviews in the spring of 1999. At the close of the academic year, we had completed interviews with 602 participants. Four hundred seventy-three sample members were deemed unreachable (because their numbers had been disconnected, their current whereabouts were unknown, etc.), and another 183 respondents were deemed ineligible (because they were not, or were no longer, undergraduate faculty or indicated that they had not attended the seminar).

This left 498 sample members to attempt to reach in the fall. After lack of success in reaching many of them, this part of the sample was deemed unreachable. To obtain an adequate number of respondents for our analyses, we then replenished the sample with another 1,174 names, again randomly selected from the participant lists.

Although we are not able to characterize the total sample of 2,930 participants in terms of their demographic characteristics or type of institution because the hard-copy lists did not contain such information, we can describe them in terms of their disciplines. Exhibit B-4 shows these disciplines.

Exhibit B-4. Disciplines of UFE Participants Selected for Telephone Survey Sample

Discipline	Percent of Sample
Astronomy	0
Chemistry	12
Computer Science	9
Engineering	13
Geosciences	2
Interdisciplinary	20
Life Sciences	8
Mathematics	28
Physics	6
Social Sciences	1

Of the telephone interviews attempted, a total of 1,118 interviews were completed, that is, 38% of our overall sample, and 19% of the total participants in 1996 and 1997 workshops. The most frequent reasons for noncompletion of interviews were: (1) we were unable to reach the sample member after multiple attempts (44%), and (2) the

[1] This number is calculated from the total number of nonduplicated faculty who attended workshops in 1996 (2,842) plus the nonduplicated number of faculty who attended workshops in 1997 minus faculty who were duplicates from 1997 (3,218-173=3,045).

sample member was ineligible (i.e., faculty who teach undergraduates- 14%). Only 4% of the sample members refused to complete the interview. Thus, 48% of sampled eligible faculty were unreachable or refused. Because of cost and technical considerations, we did not perform a separate study to analyze the reasons why they did not respond.

Characteristics of the 1,118 participants who were interviewed are shown in the second column of Exhibit B-5. The third column shows the characteristics of the universe of 1991-1997 participants, which are similar in most respects to the population of interviewed participants.

Exhibit B-5. Characteristics of Telephone Survey Respondents and 1991-1997 UFE Participants

	Percent of Telephone Survey Respondents	Percent of 1991-1997 Participants*
Gender		
Male	67	70
Female	33	30
Race/Ethnicity		
Minority, including Asian Americans and Asians	15	16
(Underrepresented minority)	6	8**
Type of institution		
2-year	23	27***
4-year	43	33***
Comprehensive	22	24***
Doctoral	12	16***
Discipline of workshop		
Astronomy	0	1
Chemistry	13	10
Computer Science	9	7
Engineering	11	13
Geosciences	2	3
Interdisciplinary	18	14
Life Sciences	12	8
Mathematics	27	28
Physics	6	10
Social Sciences	2	5

*Source: DUE Database unless otherwise noted.
**Source: Estimated from hard-copy survey responses of 1996 and 1997 workshop PIs.
***Percentage of undergraduate faculty participants only. Percentages for comprehensive and doctoral institutions were estimated from 1996 and 1997 DUE data (before those years, DUE's survey did not break down "Universities" into these two types of institutions).

Other characteristics of the respondents for which there are no comparison data available from the DUE PI surveys are presented in Chapter I.

Sample Weighting for Analyses

We compared results on various outcomes (e.g., whether respondents developed or revised a course after the workshop) by using data that were weighted for gender, minority status, type of institution, and discipline of workshop and found no significant differences in the results. Exhibit B-6 shows how small the differences in outcomes were when using weighted and unweighted data. Because results did not differ significantly, results presented in this report use unweighted data.

Exhibit B-6. Percentages of Participants Making Postworkshop Changes to Courses Using Unweighted Data and Data Weighted in Selected Ways

Participants' Postworkshop Changes to Courses	Using Unweighted Data	Using Data Weighted for Type of Institution	Using Data Weighted for Discipline of Workshop
Little or no revisions	18.4	18.2	18.2
Moderate revision to ≥ 1 course	26.9	26.7	27.4
Major revision to ≥ 1 course	30.0	30.2	31.1
Developed ≥ 1 course	5.4	5.4	5.1
Developed and revised ≥ 1 course	19.7	19.6	18.2

Appendix C

ASSESSMENT OF THE NATIONAL SCIENCE FOUNDATION'S UNDERGRADUATE FACULTY ENHANCEMENT PROGRAM

PARTICIPANT TELEPHONE SURVEY INSTRUMENT

Hello. My name is __________________. I'm calling on behalf of SRI International.

SRI is conducting a survey for the National Science Foundation as part of an evaluation of NSF's Undergraduate Faculty Enhancement Program. It is my understanding that you attended a UFE workshop about [title of workshop] held by [PI NAME] in the [month] of 199[6 or 7]. Is that correct?

IF R ANSWERS 'NO':

PROBE FOR CORRECT INFORMATION. ASK: Did you attend any workshop about [title of workshop] during [season/year]? IF R STILL ANSWERS 'NO' SAY: I'm sorry, my information must be incorrect. Thank you very much. AND END THE CALL.

IF R ANSWERS 'YES':

This survey is being conducted for the National Science Foundation as part of its efforts to learn about professional development for undergraduate faculty. The survey is soliciting responses from a sample of faculty who participated in UFE workshops during 1996 and 1997. The study is designed to collect information about the participant's experiences in UFE workshops and the impact of the workshops on their teaching and other activities, and about the indirect impact of the workshops on undergraduate student achievement.

The results of the survey will assist the National Science Foundation in assessing the effectiveness of its programs that support undergraduate education, will be used to consider modifications to current programs, and will inform and facilitate reporting as part of the Government Performance and Results Act. Any information that would permit identification of individual respondents will be held in strict confidence. Your response is voluntary and failure to provide some or all of the requested information will not in any way adversely affect you.

The interview will take about 20 minutes. If you have further questions concerning privacy or burden of this survey, I will be happy to discuss those now or at the end of the interview. [IF R ASKS FOR MORE INFORMATION, GO TO ① ON NEXT PAGE.]

Can we proceed with the interview now?

Yes → BEGIN SURVEY WITH SECTION A ON PAGE 4.

No → ASK: When would be a good time?

IF R GIVES ALTERNATIVE TIME, SAY That would be fine. Shall we call you at this same number?
IF R ANSWERS 'NO' GET ALTERNATE NUMBER.

IF R INDICATES THAT SHE OR HE IS VERY BUSY OR OTHERWISE REFUSES, TRY TO GET R TO PARTICIPATE WITH THE FOLLOWING LANGUAGE:

I understand that [TAILOR RESPONSE TO WHAT R SAID], but I hope you will be able to find the time because we are hoping to get a *complete and unbiased* picture of the UFE program and its impacts by interviewing a random sample of workshop participants. Is there a time within the next couple weeks that you could find 20 minutes?

IF R SAYS 'YES' EITHER GO TO SECTON A ON NEXT PAGE, OR GET ALTERNATE TIME.
IF R SAYS NO, SAY That's fine. Thank you for your time. Good bye.

①

IF R HAS ASKED FOR MORE INFORMATION REGARDING PRIVACY OR BURDEN, READ THE FOLLOWING:

The information requested on this survey is solicited under the authority of the National Science Foundation Act of 1950, as amended. The information from this data collection will be retained as part of the Privacy Act System of Records in accordance with the Privacy Act of 1974. Data submitted will be used in accordance with the criteria established by NSF for monitoring research and education grants, and in response to Public Law 99-383 and 24 USC 1885c. The information requested may be disclosed to qualified researchers and contractors in order to coordinate programs and to a Federal agency, court or party in a court or Federal administrative proceeding if the government is a party. Information may be added to and maintained by the Education and Training System of Records 63 Federal Register 264, 272 (January 5, 1998).

Submission of information is voluntary. Public burden for this collection of information is estimated to average .33 hours per response, including the time for reviewing instructions. Send comments regarding this burden estimate and any other aspect of this collection of information, including suggestions for reducing this burden to: Suzanne Plimpton, Reports Clearance Officer, Systems and Services Branch, Division of Administrative Services, National Science Foundation, Arlington, VA 22230. An agency may not conduct or sponsor, and a person is not required to respond to, a collection of information unless it displays a current valid OMB control number. The OMB number for this survey is 3145-0136.

SECTION A. DESCRIPTION AND EVALUATION OF WORKSHOP AND FOLLOW-UP ACTIVITIES

To classify projects by type, and to give context to later variables.

A1. First, I'm going to read a list of focus areas of workshops. Please tell me which of these were the major areas of focus of the UFE workshop you attended. Did the workshop you attended focus primarily on content or subject matter, teaching methods, lab techniques, new technologies, and/or issues regarding females and/or minority students? [CIRCLE ALL THAT APPLY]

a. Content or subject matter [IF R ANSWERS CONTENT OR SUBJECT MATTER, ASK]➔ b. Did that include incorporating and synthesizing interdisciplinary content? 1 YES 0 NO

c. Teaching methods

d. Lab techniques

e. New technologies

f. Issues regarding females and/or minority students

Now, I'd like to ask you about activities you did before, during, and after the workshop.

To describe participants' experiences in workshops and follow-up activities. Explanatory for outcomes.

A2. I'm going to read a list of possible activities you might have done ***before*** the workshop, and I'd like you to tell me whether or not you did each one. [READ LIST. CIRCLE ONE ANSWER IN EACH ROW.]

	YES	NO	DK
a. Did you read any background material, textbooks, or lab manuals?	1	0	9
b. Did you complete any questionnaires to assess your skill level, interests, teaching responsibilities, or objectives?	1	0	9
c. Did you identify a course you wanted to develop or other ways you anticipated incorporating project information at your home institution?	1	0	9
d. Did you prepare a project or problem to work on during the workshop?	1	0	9
e. Did you do any other types of activities [before the workshop]?____________________	1	0	9

A3. Now I'm going to read a list of some types of materials that can be used in courses, and I'd like you to tell me whether you worked on developing each of them at the workshop [IF R ASKS, ANSWER regardless of whether you worked on them during workshop sessions or outside of workshop sessions. READ LIST. CIRCLE ONE ANSWER IN EACH ROW.]

	YES	NO	DK
a. Textbooks	1	0	9
b. Lecture notes or other handouts	1	0	9
c. Problem sets, project descriptions, or lab exercises	1	0	9
d. Other activities__________________	1	0	9

[ASK A4 ONLY IF R ANSWERED 'YES' TO ONE OR MORE ITEMS IN A3.]

A4. By the close of the workshop, had you completed these materials so that they could actually be used, or did you need to do more work before they could be used? [READ WHATEVER ITEM(S) R ANSWERED 'YES' TO IN QA3. CIRCLE '9' FOR ANY ITEMS R DID NOT ANSWER 'YES' TO IN QA3.]

	Completed	Needed more work	N/A
a. Textbook(s)	1	2	9
b. Lecture notes or other handouts	1	2	9
c. Problem sets, project descriptions, or lab exercises	1	2	9
d. Other activities__________________	1	2	9

A5. During the workshop, did you give any presentations or practice lessons during the workshop

0 No

1 Yes ➔ A5a. How many? _______

A6. This next question concerns ***follow-up activities.*** I'm going to read a list of types of follow-up activities in which you may have participated ***after the workshop***, and I'd like you to tell me whether you participated in each type of activity. [READ ITEMS. CIRCLE ONE ANSWER IN EACH ROW.]

	YES	NO	DK
a. Did you participate in one or more formal follow-up sessions at scheduled times?	1	0	9
b. Did you participate in one or more informal group get-togethers?	1	0	9
c. Did you review or site test any materials or products developed as part of the workshop?	1	0	9
d. Did you receive any technical assistance from the PI or other project staff? [IF R ASKS,THIS REFERS ONLY TO TECHNICAL ASSISTANCE REGARDING ISSUES RELATED TO THE WORKSHOP]	1	0	9

A7. After the workshop…	YES	NO	DK
a. Did you communicate with the PI and/or other participants by telephone?	1	0	9
b. Did you communicate with the PI and/or other participants by e-mail??	1	0	9

[ASK A8 ONLY IF R ANSWERED 'YES' TO A7a OR A7b.]

A8. Was this communication ongoing or sporadic? [CIRCLE ONE ANSWER]

1 Ongoing

2 Sporadic

9 Don't recall

SECTION B. IMPACT

What Participant Learned

A13

B1. Next, I'm going to read a list of some types of knowledge and skills. For each item, I'd like you to tell me whether the workshop gave you little or none of that type of skill or knowledge, some of that skill or knowledge, or a lot of that skill or knowledge. [READ ITEMS. CIRCLE ONE ANSWER IN EACH ROW.]

To what extent did the workshop give you…	Little or none	Some	A lot	N/A
a. Increased content knowledge?	1	2	3	9
b. New or more in-depth perspectives on teaching and learning?	1	2	3	9
c. New or improved skills in teaching?	1	2	3	9
d. New or improved experimental or lab techniques?	1	2	3	9
e. New or improved technological skills	1	2	3	9
f. New or more in-depth knowledge of issues regarding females and minority students	1	2	3	9
g. New information about other resources for use in teaching	1	2	3	9
h. New contacts with colleagues from other institutions	1	2	3	9
i. Increased motivation or stimulation for teaching excellence	1	2	3	9

[IF R ANSWERED 1 OR 9 TO ALL ITEMS B1a-B1i ASK QB2, IF NOT SKIP TO QB3.]

A13

B2. Did you get any benefit out of the workshop?

1 Yes → B2a. Please describe:

0 No → B2b. Why not?

[IF R GOT NO BENEFIT OUT OF THE WORKSHOP (B2=0), SKIP TO SECTION D.]

Participants' evaluation of worth of various aspects of workshop. Explanatory for outcomes.

B3. I am going to read a list of workshop features, and I'd like you to tell me how much of a contribution each of the following made to what you got out of the workshop. Please indicate whether each item I read made no contribution to what you got out of the workshop, a small contribution, a moderate contribution, or a great contribution. If the workshop did not include a feature, please indicate that. [READ LIST. CIRCLE ONE ANSWER IN EACH ROW.]

	Little or no Contribution	A moderate Contribution	A Great Contribution	N/A
a. Preparation prior to the workshop	1	2	3	9
b. Content of the lectures or seminars	1	2	3	9
c. Study materials used during the session	1	2	3	9
d. The experience of developing products or materials at the workshop	1	2	3	9
e. Other hands-on learning activities, such as laboratories or computer work	1	2	3	9
f. Materials from the workshop that you took back to your institution	1	2	3	9
g. Presentations or practice lessons that you gave	1	2	3	9
h. Interactions with the instructors (both structured and unstructured)	1	2	3	9
i. Discussions of how participants would incorporate what was learned in the workshop into their own courses.	1	2	3	9
j. Informal interactions with other participants	1	2	3	9
k. Field trips	1	2	3	9
l. Follow-up activities [formal or informal]	1	2	3	9

Impact on Curriculum and/or Courses

B4. As a result of the UFE workshop …[READ ITEMS. CIRCLE ONE ANSWER IN EACH ROW.]

		YES	NO	DK
A6	a. Did you develop or redesign a major or a program of studies?	1	0	9
A1-A4	b. Did you develop one or more new courses? (THIS CAN INCLUDE CURRICULUM OR MATERIALS THAT YOU DEVELOPED DURING THE WORKSHOP REFERRED TO IN A3.)	1	0	9
A1-A4	c. Did you revise one or more existing courses? (THIS CAN INCLUDE THE CURRICULUM OR MATERIALS THAT YOU DEVELOPED DURING THE WORKSHOP REFERRED TO IN A3)	1	0	9
A1-A4	d. Did you develop one or more proposals requesting permission or funding to revise or develop courses?	1	0	9

IF R ANSWERED NO TO B4b AND B4c, SKIP TO B19.

D1-D4

B5. All in all, how many courses did you develop and/or revise? ______

A8

B6. Did you develop or revise [this course/these courses] in collaboration with one or more colleagues? [CIRCLE ONE ANSWER.]

1 Yes
0 No

A5, E6

IF R DEVELOPED MORE THAN ONE COURSE, ASK B7A; IF R DEVELOPED/REVISED ONLY ONE COURSE, ASK B7B.

B7a How many of the courses that you [developed/or/revised] were interdisciplinary? ___

B7b. Was the course that you [developed/revised] interdisciplinary?

1 Yes
0 No

F1

B8. Did [this course/these courses] receive formal departmental and/or program approval? [CIRCLE ONE ANSWER.]

1 Yes
2 Some did and some did not
0 No

B9. Now, I'd like to ask you to be more specific about the types of changes you made in your course(s) as a result of your participation in the UFE workshop.

			In how many courses?	How important was this change to the course(s)? Was it… (1) of little or no importance (2) of moderate importance (3) of major importance
A1	b. Did you introduce ***new*** content that you learned at the UFE workshop?	1 Yes ➔ 0 No	___ ➔	1 2 3
A1	a. Did you change the content to focus on key issues or "big ideas?"	1 Yes ➔ 0 No	___ ➔	1 2 3
A3	c. Did you introduce new experimental techniques or lab techniques that you learned at the UFE workshop?	1 Yes ➔ 0 No	___ ➔	1 2 3
A4	d. Did you introduce new equipment, materials or computer software that you learned at the UFE workshop?	1 Yes ➔ 0 No	___ ➔	1 2 3
A2	e. Did you change teaching methods in any other way?	1 Yes ➔ 0 No	___ ➔	1 2 3

A1-A4

B10. Please describe in your own words the changes you made to your classes as a result of your participation in the UFE workshop. [INTV: THIS INCLUDES DESCRIPTION OF NEW CLASSES.]

____

____

____

____

A7, A14

B11. Have you taught one or more of the courses you [developed/(or)/revised] as a result of your participation in the UFE workshop. [CIRCLE ONE ANSWER]

1 Yes➔CONTINUE WITH Q B12.

0 No➔ SKIP TO Q. B19

.

CONTINUE WITH B12 IF R DEVELOPED/REVISED > 1 COURSE. SKIP TO B13 IF R DEVELOPED/REVISED 1 COURSE

A7, A14

B12. How many? ___

E5

B13. Have you team taught [this course/any of these courses]?

1 Yes
0 No

B1-B4 (B14a)

C1-C4 (B14b, B14c)

B14. a. In all, approximately how many students have completed [this course/these courses]? ________

b. Approximately what percentage of these students are female? ______% [IF R NEEDS PROMPTING, SAY: Please give your best estimate.]

c. Approximately what percentage of these students are from underrepresented groups? ______% [IF R NEEDS PROMPTING, SAY Please give us your best estimate]

Sustained effects

B15. If you have taught this course more than once since participating in the UFE workshop, how did what you did as a result of your participation in the UFE workshop change over time? (INTV PROMPT: FOR EXAMPL.E, DID YOU INCREASE OR DECREASE WHAT YOU DID? DID IT BECOME MORE KEY?)

____

____

____

B16. [Is the course/Are these courses] still being offered?

F2

Barriers to sustained effects.

1 Yes
0 No ➔ B16a. Why not?

____

____

____

____

Impact on Students

B17. I'm going to read a list of various types of knowledge and skills. For each item I read, I'd like you to compare the average level of knowledge and skills of students who completed the courses you developed or modified as a result of your participation in the UFE workshop with the knowledge and skills of students who completed similar courses you taught previously. If there is no valid basis for comparison, please indicate that. [INTV: FIRST ASK WHETHER BETTER/WORSE, OR ABOUT THE SAME. THEN, IF R ANSWERS BETTER OR WORSE, ASK "SUBSTANTIALLY, OR SOMEWHAT…"]

1=Substantially worse
2=Somewhat worse
3=No difference
4=Somewhat better
5=Substantially better
9=No valid comparison possible

B9	a.	In-depth knowledge of subject area	1	2	3	4	5	9
B10	b.	Problem-solving skills	1	2	3	4	5	9
B11	c.	Communication skills	1	2	3	4	5	9
B12	d.	Ability to apply new knowledge	1	2	3	4	5	9
B13	e.	Critical thinking skills	1	2	3	4	5	9
B14	f.	Ability to collaborate with others	1	2	3	4	5	9
B15	g.	Ability to use advanced technology	1	2	3	4	5	9
B16	h.	Understanding of the scientific method	1	2	3	4	5	9

B9-B16, C9-C16

B18. Please describe in your own words, the impact of the changes you made as a result of your participation in the UFE on your students?

____

____

____

____

Impact on Non-Classroom Activities

B19. [FOR EACH ITEM, CIRCLE ONE ANSWER IN EACH COLUMN.]

	I'm going to read some activities in which faculty sometimes engage. I'd like to know whether you have engaged in these activities since returning from the UFE project you attended, regardless of their relationship to that faculty project.		How much influence did your participation in the UFE workshop have on your engaging in this activity?			
			None	A little	Moderate	Great
A11, A15	a. Have you participated in any further professional development activities or workshops designed to change the content of courses or to improve instruction?	1 Yes ➔ 0 No	1	2	3	4
A10, E4	b. Have you begun any new communication or continued existing communication with experts in one or more SMET disciplines.	1 Yes ➔ 0 No	1	2	3	4
E2	c. Have you established any new research or teaching collaborations with colleagues	1 Yes ➔ 0 No	1	2	3	4
A9, A15	d. Have you attended any professional meetings, seminars, or workshops	1 Yes ➔ 0 No	1	2	3	4
G1	e Have you submitted one or more articles to professional journals	1 Yes ➔ 0 No	1	2	3	4
G1	f. Have you delivered one or more papers at a professional meeting	1 Yes ➔ 0 No	1	2	3	4
G1	g. Have you made one or more presentations to local campuses or community organizations	1 Yes ➔ 0 No	1	2	3	4

B20. Has your participation at the UFE workshop had any impact on you, your courses, or your labs, other than the things we've just covered,?

0 No
1 Yes ➔ B20a. Please tell me about these impacts.

____

____

____

____

Impact on Broader Community

B21. Have you shared any information or skills you learned in the UFE workshop with colleagues either in your institution or in other institutions … [READ LIST. CIRCLE ONE ANSWER IN EACH ROW.]

			YES	NO	DK
G2	a.	Through informal discussions with one or more colleagues?	1	0	9
G1	b.	Through presentations to one or more colleagues?			
G3	c.	Through observation of your class or laboratory by one or more colleagues?	1	0	9
G4	d.	Through participation in any department or campus committees on curricular change and/or reform?	1	0	9
	e.	Through any other activities? (specify), ______________________________	1	0	9

[IF NO ITEMS IN B20 ARE CIRCLED, SKIP TO QC2.]

B22. To the best of your knowledge, as a result of what you learned at the UFE workshop, …[READ LIST. CIRCLE ONE ANSWER IN EACH ROW.]

			YES	NO	DK
G5	a.	Have any of your colleagues modified the content of a course or laboratory?	1	0	9
G5	b.	Have any of your colleagues developed a new course or laboratory?	1	0	9
G6	c.	Have any of your colleagues attended any UFE workshops?	1	0	9
	d.	Have any of your colleagues made any other changes? (specify) ______________________________	1	0	9

SECTION C. BARRIERS TO IMPLEMENTATION

IF R DID NOT DO ANYTHING IN HIS/HER COURSES (NONE OF B4 ANSWERS = 1), SKIP TO C2. OTHERWISE ASK C1.

Explanatory

C1. We're interested knowing whether you encountered any barriers to implementing what you learned at the UFE workshop. In answering, please include any type of barrier you may have experienced. For instance, barriers might include that you have not taught any courses that relate to the workshop since your participation, that heavy teaching demands have not allowed you to complete revisions of a course, or that you were not able to obtain equipment you needed. Did you encounter any barriers to implementing what you learned at the UFE workshop? [CIRCLE ONE ANSWER.]

0 No

1 Yes ➔ C1a. Please tell me about these barriers.

____

____

____

____

Explanatory

C2. When you attended the UFE workshop, did you intend to develop any new courses or modify any existing courses? [CIRCLE ONE ANSWER.]

0 No ➔ C2a. What were your principal reasons for attending the workshop?

____

____

____

1 Yes ➔ C2b. Can you tell me the reasons you did not do this after the workshop?

____

____

____

____

SECTION D. DEMOGRAPHIC INFORMATION

D1. At the time you participated in the UFE project, how many years had you been on the faculty of the institution where you were teaching at that time? __________years

D2. Which of the following best describes the college/university where you were employed when you attended the UFE project? [READ LIST. CIRCLE ONE ANSWER.]

1 Two-year college
2 Four year college
3 Comprehensive university
4 Doctoral institution
5 Other (specify) _____________________

D3. Was the institution where you were employed when you participated in the UFE project a tribal college or an historical black college or university? [CIRCLE ONE ANSWER.]

1 Tribal college
2 Historical black college or university
3 None of the above

D3. What was your tenure status at the time you participated in the UFE project? [CIRCLE ONE ANSWER.]

1 Not applicable: no tenure system at college/university
2 Not applicable: no tenure system for my position
3 Not on tenure track
4 On tenure track but not tenured
5 Tenured

D4. Which of the following best describes your academic rank at your college/university? [CIRCLE ONE ANSWER.]

1 Not applicable: no ranks system at college/university
2 Not applicable: no ranks for my position
3 Professor
4 Associate Professor
5 Assistant Professor
6 Instructor
7 Lecturer
8 Other (Specify) ___________________________

D5. What discipline (that is, major field) were you teaching at your institution when you attended the faculty project? [INTV: CIRCLE ALL DISCIPLINES GIVEN BY R; PROMPT AS NECESSARY]

1 Astronomy
2 Chemistry
3 Computer Science
4 Engineering
5 Geosciences
6 Life Sciences
7 Mathematics
8 Physics
9 Social Science
10 Non-SMET discipline

D6. INTV: IS R MALE OR FEMALE? [CIRCLE ONE ANSWER]

1 Male
2 Female

D7. What is your date of birth? Month_____ Day____ Year_____

D7. Are you Hispanic or Latino or NOT Hispanic or Latino? [CIRCLE ONE ANSWER.]

1 Hispanic or Latino
0 Not Hispanic or Latino
9 DK or Refused

D8. I'm going to read a list of race categories. Please choose one or more categories that best indicate you race. (INT: READ LIST. CIRCLE ALL THAT APPLY)

(9 REFUSED)

1 American Indian or Alaska Native
2 Asian
3 Black or African American
4 Native Hawaiian
5 Native Hawaiian or Other Pacific Islander
6 White

D9. What was your citizenship when you participated in the UFE project? Were you a U.S. Citizen or national, a permanent resident, or another type of non-=US Citizen (that is, a temporary resident)? [CIRCLE ONE ANSWER.]

1 U.S. Citizen or national
2 Permanent resident
3 Other non-U.S. Citizen (that is, temporary resident)
9 Refused

D10. Do you have a hearing impairment, visual impairment, a mobility/orthopedic impairment, and/or some other type of disability? [CIRCLE ALL THAT APPLY.]

1 Hearing impairment
2 Visual impairment
3 Mobility/Orthopedic Impairment
4 Other (specify) ____
5 None
9 Refused

INTV Those are all of my questions. Would you like to add any other comments regarding your experiences at the UFE workshop or the impact of the UFE program on your teaching or your students' learning?

INTV: END INTERVIEW BY SAYING: Thank you very much for completing this interview. DESCRIBE WHERE STUDY FINDINGS WILL BE POSTED.

Appendix D

NAMES AND AFFILIATIONS OF UFE EVALUATION ADVISORY PANEL MEMBERS AND SITE VISIT CONTENT EXPERTS

Advisory Panel Members

Name	Affiliation	Discipline
Dr. Susan A. Henry, Chair	Carnegie Mellon University, Dean of Mellon College of Science	Biological Sciences
Dr. Fred Bowers	Spelman College	Mathematics
Dr. Karen C. Cohen	Karen C. Cohen Associates	Evaluation
Dr. Mary Beth Monroe	Southwest Texas Junior College	Physics
Dr. Surendra Shah	Northwestern University	Civil Engineering
Dr. Nick Smith	Syracuse University	Education
Dr. DeWitt B. Stone, Jr.	Clemson University, Assistant Vice President for Academic Affairs	Chemistry

Content Experts on Site Visits

Name	Affiliation	Discipline
Dr. Fred Bowers	Spelman College	Mathematics
Dr. Alphonse Buccino	President, Contemporary Communications; Former Dean, University of Georgia	Mathematics
Dr. Chris Hendrickson	Carnegie Mellon University, Head of Department	Civil Engineering
Dr. Susan A. Henry	Carnegie Mellon University, Dean of Mellon College of Science	Biological Sciences
Dr. Mary Beth Monroe	Southwest Texas Junior College	Physics
Dr. DeWitt B. Stone, Jr.	Clemson University, Assistant Vice President for Academic Affairs	Chemistry

Appendix E

CALCULATIONS

Chapter II

Page II-1. Calculation of Numbers of Participants for Exhibit II-2.

Both the numbers of applicants and of participants are based on the numbers reported by PIs in DUE's annual surveys, which totaled 24,832 applicants and 17,507 participants (and which include duplicate counts). However, not all workshop PIs responded to DUE's survey. To obtain the total number of applicants and participants at *all* workshops (including those for which PIs did not complete DUE's surveys), we computed the mean number of applicants/participants for all the workshops for which we had data in a given year. We then imputed that number to that year's workshops for which we had no data and summed over all the year's workshops.

For example, 54 workshops were held in 1991. PIs reported data for 49 workshops, and the total of participants for those workshops was 1,182. To estimate the total for all 54 workshops, we took the mean number of respondents for the 49 workshops (1,182/49=24.122) and used it as the number of participants for the five workshops for which there were no data. Then we summed the 1,182+(5*24.122) to get 1,303.

Page II-2. Calculation of Numbers of Participants for Exhibit II-3.

From a thorough examination of 1996 and 1997 data, we estimated that approximately 90% of UFE participants were faculty who taught undergraduates. The same data also show that approximately 6.3% of faculty attended more than one workshop in a given year and that approximately 6.1% of faculty attended at least one workshop in two subsequent years also. We assumed that the propensity to attend another workshop decreased each year. With these estimates and assumptions, we estimated the unduplicated numbers of undergraduate faculty as follows:

	1991	1992	1993	1994	1995	1996	1997	Total
Total UFE participants	1,303	2,268	2,871	2,460	3,273	3,395	3,845	19,416
Not undergraduate faculty at 10.01%	-130	-227	-287	-246	-328	-340	-385	-1,944
Within-year duplicates at 6.30%	-82	-143	-181	-155	-206	-214	-242	-1,223
Faculty participants (nonduplicates within year)	**1,090**	**1,898**	**2,403**	**2,059**	**2,739**	**2,842**	**3,218**	**16,250**
Repeaters across years								
Repeaters from previous year (6.10%)		-66	-116	-147	-126	-167	-173	-795
Repeaters from 2 years previous (4.88%)			-53	-93	-117	-101	-134	-498
Repeaters from 3 years previous (3.90%)				-43	-74	-94	-80	-291
Repeaters from 4 years previous (3.12%)					-34	-59	-75	-168
Repeaters from 5 years previous (2.50%)						-27	-47	-75
Repeaters from 6 years previous (2.00%)							-22	-22
Unduplicated undergraduate faculty participants	**1,090**	**1,832**	**2,234**	**1,777**	**2,388**	**2,394**	**2,686**	**14,402***

*Total equals the sum of the numbers in the column, but not the sum of the numbers in row because of duplicates across years.

Chapter IV

Page IV-4. Extrapolation for Numbers of Courses.

	New Courses	Courses with Major Revisions	Courses with Moderate Revisions
Respondents who both developed and revised one or more courses (20%): The mean number of courses developed and revised for this group was 2.76. We assume that half of these courses were new and half were revised. Revised courses were assumed to be about 1/3 major revisions, 1/3 moderate revisions, and 1/3 minor revisions, yielding the following extrapolations for all participants:			
(1) 6.66% of respondents developed on average 1.38 new courses and made *major* revisions on average to 1.38 courses:			
➢ New courses = 6.66% X 14,402 (adjusted number of participants) X 1.38 courses =	1,323		
➢ Major revisions = 6.66% X 14,402 X 1.38 courses		1,323	
(2) 6.66% of respondents developed on average 1.38 new courses and made *moderate* revisions on average to 1.38 courses:			
➢ New courses = 6.66% X 14,402 (adjusted number of participants) X 1.38 courses =	1,323		
➢ Moderate revisions = 6.66% X 14,402 X 1.38 courses =			1,323
(3) 6.66% of respondents developed on average 1.38 new courses and made *minor* revisions on average to 1.38 courses:			
➢ New courses = 6.66% X 14,402 X 1.38 courses =	1,323		
➢ (Courses with only minor revisions are not being counted here)			
Respondents who developed one or more courses but did not revise any courses (5%): Calculation for this group was straightforward, using the mean number of courses developed by this group, which was 1.41. New courses = 5% X 14,402 X 1.41 courses =	1,015		
Respondents who made major revisions to one or more courses but did not develop any new courses (29%): The mean number of courses this group revised was 2.13. We assume that half of the mean number of courses (1.065) underwent major revisions. We further assume that on average 1/3 of the respondents made major revisions to the remaining 1.065 courses, 1/3 made moderate revisions, and 1/3 made minor revisions It follows that:			
(1) 9.6667% of respondents made major revisions on average to 2.13 courses:			
Major revisions = 9.6667% X 14,402 X 2.13 courses =		2,965	
(2) 9.6667% of respondents made major revisions on average to 1.065 courses and made moderate revisions on average to 1.065 courses			
➢ Major revisions = 9.6667% X 14,402 X 1.065 courses =		1,482	
➢ Moderate revisions = 9.6667% X 14,402 X 1.065 courses =			1,482
(3) 9.6667% of respondents made major revisions on average to 1.065 courses and minor revisions to 1.065 courses			
➢ Major revisions = 9.6667% X 14,402 X 1.065 courses =		1,482	
➢ (Courses with only minor revisions are not being counted here)			

Extrapolation for Numbers of Courses (concluded).

	New Courses	Courses with Major Revisions	Courses with Moderate Revisions
Respondents who made at most moderate revisions to one or more courses (27%): The mean number of courses developed and revised for this group was 1.98. We assume that, on average, half of the respondents in this group (13.5%) made moderate revisions to the mean number of courses (1.98) and half (13.5%) made moderate revisions on average to .99 courses and minor revisions to .99 courses. It follows that:			
(1) 13.5% of respondents made moderate revisions to 1.98 courses:			
Moderate revisions = 13.5% X 14,402 X 1.98 courses =			3,849
(2 13.5% of respondents made moderate revisions to .99 courses and minor revisions to .99 courses:			
➢ Moderate revisions = 13.5% X 14,402 X .99 courses =			1,925
➢ (Courses with only minor revisions are not being counted here)			
Total Courses	4,984	7,252	8,579

Total number of new and revised courses = 4,984 + 7,252 + 8,579 = 20,815

Chapter V

Page V-2. Number and Characteristics of Students in Participants' New and/or Revised Courses.

(1) N of students of participants who developed new courses and/or made major revisions to existing courses.

A. All students:

First we calculated an adjusted yearly number of students per respondent as follows:

(1) Survey respondents who attended workshop in 1996, mean N of students completing courses per year (with deletion of observations with values of more than 3,000)	71.94
(2) Survey respondents who attended workshop in 1997, mean N of students completing courses per year (with deletion of observations with values of more than 2,000)	69.51
(3) Mean yearly N of students per participant for both years	72.73
(4) Adjustment for possible duplicate counts of students—2/3 of mean yearly N of students per participant	47.15

Next, we performed the following calculations:

Year:	1991	1992	1993	1994	1995	1996	1997
(1) N participants (from Exhibit II-2)	1,090	1,898	2,403	2,059	2,739	2,842	3,218
(2) Estimated percent of participants who developed or made major revisions to courses (from Exhibit IV-2)	54%	54%	54%	54%	54%	54%	54%
(3) Estimated N of participants who developed new course or made major revisions to existing courses (line 1 X line 2)	589	1,025	1,298	1,112	1,479	1,535	1,738
(4) Adjusted mean N of students per participant X N of participants who developed or revised course (line 3 X 47.15)	27,754	48,328	61,186	52,427	69,742	72,642	81,938
(5) N of years to fall of 1999	8	7	6	5	4	3	2
(6) Estimated total number of students completing courses through summer of 1999 (line 4 X line 5)	**222,033**	**338,295**	**367,118**	**262,136**	**278,967**	**217,925**	**163,877**

Total for 1991-1999 (sum across cells in line 6): 1,850,351

B. N of female students: The mean percent of female students given by survey respondents who made major revisions to courses and/or developed new courses was 46.33. So:

46.33% of 1,850,351 = 857,268

C. N of students from underrepresented minority groups: The mean percent of underrepresented minority students given by survey respondents who made major revisions to courses and/or developed new courses was 28.49. So:

28.49% of 1,850,351 = 527,165

D. N of students in each type of institution: The number of students in each type of institution was calculated in the same way as the number of students in all institutions (see A above).

(2) N of students of participants who made *moderate* revisions to existing courses:

A. All students:

First we calculated an adjusted yearly number of students per respondent as follows:

(1)	Survey respondents who attended workshop in 1996, mean N of students completing courses per year (with deletion of observations with values of more than 3,000)	57.93
(2)	Survey respondents who attended workshop in 1997, mean N of students completing courses per year (with deletion of observations with values of more than 2,000)	90.45
(3)	Mean yearly N of students per participant for both years	74.19
(4)	Adjustment for possible duplicate counts of students—2/3 of mean yearly N of students per participant	49.46

Next, we performed the following calculations:

Year:	1991	1992	1993	1994	1995	1996	1997
(1) N participants (from Exhibit II-2)	1,090	1,898	2,403	2,059	2,739	2,842	3,218
(2) Estimated percent of participants who made moderate revisions to courses (from Exhibit IV-2)	27%	27%	27%	27%	27%	27%	27%
(3) Estimated N of participants who made moderate revisions to courses (line 1 X line 2)	294	512	649	556	740	767	869
(4) Adjusted mean N of students per participant X N of participants who made moderate revisions to courses (line 3 X 49.46)	14,556	25,347	32,091	27,497	36,578	36,321	42,975
(5) N of years to fall of 1999	8	7	6	5	4	3	2
(6) Estimated total number of students completing courses through summer of 1999 (line 4 X line 5)	**116,451**	**177,428**	**192,545**	**137,485**	**146,312**	**108,962**	**85,950**

Total for 1991-1999 (sum across cells in line 6): 965,133

B. N of female students: The mean percent of female students given by survey respondents who made moderate revisions to courses was 47.10. So:

47.10% of 965,133 = 454,577

C. N of students from underrepresented minority groups: The mean percent of underrepresented minority students given by survey respondents who made moderate revisions to courses was 24.05. So:

24.05% of 965,133 = 232,114

D. N of students in each type of institution: The number of students in each type of institution was calculated in the same way as the number of students in all types of institutions (see A above).

Chapter VI

Page VI-3. To calculate the probability of developing or revising a course associated with several variables at a time, use the coefficients in the column entitled “Log of the Odds Ratio.”

Variable	Log of the Odds Ratio
Intercept	-0.277
Length of workshop (in days)	0.058
Focus of workshop	
Included teaching methods	0.610
Included new technology	0.526
Included new content	0.022
Included lab techniques	-0.196
At workshop, participant:	
Worked on lecture notes/handouts	0.584
Worked on problem sets, project descriptions, or lab exercises	0.617
Worked on textbooks	-0.098
Gave presentation	-0.230
Completed materials	0.117
Participant's follow-up activities	
Site tested materials at own campus	0.250
Received technical assistance from PI or workshop staff	0.203
Formal follow-up session(s)	0.046
Informal gathering(s)	0.063

To calculate the change in probability associated with several variables:

(1) Add the coefficient associated with the intercept (-0.277) to the coefficient(s) whose effect you desire to calculate. (2) Take the exponent of the result (which gives the odds ratio for the combination of variables). (3) Divide the result of (2) by 1+ that result. (4) Subtract 0.431 (the probability of developing and/or revising a course associated with the intercept) from the result of (3). The result of (4) will be the change in the probability of developing and/or revising a course associated with presence of all the variables of interest (and the absence of all others).[1]

For example, to calculate the difference in probability of developing and/or revising one or more courses for a participant who attended a workshop that included teaching methods *and* new technology compared with participant who attended a workshop that included none of the variables in the model, the calculation would be as follows:

(1) -0. 277 + 0.610 + 0.526 = 0.859
(intercept) (teach. Meth.) (new technol.)

(2) exp(0.859) = 2.361 (odds ratio for this combination of variables)

(3) 2.361/(1+2.362) = 0.702 (probability of developing or revising a course)

(4) 0.702 - 0.431 = 0.271 (change in probability)

[1] The change is the increase or decrease in probability of developing or revising a course associated with the variables of interest, compared with the probability of developing or revising a course if *all variables in the model have a value of zero* (for dichotomous variables, a value of 0 means an absence).

Thus, the probability of developing and/or revising at least one course would be 27.1 percentage points higher for the first participant than for the second participant.

Chapter VII

The number of undergraduates in the United States. from 1991-92 to 1998-99 was calculated as follows:

Appendix Table 4-32 in *Science Indicators—2000* shows the total numbers of undergraduates in the United States as follows:

1990-91	**1992-93**	**1993-94**	**1994-95**	**1995-96**	**1996-97**
12,011,657	12,693,778	12,482,813	12,417,701	12,399,826	12,424,750

Note that no numbers were available for 1991-92 or for after 1996-97. For the 1991-92 undergraduate population, we interpolated between the numbers for 1990-91 and 1992-93 by taking the mean or (12,352,718). We assumed that the population was the same for 1997-98 and 1998-99 as for 1996-97. Because of dropout, we also assumed that 1/3 (rather than 1/4) of the student population for each year were new students (incoming freshmen). Thus, to the number for 1991-92 we added 1/3 of the student population for each of the subsequent years, as follows:

All 1991-92 undergraduates	12,352,718
New 1992-93 students (1/3 of 1992-93 undergraduates)	4,231,259
New 1993-94 students (1/3 of 1993-94 undergraduates)	4,160,938
New 1994-95 students (1/3 of 1994-95 undergraduates)	4,139,234
New 1995-96 students (1/3 of 1995-96 undergraduates)	4,133,275
New 1996-97 students (1/3 of 1996-97 undergraduates)	4,141,523
Estimated new 1997-98 students (1/3 of estimated 1997-98 undergraduates)	4,141,523
Estimated new 1998-99 students (1/3 of estimated 1999-99 undergraduates)	4,141,523
Estimated unduplicated total undergraduates 1991-92 through 1998-99	**41,441,994**

Appendix F

SUMMARY REPORTS OF THE EIGHT UFE WORKSHOP VISITS

This appendix presents summary reports of the eight workshops visited in 1998. A description of how workshops were chosen for visits is presented in Chapter III. Each summary presents a description of the goal(s) of the workshop, the activities conducted, its leaders and participants, and its impact. Each is followed by an example of the actual workshop schedule.

(1) THE ART AND SCIENCE OF MATHEMATICAL MODELING: A WORKSHOP FOR COLLEGE MATHEMATICS TEACHERS

Principal Investigator:	Robert McKelvey
Organization:	University of Montana, Missoula
Workshop dates:	July 29-August 7, 1998
Workshop location:	University of Montana, Missoula

Sources of Data

An SRI researcher visited the workshop on August 3-4, 1998. Before the visit, the project's proposal was examined. The researcher was accompanied by an outside content expert on August 3. During the visit, all activities were observed, and interviews were conducted with the project PI, 3 workshop instructors, and 10 participants. The PI provided written and oral updates in the spring of 2000.

Project Goal

The project's overarching goal was to increase the use of open-ended problem-solving activities focusing on real-world issues among faculty teaching undergraduate mathematics. To accomplish this, the project sought to:

- Introduce model building to a group of college mathematics teachers.
- Help them gain the skill and confidence necessary to introduce modeling activities into their own undergraduate teaching.
- Encourage participants to incorporate modeling as a permanent component of their own ongoing scholarly activities.

Project Description

This 2-week summer workshop focused on mathematical modeling of environmental and natural resource conflicts. The theme was the result of the PI's conviction that applied mathematical modeling can help undergraduate students discover the central role that mathematics plays in modern science, and thereby demonstrate to them the value of further mathematical studies.

Activities

The workshop included a combination of lectures, computer lab experiences, field trips, and time to work on individual projects. The PI, staff, and guest lecturers presented sessions on a variety of mathematical models (e.g., optimal control problems, game theory, and dynamic models). In most sessions, the models were well integrated with environmental phenomena. For example, the session on decision theory used examples regarding endangered species, such as the northern spotted owl. To give participants firsthand knowledge of some of the ecological phenomena covered in the sessions, there were two field trips. Each afternoon, participants did hands-on activities in a computer lab, where they were taught software that could be used to estimate the various models (e.g., Mathlab). The computer lab was also open in the evenings.

Long breaks between sessions, social activities such as a picnic, and the housing of all participants in a single dorm were scheduled so that participants could interact informally. Participants took good advantage of these opportunities, discussing the various models, their previous experiences teaching modeling, and how they would apply what they had learned at the workshop in their own courses. Toward the end of the workshop, a full session was devoted to discussions of modeling's place in the curriculum, challenges to teaching it, and strategies for overcoming those challenges.

During the following year, participants were expected to teach a modeling course, or at least several units of modeling in a course, for undergraduate students. An Internet discussion forum was provided. In the spring of 1999, participants submitted abstracts of the courses they had taught or other postworkshop activities. The abstracts were compiled and distributed at a 3-1/2-day meeting in the summer of 1999.

Leadership

Robert McKelvey, currently a professor emeritus, came to the University of Montana, Missoula, more than 25 years ago to revamp the math department. McKelvey strongly believes that most mathematics should be applied and interdisciplinary. He has specialized in environmental and natural resource modeling for more than 20 years, with current research focusing on game theoretic models of international environmental disputes. McKelvey is a recent past president of the Resource Modeling Association and edits the research journal *Natural Resource Modeling.*

Workshop instructors included eight faculty, six of them from the Mathematics Department of the University of Montana at Missoula. Each specialized in a particular area of modeling (e.g., game theory, discrete-state models). One was an expert in mathematics education. Five content experts spoke as guest lecturers.

Participants

The 28 participants consisted of 19 males and 9 females. Two were from underrepresented minority groups (one Hispanic and one African American). Participants came from all over the country, mostly from small 4-year or comprehensive institutions. Most taught modeling or related courses. Two were attending with the primary goal of developing programs of study for mathematics majors.

Preference was given to faculty in their first 5 years of teaching. Some more experienced faculty were accepted—particularly those whose work would have an impact on a broader scale than their own courses (for example, the two who were designing programs of study). Participants received a *per diem* payment for the 2 weeks of the workshop and were housed in a dorm at the university.

Project Impact

During interviews and/or at observed workshop sessions, all participants indicated that they intended to use in their courses what they had learned in the workshop. Of the two expected to design mathematics majors, one had recently been hired for this purpose—her college was converting from a 2-year institution to a 4-year institution, and she was to design the upper-division sequence. The other was the chair of a mathematics department that did not have the number of majors they believed they should. The chair was revamping the major in hopes of attracting more students.

Of 13 participants who responded to a survey by the project director in the spring of 2000, all indicated that since the workshop they had taught a modeling course, taught modeling in their other mathematics courses, or were engaged with students doing modeling as individual study.

Ten participants reported having spoken to their colleagues about using modeling to teach mathematics. Several wrote that their colleagues were not very receptive; however, six respondents indicated that what they had done in their own courses and their discussions with colleagues had brought about more widespread changes. For example, one stated that he would be working on ways to fit modeling into a new environmental science major; another said that her department had made a formal decision to emphasize modeling and applications throughout the curriculum; and a third indicated that his department was no longer going to remove the modeling course from the curriculum. Participants also reported developing new collaborations and new research interests.

EXHIBIT F-1
TYPICAL WEEKLY SCHEDULE: MODEL BUILDING WORKSHOP

Monday		
8:00 - 9:30 a.m.	Lecture: Modeling environmental and natural resource conflicts 1	Bob McKelvey, PI
10:15 - 11:45 a.m.	Lecture: Modeling the modes of cooperation—Concepts from collective choice theory and game theory 1	Phil Straffin
1:15 - 2:45 p.m.	Lecture: Optimization modeling 1	Jenny McNulty
3:30 - 5:30 p.m.	Computer lab	Dick Lane
Tuesday		
8:00 - 9:30 a.m.	Lecture: Deterministic models in ecology and conservation biology: the dynamics of discrete and continuous nonlinear systems 1	Bill Derrick
10:15 - 11:45 a.m.	Lecture: Modeling the modes of cooperation—Concepts from collective choice theory and game theory 2	Phil Straffin
1:15 - 2:45 p.m.	Discussion: Problems of introducing mathematical modeling into undergraduate courses	Jim Hirstein
3:30 - 5:30 p.m.	Computer lab	Jenny McNulty
Wednesday		
8:00 - Noon	Field trip to Remount Station	Park Ranger
1:00 - 2:15 p.m.	Guest lecture: Ecology of exotic plants	Dean Pearson
2:45 - 4:00 p.m.	Lecture: Modeling environmental and natural resource conflicts 2	Bob McKelvey
5:30 – 9:30 p.m.	Picnic dinner—Bass Creek	
Thursday		
8:00 - 9:30 a.m.	Lecture: Deterministic models in ecology and conservation biology: the dynamics of discrete and continuous nonlinear systems 2	Bill Derrick
10:15 - 11:45 a.m.	Lecture: Modeling the modes of cooperation—Concepts from collective choice theory and game theory 3	Phil Straffin
1:15 - 2:15 p.m.	Guest lecture: Water conservation—scientists as citizens	Vicki Watson
2:25 - 3:15 p.m.	Guest lecture: Predicting forest fires through modeling	Kevin McKelvey
3:30 - 5:30 p.m.	Computer lab	Jim Hirstein
Friday		
8:00 - 9:30 a.m.	Guest lecture: Optimal control problems	Alvaro Bolano

10:15 - 11:45 a.m.	Facilitated discussion: Integrating modeling into participants' classrooms	Jim Hirstein
1:15 - 2:15 p.m.	Guest lecture: Statistical aspects of simulation	David Patterson
3:45 - 5:30 p.m.	Computer lab	Bill Derrick

Computer lab open evenings, 7:30 - 9:30 p.m., Monday, Tuesday, Thursday, and Friday. Monitoring support available.

(2) TEACHING TEACHERS TO TEACH ENGINEERING (T^4E)

Principal Investigator:	Lt. Col. Stephen Ressler
Organization:	United States Military Academy (USMA), West Point, NY
Workshop dates:	July 26-31, 1998
Workshop location:	USMA, West Point

Sources of Data

An SRI researcher visited the T^4E workshop on July 30-31, 1998. On July 30, the researcher was accompanied by an outside content expert. Before the visit, the project's proposal was examined. During the visit, all workshop activities were observed, and interviews were conducted with the project's PI and senior staff, as well as with 14 participants. In the spring of 2000, the PI provided oral and written updates, and a Web site related to the project was examined.

Project Goal

The project's central goal was to raise the standard of teaching excellence in undergraduate engineering programs nationwide by:

- Increasing the number of engineering faculty who have studied and practiced sound, proven teaching methods.
- Creating a nationwide network of engineering educators and administrators who are committed to promoting better teaching and improved teacher training.

Project Description

The 5½-day workshop emphasized effective lecture techniques and interaction with students. It included seminars and demonstration classes for the whole group, as well as extensive hands-on experience and mentoring.

Activities

Seminars focused on particular topics such as organization and presentation of classes, establishing objectives, student learning styles, instructional technology, student-teacher relations, promotion and tenure, and success in academe. An entire seminar session, led by two ex-participants who had returned as staff, was dedicated to a discussion of how participants might incorporate what they had learned in the workshop, barriers that might arise, and how those barriers might be overcome. Demonstration classes were taken from real engineering courses, with a staff member taking the role of the professor and the participants taking the role of undergraduate students.

The heavy focus on practice classes was intended to help participants build confidence, poise, and self-assessment skills. Practice lectures and mentoring took place in small groups consisting of four participants, plus at least one senior mentor (a senior faculty member at USMA) and at least one junior mentor (a new USMA faculty member who had just completed USMA's version of the T^4E workshop for its own faculty). Four of the small groups also included a senior observer. Working in small groups allowed each participant to present three practice classes and to receive in-depth feedback from group members immediately following each one. Thus, each attendee had the opportunity to act as presenter or observer/critic for 12 practice classes.

All practice lectures and comments were videotaped, and tapes were made available for participants to view during the week. An empty classroom was made available to each participant for the entire week so that he or she could practice teaching techniques and skills.

Follow-up for participants was principally through a Web site and e-mail. Senior observers were provided long-term technical assistance to establish teacher training programs at their institutions.

Leadership

The project's PI in 1998 was Lt. Col. Stephen Ressler, Deputy Head of the Department of Civil and Mechanical Engineering. Co-PIs were Col. Tom Lenox, Dr. Chris Conley, Dr. Mark Costello, and Lt. Col. Jon Klegka, all on the faculty of the Department of Civil and Mechanical Engineering. Both Lenox and Conley were PIs of T^4E projects under previous UFE grants. Ressler and Lenox were the workshop's primary seminar instructors. Both have won awards for their teaching and have written or presented more than 40 papers on various aspects of undergraduate engineering education. Seven senior faculty from USMA and nonmilitary institutions served as mentors in the small-group sessions, and nine junior USMA faculty served as assistant mentors.

Participants

Twenty-seven undergraduate faculty from U.S. colleges and universities attended the workshop, 23 as regular participants and 4 as senior observers. Participants included eight women and two Americans from underrepresented minority groups (there was also one participant from Latin America and one from Africa). Participants and observers came from all areas of the country and all levels of experience and tenure. Most came from research/doctoral institutions (16); somewhat fewer came from comprehensive institutions (8). Three came from baccalaureate or 2-year institutions.

To recruit participants, the project sent an information packet to engineering deans and department heads in the United States; presentations also were given at the American Society for Engineering Education (ASEE) conference, and ads were placed in an ASEE publication. Women and minority faculty were targeted by placing an ad in the Society of Women Engineers magazine and by posting a notice at the conference of the National Society of Black Engineers. Nevertheless, the largest single source of recruitment was word of mouth from participants at previous years' workshops.

Each applicant was required to provide a resume, an administrative letter of support, and a statement regarding reasons for attending the workshop, teaching philosophy, and how the applicant intended to work to improve teaching in his or her home institution after the workshop.

Participants were housed in a hotel at USMA; however, unlike many UFE projects, T^4E did not fund participants' lodging. The project did provide meals, as well as materials and supplies.

Project Impact

The T^4E project appears to have achieved its goal of improving participants' teaching. Fifteen of the 17 participants who responded to a survey the year following the workshop reported that their teaching had improved because of the workshop, and 13 reported that their student evaluations had improved (2 others had very high student evaluations before attending the workshop). Two participants reported that they had been nominated for institutional teaching awards.

T4E has been used as a model for workshops in other USMA departments. In addition, six participants from other institutions reported using T4E workshop materials to teach seminars or mini-workshops for faculty at their institutions, and five reported increasing their involvement with institutional centers for teaching excellence, peer review programs, and informal activities with department colleagues.

On a wider scale, in the years following the workshop, the PIs published a paper regarding the T4E model in the *Journal of Engineering Education* (February 2000) and made several presentations at ASEE meetings. In 1999, a committee of experts commissioned by the American Society of Civil Engineers (ASCE) recommended that the Society adopt the T4E workshop model for workshops to be conducted as part of its new faculty development initiative in Excellence in Civil Engineering Education. ASCE is sponsoring two such workshops in the summer of 2000, one at USMA and one at the University of Arkansas. ASCE plans to continue to expand the initiative using the T4E model. (For more information, see http://www.asce.org/exceed/.)

EXHIBIT F-2
SCHEDULE FOR T4E WORKSHOP

Sunday, 26 July 98

1500-1630	Introduction to T4E	LTC Steve Ressler
1730-1900	Seminar I - Learning to Teach	LTC Steve Ressler

Monday, 27 July 98

0800-0900	Demo Class I - Introduction to Vibration Engineering	COL Tom Lenox
0900-1130	Seminar II - Principles of Effective Teaching. Seminar III - Teaching Assessment. Seminar IV - An Introduction to Learning Styles	LTC Steve Ressler
1300-1500	Seminar V - Lesson Objectives. Seminar VI - Planning a Classroom Presentation	LTC Steve Ressler
1500-1645	Lab I - Lesson Objectives and Board Notes. (Each participant will: (1) develop lesson objectives for his or her first prepared class, (2) write the objectives on the chalkboard, (3) develop one or more “boards” for his/her first prepared class.)	Team Mentors
1645-1700	Mentor’s Wrap-up and Guidance for Tomorrow	Team Mentors

Tuesday, 28 July 98

0800-1130	Seminar VII - Communication Skills: Writing & Speaking. Seminar VIII - Communication Skills: Questioning. Seminar IX - Teaching with Technology	COL Tom Lenox

1300-1325	Lab II - Practice Class - Participant A	Team Mentors - Participants A & B present the first 25 mins. of their first prepared class; each class is followed by a 20 min. assessment.
1325-1345	Lab II - Teaching Assessment - Participant A	
1345-1410	Lab II - Practice Class - Participant B	
1410-1430	Lab II - Teaching Assessment - Participant B	
1500-1525	Lab II - Practice Class - Participant C	Team Mentors - Participants C & D present the first 25 mins. of their first prepared class; each class is followed by a 20 min. assessment.
1525-1545	Lab II - Teaching Assessment - Participant C	
1545-1610	Lab II - Practice Class - Participant D	
1610-1630	Lab II - Teaching Assessment - Participant D	
1630-1645	Mentor's Wrap-up and Guidance for Tomorrow	Team Mentors

Wednesday, 29 July 98

0800-0900	Demo Class II - Eccentric Bolted Connections	LTC Steve Ressler
0900-0930	Discussion of Demo Class	COL Tom Lenox
0950-1040	Lab III - Practice Class - Participant B	Participants B & C present their prepared class; each is followed by an assessment and discussion.
1040-1110	Lab III - Teaching Assessment - Participant B	
1110-1200	Lab III - Practice Class - Participant C	
1200-1230	Lab III - Teaching Assessment - Participant C	
1330-1420	Lab III - Practice Class - Participant D	Participant D presents first prepared class.
1420-1450	Lab III - Teaching Assessment - Participant D	
1500-1550	Lab III - Practice Class - Participant A	Participant A presents entire first prepared class.
1550-1620	Lab III - Teaching Assessment - Participant A	
1620-1630	Mentor's Wrap-up and Guidance for Tomorrow	Team Mentors

Thursday, 30 July 98

0800-0825	Lab IV - Practice Class - Participant C	Participants C & D present the first 25 mins. of their second prepared class; each class is followed by a 30 min. assessment and discussion.
0825-0855	Lab IV - Teaching Assessment - Participant C	
0855-0920	Lab IV - Practice Class - Participant D	
0920-0950	Lab IV - Teaching Assessment - Participant D	
1010-1035	Lab IV - Practice Class - Participant A	Participants A & B present the first 25 mins. of their second prepared class; each class is followed by a 30 min. assessment and discussion.
1035-1105	Lab IV - Teaching Assessment - Participant A	
1105-1130	Lab IV - Practice Class - Participant B	
1130-1200	Lab IV - Teaching Assessment - Participant B	
1200-1330	Luncheon Seminar: Overview of USMA and the USMA Academic Program	BG F. Lamkin
1330-1430	Demo Class III - TBD	Dr. Jerry Samples
1430-1445	Discussion of Demo Class	LTC Steve Ressler
1500-1630	Seminar X - application of the T^4E Model	Drs. Schmucker, Isaacs

Friday, 31 July 98

0800-1000	Seminar XI - Developing Interpersonal Rapport with Students	LTC Ressler
1000-1100	Course Assessment and Discussion	LTC Ressler
1100-1130	Discussion of Follow-up Activities	LTC Ressler

Evenings (after hours): Class preparation and rehearsal (optional). Arrange with senior mentor for after hours access to classrooms.

(3) UNDERGRADUATE FACULTY WORKSHOP IN COMPUTER NETWORKS

Principal Investigator:	Herman Hughes, Ph.D.
Organization:	Michigan State University
Workshop dates:	July 27-August 7, 1998
Workshop location:	Michigan State University

Sources of Data

An SRI researcher and an outside content expert visited the Undergraduate Faculty Workshop in Computer Networks on August 3-4, 1998. Before the visit, the project's proposal was examined. During the visit, all activities were observed, and interviews were conducted with the project PI, the Co-PI, 4 project staff, and 15 participants. In the spring of 2000, the PI provided SRI researchers an oral update. In addition, a telephone interview was conducted with one participant, and written communications were received from three others.

Project Goal

In the 1990s, most computers in organizations were or shortly would be networked. Most major universities were offering state-of-the-art undergraduate courses in computer networking; however, such courses were not available at many small colleges, including Historically Black Colleges and Universities (HBCUs), because of a lack of computer science faculty with training in this area, as well as a shortage of networking equipment.

This project's primary goal was to provide a mechanism for faculty in small colleges and universities to add up-do-date computer network education and training to their undergraduate programs. Specific objectives were to:

- Provide participants with basic network fundamentals.
- Introduce them to emerging technologies, such as wireless communication and high-speed networking.
- Allow them to work on experiments that make use of high-speed network facilities.
- Enable them to interact with network experts.
- Encourage them to develop and use instructional materia ls in the areas of computer networks.
- Promote sustained interaction among the participants after the project.

Project Description

The 2-week-long workshop was divided about equally between (1) presentations and discussions of network concepts and theory and (2) laboratory assignments involving various implementations of protocols and network designs. The first week focused on basic concepts and theory of networks; the second week covered primarily high-speed networking.

Activities

Presentations were given by expert guest lecturers, as well as by the PI and workshop staff. For example, Dr. Hughes spoke on the prospects of various competing technologies, the evolution of ISDN and its role in the sharing of medical technology, data link layers; framing, and methods of error detection and correction in passing data through computer networks. A guest lecturer from AT&T Laboratories spoke regarding real-time applications of the Internet, focusing primarily on technologies such as Packet Phones and Multicast Backbone (*Mbone).*

On most days, theoretical presentations were followed by an hour-long discussion of practical issues, such as sources of grants for equipment or how participants might proceed on campuses with no formal computer or network maintenance programs. The discussions were led by faculty from small campuses and allowed a free-flowing exchange regarding participants' anticipated barriers to implementing what they were learning, as well as suggested solutions.

Each afternoon, participants worked in the campus computer lab on assignments related to the day's presentations or on exercises for their own courses. Some participants worked individually, and others worked in groups. Dr. Hughes also held informal meetings regarding pointers on proposals to NSF for equipment.

Toward the end of the workshop, participants presented their exercises to the entire group. However, this was not the end of their work. They continued to work on their laboratory exercises and communicate with one another and with the PI as they developed presentations for a panel session at the 1999 meeting of the Association for Computing Machinery's Special Interest Group on Computer Science Education (SIGCSE). The SIGCSE meetings served not only as a vehicle for disseminating participants' projects, but also as an opportunity for participants to discuss their courses and experiences with colleagues from other institutions.

In 2000, the project offered a $1,000 grant to each participant for equipment or materials associated with a networking course, on the condition that his or her institution provide matching funds. This funding greatly facilitated participants' work.

Leadership

Dr. Herman Hughes has been professor of computer science at Michigan State University since 1984. As of 1998, he was director of the university's High-Speed Network and Performance Research Laboratory. Prior to the 1998 grant, Dr. Hughes had received three UFE grants for workshops on computer networks and three other NSF grants for equipment and research regarding computer networks. Throughout his career, Dr. Hughes, an African American himself, has shown a particular concern for training minorities in the area of computer networking.

Other workshop presenters from Michigan State included Dr. Erik Goodman, director of computer services for the College of Engineering; Dr. Thomas Atkinson, coordinator for Michigan State's campuswide network system; and Dr. Lewis Greenberg, director of MSU's campuswide network services. Guest presenters included Dr. Raj Jain of Ohio State University, who was a fellow of the Institute of Electrical and Electronics Engineers (IEEE) and of the Association for Computing Machinery (ACM), and Dr. Nicholas Maxemchuk of AT&T Bell Labs, also an IEEE fellow.

Participants

Although Dr. Hughes had hoped to have 20 participants, relatively few applications were received, compared with previous offerings, resulting in 15 participants. Dr. Hughes made a special effort to include women, minorities, and faculty from HBCUs. Of the participants, 4 were females and 11 males; 5 were whites, 3 African Americans, and 7 Asian Americans or Asians. Five were from baccalaureate institutions, seven were from comprehensive institutions, and three were from research/doctoral institutions. Six came from HBCUs.

Participants were recruited through mailings to chairs and faculty in computer science and electrical engineering departments at HBCUs and institutions with large

Hispanic enrollments nationally, and to small colleges in Michigan. Brochures also were distributed at selected meetings and made available on the PI's Web page. Department chairs were asked to nominate a full-time faculty member for participation. Applicants were selected on the basis their letters of recommendation, the strength of their background, and their stated reasons for wanting to attend the workshop.

Participants received a stipend to cover their living expenses during the workshop and funds to travel to the ACM meetings for the follow-up activity.

Project Impact

In the spring of 2000, the PI expressed certainty that every participant had taught a networking class during the 2 years following the workshop. He reported that the five participants who had taught networking for the first time had indicated to him that the workshop had provided invaluable preparation. He also stated that eight more participants had reported making substantial changes to the networking courses they had previously taught.

Of the four participants from whom the SRI evaluator received communications in the spring of 2000, three reported having changed their teaching methods because of the workshop, incorporating more laboratory time with hands-on exercises. One of the three had made only small changes in content but was planning to make substantial changes in fall 2000. All three felt that their students' understanding of concepts had increased because of the changes they had made. The fourth reported having made only small changes in content.

At the workshop, several participants reported believing that they would not be able to apply everything they had learned at the workshop in their their own institutions because of lack of technology; however, as of the spring of 2000, most had overcome these barriers, according to communications to SRI from the PI and participants. To update their campuses' technology, many had obtained grants from outside their institutions, such as NSF grants for Instrumentation and Laboratory Improvement, and all but one had obtained the $1,000 grant from the project and corresponding matching funds from their institutions. One participant reported having taken advantage of a technology manufacturer's special offer to institutions of higher education; he credited his awareness of such special offers to the workshop.

Participants at Dr. Hughes' 1997 workshop (the year before SRI's site visit) had put together a volume of more than 40 computer networking exercises, published as *Network and Data Communications Laboratory Manual* (Prentice Hall) in 1999. (For more information, see http://www.prenticehall.com/allbooks/esm_0130117021.html.) Thus, there was less pressure for participants at the 1998 workshop to publish their exercises in a volume. However, as stated earlier, the latter did develop polished exercises, presented them at a conference, and placed them on a Web site.

Exhibit F-3
SCHEDULE FOR COMPUTER NETWORKING WORKSHOP

Week #1 (Monday - Friday)

8:30 - 11-30 a.m.	Discussion of concepts, and theoretical aspects of networks.
1:00 - 2:00 p.m.	Open discussions and sharing experiences, guest presenters.
2:30 - 5:00 p.m.	Laboratory assignments: Comparing FTP over fast Ethernet vs. ATM, Transmitting data over an unreliable channel via *sockets*, Studying Packet Switching and Congestion Control, using COMNET.

Week #2 (Monday - Friday)

8:30 - 11-30 a.m.	Discussion of concepts, and theoretical aspects of networks, including high-speed networks and wireless communications.
1:00 - 2:00 p.m.	Open discussions and sharing experiences, guest presenters.
2:30 - 5:00 p.m.	Laboratory assignments: using the high speed networking research laboratory to measure ATM cell loss rate and end-to-end delay for subsequent statistical analysis. Generate the transmitter, the receiver, and the jammer node to study wireless communications, using OPNET.

(4) IAS/PARK CITY MATHEMATICS INSTITUTE (UNDERGRADUATE FACULTY PROGRAM OF THE INSTITUTE FOR ADVANCED STUDY)

Principal Investigator:	Robert D. MacPherson
Organization:	Institute for Advanced Study (IAS), Princeton, NJ
Workshop dates:	July 12-August 1, 1998
Workshop location:	Conference facility in Park City, Utah

Sources of Data

An SRI researcher visited the IAS/Park City Mathematics Institute (PCMI) on July 29 and 30, 1998. The project's proposal was examined before the visit. On July 29, the researcher was accompanied by an outside content expert. Workshop activities were observed, and interviews were conducted with the project's PI, staff, and 13 workshop participants. Two years after the site visit, two project evaluation reports and two project Web sites were examined.

Project Goals

The main goal of PCMI, of which the Undergraduate Faculty Program (UFE) was a part, was to promote interaction between the education and research communities in mathematics. The goals of the Undergraduate Faculty Program also focused on learning content and teaching methods and on dissemination. Specifically, the UFP's goals were to:

- Give higher education mathematics faculty the opportunity to develop their mathematical knowledge and their teaching skills in an environment where both research and educational goals are being pursued.
- Provide faculty an opportunity to interact with other members of the mathematics community.
- Disseminate newly acquired knowledge to the mathematics community at large.

Project Description

The Undergraduate Faculty Program was one of six separate but overlapping programs at the 1998 PCMI (other programs were the Mathematics Education Research Program, the High School Teacher Program, the Research Program, the Undergraduate Program, and the Graduate Summer School).

Activities

The focus of the 1998 UFP was linear algebra, and all UFP presentations, discussions, and hands-on sessions were related to that topic. Typically, the workshop included two hour-long UFP sessions per day, one of which covered curriculum and pedagogy or allowed participants to experiment with technology. Examples of topics at this type of session included geometry vs. algebra in the classroom, classroom incident cases, and comparing linear algebra textbooks. The other scheduled session was used for three interest groups to meet separately and work on a particular topic. Toward the end of the workshop, each interest group gave a report in a whole-group session.

The rest of the day, participants were able to work on projects for their own courses, do additional work with their small groups, attend sessions sponsored by other PCMI programs, or attend cross-program sessions targeted at all PCMI participants. At most times, sessions of various programs were held concurrently. Thus, participants were able to tailor their activities to their individual needs. For example, those who wanted to improve their content knowledge could attend sessions of the Mathematics Education Research Program or the Graduate Summer School, while those who wanted to increase their understanding of undergraduate students could attend sessions sponsored by the Undergraduate Program. The 11 cross-program sessions focused on content or on policy issues, such as the National Council of Teachers of Mathematics (NCTM) standards and the Third International Mathematics and Science Study (TIMSS).

Participants' attendance at sessions outside of their own program was an important component of the workshop, given PCMI's goal of facilitating interaction among a broad range of people in the mathematics community. Numerous social activities also were scheduled for this purpose.

Because PCMI ran so many concurrent sessions, summaries of each day's sessions were posted on-line so that participants could get an overview of those they had not attended. Reports from each small working group were also placed on a Web site. Descriptions of sessions and reports, including the UFP working groups' reports, are available at http://pcmi.knox.edu and http://www2.admin.ias.edu/ma/98report.htm.

Leadership

The PI was Robert MacPherson, a faculty member of the Institute for Advanced Study. Dr. MacPherson oversaw the development and management of the UFP, along with a number of members of the PCMI Oversight/Steering Committee. Working closely with Dr. MacPherson was Daniel Goroff of Harvard University, who was responsible for the content and operations of the workshop. He also was a presenter/discussion leader in UFP workshop sessions. Other presenters/discussion leaders included Guershon Harel of Purdue University, Wilfried Schmid of Harvard University, John Polking of Rice University, Roger Howe of Yale University, William Barker of Bowdoin College, and Joan Ferrini-Mundy of the National Research Council.

Participants

Fifteen undergraduate faculty attended. Despite the project's attempts to recruit females and faculty from underrepresented minority groups (see next paragraph), there were only three female participants, one African American, and no Hispanics. One participant came from a 2-year college, and the remaining 14 came about evenly from baccalaureate institutions (4), comprehensive institutions (5), and research/doctoral institutions (5).

The program was advertised principally though a detailed brochure distributed to professional associations (e.g., The Mathematical Association of America, the American Association for the Advancement of Science), PCMI alumni, and Historically Black Colleges and Universities. Organizers also made personal contacts with colleagues. Advertisements were placed in selected journals targeting women and minorities, such as *Black Issues in Higher Education, The Winds of Change,* the MAA Focus, the AWM newsletter, SIAM newsletter, and the MER newsletter.

The majority of the participants interviewed indicated that they had learned of UFP from advertisements received via regular mail or on the Internet. Others heard about the workshop from someone at their institution (e.g., their department chair) or were specifically invited to attend after participating in mathematics workshops the previous summer.

Participants were provided lodging, two meals a day, and educational materials.

Project Impact

Most participants planned, on returning to their home institutions, to revise existing courses or create new ones in linear algebra, integrating concepts learned at the PCMI or the use of computer software packages. Some had ideas for conferences and/or journal papers that would focus on educational and pedagogical issues in mathematics. Two came away from their PCMI experience with a desire to encourage the support of undergraduate research in mathematics at their home institutions. Others expressed a desire to become more involved in mathematics teacher preparation. One felt that the PCMI experience would help in completing a linear algebra textbook project.

According to the 11 respondents' answers to a survey conducted by the project's evaluator in the spring and summer of 1999, all had improved their knowledge of undergraduate teaching "some" or "a great deal" at the workshop. In addition, 10 had improved their knowledge of mathematics in general, and 9 had improved their knowledge of mathematics research "some" or "a great deal." Although only four had increased their frequency of interactions with undergraduate students, eight reported that the value they received from such interactions had improved. Two had increased their interactions with mathematics education researchers at least "some," and six indicated that the value they received from such interactions had improved "some."

More than half had increased their work for mathematics reform; two had increased their participation on mathematics curriculum or reform committees "a great deal," and eight had increased their participation "some." Similarly, most reported having engaged in dissemination efforts. Ten of the 11 respondents had made presentations related to the UFP program; 4 of them to 1-10 people, 3 of them to 11-25 people, and 3 to more than 25 people. Another dissemination effort came from a collaboration begun at the workshop; two participants coauthored a journal article titled "Teaching Linear Algebra: Issues and Resources" (Jane M. Day and Dan Kalman; publication in the *College Mathematics Journal* pending as of June 2000).

Exhibit F-4
TYPICAL DAILY SCHEDULE FOR PARK CITY MATHEMATICS INSTITUTE

(Shows Concurrent Sessions)

US = Undergraduate Student Program
T = High School Teacher Program
ER = Mathematics Education Research Program
G = Graduate Summer School
MR = (Mathematics) Research Program
MS = Microsoft
UF = Undergraduate Faculty Program

July 28, 1998

8:30 - 9:30 a.m.	ER - Seminar. G - Lecture. T - Building Mathematics in the Classroom. **UF - Pedagogy Group: Reports from concept sub-groups.** US - Class; Continuous Symmetry.
9:40 - 10:40 a.m.	ER - Seminar. G - Problem sessions. MR - Seminar. T - Advanced Mathematics. US - Class; Introduction to Lie Groups.
11:00 - Noon	G - Lecture. T - Teaching Mathematics with Technology. **UF - Technology Group: Reports on sample problems.** US - Working Problem Session.
1:30 - 2:30 p.m.	G - Lecture. T - Cincinnati Site Presentation. **UF - Working Problem Groups.**
2:45 - 3:45 p.m.	**Cross Program Activity: How to Read Your PCMI T-Shirt.**

4:15 - 5:15 p.m.	MR - Seminar: Equivariant D-modules on a semisimple Lie algebra and a homomorphism of Harish-Chandra. **T/UF - Seminar: Linear algebra in the high school curriculum.**
5:30 p.m.	MS Activity: Netmeeting with Jennifer Chayes and Christian Borgs of Microsoft. G - Seminar: Affine Hecke algebras.
7:00 p.m.	**UF - Panel Discussion: Getting your textbook published.**

(5) MOLECULAR GENETIC AN ALYSIS APPLIED TO EVOLUTION, ECOLOGY, AND SYSTEMATIC BIOLOGY: AN EXTENDED LABORATORY COURSE

Principal Investigator:	Frank T. Bayliss
Organization:	San Francisco State University, San Francisco, CA
Workshop dates:	August 1-14, 1998
Workshop location:	San Francisco State University

Sources of Data

An SRI reseacher visited the Molecular Genetic Analysis workshop on August 1 and 13, 1998. On August 13, the researcher was accompanied by an outside content expert. All workshop activities were observed, and interviews were conducted with the project PI, the Co-PI, four project staff, and participants. Before the site visit, the project's proposal was examined. Oral and written updates were received from the PI in June 2000.

Project Goals

The primary goals of the project were that undergraduate faculty who specialize in evolutionary biology, ecology, and systematic biology:

- Increase their knowledge of molecular biology and techniques.
- Incorporate molecular biology and its techniques into their laboratories and research.

Project Description

The project's principal component was an intensive 14-day course in molecular genetics and evolutionary biology designed to broaden participants' content knowledge and their skills in laboratory techniques through lectures, demonstrations, and experiments.

Activities

The workshop opened with a 1-day symposium consisting of presentations and poster sessions by 15 faculty who had participated in earlier similar workshops. The remainder of the workshop was divided between staff presentations and hands-on laboratory work. Seminars were held on five evenings. A broad range of topics was covered, including DNA replication and polymerase chain reaction, DNA sequencing/restriction analysis, and genetic distance and maximum likelihood. Practical topics also were covered, and laboratory techniques were demonstrated.

Approximately half the workshop's time was devoted to laboratory sessions during which participants worked in five-person groups to learn techniques and to develop teaching modules incorporating the techniques. Although each group specialized in the application of molecular techniques to a given content area (vertebrates, invertebrates, or plant systems), participants were free to develop modules within that area individually or collaboratively. The PI rotated regularly through the labs, monitoring the work of all groups. In addition, two staff members were available to each group for logistical and organizational assistance.

During the last 2 days of the workshop, all projects were presented to the whole group by their developers. Presentations included content background, as well as a description of the experimental techniques and results. The atmosphere for the presentations was informal, allowing for questions, answers, and discussion.

The project also included preworkshop preparation and postworkshop assistance. To prepare for the workshop, participants were required to read various materials, complete homework assignments, and begin preparation of a laboratory exercise. After the workshop, San Francisco State University (SFSU) faculty and an instructional support technician provided technical assistance to participants, primarily via e-mail. In addition, participants were asked to submit summaries of their projects and materials for inclusion on the project Web site. A 4-day follow-up session that was planned for the summer following the workshop was cancelled because a majority of the participants had time conflicts.

Leadership

The PI, a full professor at SFSU, has a long history of conducting similar workshops. In addition to coordinating the Molecular Genetic Analysis workshop at SFSU, for several years, Dr. Bayliss had taught numerous short courses in the Chautauqua program, and had organized and taught in a number of science education projects funded by NSF and NIH grants. Throughout, Dr. Bayliss has focused on introducing modern techniques into the biology laboratory and promoting collaboration among biologists of varying backgrounds. At SFSU he has built a team of like-minded faculty members, as well as a group of staff and graduate assistants who worked with him to conduct the 2-week course.

Participants

Twenty persons participated in the workshop, but only 13 were undergraduate faculty from U.S. institutions. (Seven participants either were undergraduate faculty from foreign institutions or were not undergraduate faculty; two were preservice teachers from the PI's institution.) U.S. undergraduate faculty participants included 3 females and 10 males. None were from underrepresented minority groups. One was from a 2-year college, three from baccalaureate institutions, four from comprehensive universities, and five from research/doctoral institutions.

Participants were recruited through announcements in publications of professional associations, such as the American Association for the Advancement of Science (AAAS) and the American Society for Microbiologists, and through targeted electronic bulletin boards and newsgroups on the Internet. Brochures also were sent to biology departments in colleges and universities across the country and to faculty who had participated in past workshops. Applicants were asked to submit a statement describing their research, proposing a project for the workshop, and committing to attend the follow-up session. Participants' laboratory materials and supplies were paid for through the UFE grant, as were lodging and meals for participants from outside the local area.

Project Impact

All participants who were interviewed expected the workshop to change and enrich their teaching. The types of courses varied, ranging from ecology to health topics. The numbers of students each participant anticipated would be affected ranged from several dozen to several hundred each year. Several participants indicated that they would seek funding to develop new courses, make substantial revisions to existing courses, and/or develop projects for undergraduates incorporating molecular genetic analysis. Several indicated that they would be spearheading broad curricular change at their home institutions. They felt that the experience and knowledge they had gained would increase their credibility as advocates of curriculum change.

The project did not conduct a systematic follow-up study of the impact of the workshop on participants. However, as of the summer of 2000, the PI had heard from four undergraduate faculty who had participated in the workshop and one who had participated in the symposium. Two faculty participants had submitted grant proposals to improve instruction at their home institutions. The other two had attended further professional development activities on molecular biology the year following the workshop. The symposium participant had published his research findings in a refereed journal and acknowledged the UFE workshop in the publication.

Exhibit F-5.
MOLECULAR GENETIC ANALYSIS WORKSHOP – FIRST WEEK

Saturday, August 1, 1998: meeting at Seven Hills Conference Center for talks and posters presented by the 1996 and 1997 UFE participants. 1998 UFE participants are strongly encouraged to attend.

Monday, August 3, 1998

8:30 a.m.	Orientation and introductions	Faculty and students
	Central Dogma of Molecular Biology, Nucleic Acid Structure and Function	Bayliss
9:30 a.m.	DNA Replication/Polymerase Chain Reaction (PCR)	Bayliss
10:30 a.m.	Laboratory facility: (a) Orientation to Facilities, (b) Extract DNA from "cheek" cells of participants and set-up PCR for VNTR analysis, (c) Load agarose mini-gel with pre-digested DNA's	Bayliss
1:30 p.m.	Laboratory: Thematic Research Groups meet and plan projects	
	Group I: Plants	Patterson, Bayliss, Spicer
	Group II: Invertebrates	Spicer
	Group III: Fish/Misc. Invertebrates	Routman
	Group IV: Vertebrates	Girman
7:00 p.m.	Keynote lecture	

Tuesday, August 4, 1998

8:30 a.m.	DNA Sequencing/Restriction Analysis	Bayliss
9:30 a.m.	Complex Genome and the Search for Variation	Routman
10:30 a.m.	Laboratory facility: (a) Load agarose gels to visualize DIS80 VNTR PCR products, (b) Start preparation of samples for thematic research projects	Bayliss
1:00 p.m.	Laboratory: (Commence thematic group projects)	
	Group I: Plants	Patterson, Bayliss, Spicer
	Group II: Invertebrates	Spicer
	Group III: Fish/Misc. Invertebrates	Routman
	Group IV: Vertebrates	Girman
7:00 p.m.	Seminar speaker	

Wednesday, August 5, 1998

8:30 a.m.	Detection of Sequence Variation w/ DGGE and SSCP	Girman
9:30 a.m.	Basic and Computer Assisted Primer Design	Staff
10:30 a.m.	Laboratory facility: (a) Work on research projects	

7:00 p.m.	Seminar	Derek Girman

Thursday, August 6, 1998

8:30 a.m.	Analysis of Molecular Data: Diversity and Divergence	Routman
9:30 a.m.	Phylogeny Estimation and Population Genetics	Spicer
2:00 p.m.	Group research projects (Groups I - IV)	

Friday, August 7, 1998

8:30 a.m.	Parsimony	Spicer
9:30 a.m.	Genetic Distance and Maximum Likelihood	Spicer
1:00 p.m.	Group research projects (Groups I - IV)	
7:00 p.m.	Open	

Saturday, August 9, 1998

9:00 - Noon	Demonstrations of Lab Equipment	Staff
	Computer Software Molecular Analysis	De Geoffrey
1:00 p.m.	Open laboratory	

Sunday, August 10, 1998: 9:00 a.m. - Open laboratory

(6) USING MATHCAD IN TEACHING PHYSICAL CHEMISTRY

Principal Investigator:	Sidney H. Young
Organization:	University of South Alabama, Mobile, AL
Workshop dates:	July 19-23, 1998
Workshop location:	University of South Alabama

Sources of Data

An SRI researcher visited this workshop on July 20-21, 1998, and was accompanied on the first day by an outside content expert. The project's proposal was reviewed in advance. All workshop activities were observed, and interviews were conducted with the project's PI, the 2 co-PIs, and 12 participants.

Project Goals

The project's goals were to help undergraduate chemistry faculty to:

- Gain fluency in using Mathcad.
- Develop and present mathematical methods useful in physical chemistry lecture and laboratory courses.

Project Description

This project included two workshops held at the University of South Alabama, one in the summer of 1997 and another in 1998. The workshops were organized to offer physical chemistry faculty the means of incorporating numerical methods into the undergraduate curriculum using Mathcad, a software package that displays equations as they are written in text and reference books, and allows them to be solved by using functions from a pull-down menu bar. The ease of its use allows chemistry instructors and students to focus on the chemistry of experiments, rather than on solving mathematical problems or on generating complex computer programs.

Activities

During the visited (1998) workshop, participants learned the basics of using Mathcad and worked on individual projects involving the use of Mathcad for their own courses. The first day was dedicated to a presentation of how to use Mathcad, followed by hands-on exercises. Participants also were asked to identify a teaching project they wished to develop later in the workshop.

The following 2½ days included presentations of mathematics content related to physical chemistry (e.g., statistical methods and calculus methods). As the presenter discussed the content, he modeled how to manipulate data and equations with Mathcad, and fielded participants' questions. For each content area, there was a lengthy discussion of its relationship to chemistry, and there were hands-on Mathcad activities. Throughout the presentations and discussions, emphasis was placed on how different methods could be adapted for students with various types of learning styles.

On Thursday morning, participants worked on their own teaching projects. The session was quite informal; participants worked either singly or in small groups, and the co-PIs walked around the room and conferred with participants, offering advice and suggestions. On Thursday afternoon, all participants presented their work in progress.

After the workshop, participants were encouraged to test modules developed by other participants and to keep in touch with the project leaders and with each other via the project's Web site and electronic mail. Once completed, the modules were submitted for posting on the Web site. In addition, participants were expected to present at a symposium at the American Chemical Society (ACS) meetings.

Leadership

The Principal Investigator of this project was Sidney Young, a tenured professor in the University of South Alabama (USA) chemistry department. Dr. Young is seen as a leader of educational reform among physical chemists in both his own institution and the larger field. He has played an important role in incorporating Mathcad into the undergraduate curriculum at USA and has engaged a number of his colleagues in the chemistry department in this effort. Dr. Young and his two Co-PIs, Jeffry Madura and Andrzej Wierzbicki, have been collaborating since 1994 and have coauthored several articles on using software to teach numerical methods in physical chemistry.

Participants

Thirteen participants attended the workshop. Three were female; none were from underrepresented minority groups. Although the majority of the participants were physical chemists, four specialized in other areas (e.g., organic chemistry, biochemistry). Four were from baccalaureate institutions, six were from comprehensive institutions, and three were from research/doctoral institutions.

The project was advertised through brochures mailed to chemistry departments and through announcements in disciplinary journals and on a chemistry discussion list on the Internet. In addition, project staff personally contacted schools within USA's region. The project sought to have a balance of participants in terms of geographic region, university size, and interests in the use of numerical methods in science. These goals were accomplished to some degree, although most participants came from the Southeast United States. The project also sought to include minority faculty, but none applied.

The grant paid for the participants' room and board (participants were housed in a dormitory in the same building as the workshop laboratory), as well as for a host of written materials and copies of the Mathcad software.

Project Impact

Although participants interviewed at the workshop talked about different kinds of outcomes emerging from this experience, all agreed that the workshop had met its goals of helping them gain fluency in Mathcad and developing modules for their courses. All felt that what they had learned would allow them to teach undergraduates more effectively, focusing on inquiry-based learning and deemphasizing mechanical calculations and rote memorization. They felt that this change would enable them to recruit and retain more students.

As stated earlier, participants' modules using Mathcad were placed on the project's Web site, and participants were expected to present at a symposium at American Chemical Society meetings. The Web site and symposium almost guaranteed widespread dissemination, given that the Web site had received more than 500 "hits" a month in the period before the workshop, and the meetings usually had very broad attendance.

Exhibit F-6
SCHEDULE FOR MATHCAD WORKSHOP

Sunday

9:00 a.m. - Noon	General Introduction to Workshop. Introduction to Mathcad - Sid Young
1:30 p.m. - 5:00 p.m.	Mathcad Lab; begin to work on project

Monday

9:00 a.m. - Noon	Blending numerical methods into the Physical Chemistry course - invited speaker, Peter Atkins. Calculus methods - Jeffry Madura
1:30 p.m. - 5:00 p.m.	Calculus lab; continue work on project

Tuesday

9:00 a.m. - Noon	Statistics methods; using Mathcad in the laboratory - Sid Young
1:30 p.m. - 5:00 p.m.	Statistics lab; continue work on project

Wednesday

9:00 a.m. - Noon	Matrix and differential equations methods - Jeffry Madura
1:30 p.m. - 5:00 p.m.	Free time

Thursday

9:00 a.m. - Noon	Work on projects
1:30 p.m. - 5:00 p.m.	Progress report on projects; wrap-up

Evenings: Computer time available

(7) INNOVATIVE PHYSICS EXPERIMENTS FOR BEGINNING COLLEGE FACULTY

Principal Investigator:	Deva Sharma
Organization:	Winston-Salem State University, North Carolina
Workshop dates:	July 26-31, 1998
Workshop location:	Winston-Salem State University

Sources of Data

An SRI researcher visited this workshop on July 28-29, 1998. On July 28, the researcher was accompanied by an outside content expert. During the visit, all activities were observed, and interviews were conducted with the project PI and 18 participants. In spring of 2000, the PI provided written and oral updates.

Project Goals

Most U.S. universities offer freshman-level general physics courses, which generally have large enrollments. Experiments for such courses can be quite expensive. To reduce the courses' costs without sacrificing hands-on work, this project's main goals were to:

- Develop inexpensive innovative experiments for physics faculty.
- Provide beginning physics faculty with knowledge regarding appropriate innovative experiments, and how these can be done inexpensively.
- Have beginning physics faculty develop, test, and evaluate innovative experiments.
- Disseminate experiments to beginning physics faculty.

A related goal was to engender communication and collaboration among faculty from diverse campuses.

Project Description

Activities

This project had a decidedly practical focus. Most presentations focused on demonstrating existing innovative experiments and, especially, discussing how they could be carried out in poorly equipped settings. An entire session titled "How to Build and Maintain an Inexpensive Laboratory" included a discussion of equipment at each participant's campus, ways additional items could be found, how old items could be replaced, and how even broken equipment could be used to illustrate physical principles.

The workshop introduced Internet sites containing materials, videos, lesson plans, instructional activities (e.g., Fermi Labs' Introduction to Particle Physics site), and catalogs of CDs and laser discs that could be used in physics instruction. These types of electronic materials were viewed as particularly useful because they can enable students to perform virtual experiments when equipment is not available.

Teaching methods were a secondary focus of the workshop; most demonstrations included some discussion of teaching methods, and pedagogy was the sole focus of one session, titled "Research in Physics Education and Its Effect on the Classroom and Lab."

An important component of the workshop was participants' hands-on development of new experiments. Because of preworkshop communications from the PI, participants came to the workshop well prepared for this activity. Approximately 20% of the time was allocated for groups of five participants (one senior faculty member and four beginning faculty members) to work on particular physics themes and enumerate activities that could be used to illustrate the themes. During these sessions, all participants were highly engaged at their individual work and in discussions with others in their group. These efforts resulted in 28 new experiments, such as "Projectile Motion," "Index of Refraction Using an Overhead Projector," and "Balloons and Coulomb's Law." Toward the end of the workshop, all experiments were presented by their developers to the entire group.

During the year following the workshop, the new experiments were field tested, evaluated, and refined by the PI and three participants at their institutions. A kit containing a volume with descriptions of the refined experiments, a list of materials needed to conduct them, and many of the actual materials was then sent to each participant. The PI maintained contact with participants during the year after the workshop, and an informal follow-up was held at the 1999 American Association of Physics Teachers (AAPT) meetings, at which several participants presented their experiments. Further dissemination of the experiments took place when the PI presented the experiments at a subsequent AAPT meeting.

Leadership

Dr. Sharma, the PI, has been a professor of physics at Winston-Salem State University (an HBCU) since 1979, teaching mainly introductory physics and physical sciences. The Innovative Physics Experiments project built on 10 previous workshops in physics pedagogy led by Dr. Sharma and on many innovative physics experiments in whose development he had taken part.

Presenters included a past president and the vice president of the American Association of Physics Teachers; the chair of the Physics Department of University of North Carolina, Asheville; and a physics education specialist from North Carolina State University, Raleigh. When participants worked in the computer lab room, college computer staff were available to help troubleshoot any hardware or software problems.

Participants

Twenty-four faculty members—3 females and 21 males—attended the 1998 workshop. Although 12 of the participants were from HBCUs and 3 were from Hispanic-serving institutions, only 1 was African American (2 more were from sub-Saharan Africa), and 2 were Hispanics/Latinos. The plurality of participants (42%) came from 4-year institutions. Approximately 30% came from comprehensive institutions and another 25% from 2-year institutions. One respondent was from a research/doctoral institution. All the participants taught physics and/or physical sciences; however, most came from schools that do not offer an undergraduate degree in physics.

The PI recruited participants by mailing invitations to every HBCU in the country and to all small colleges in the South. Applicants had to be teachers of freshman-level and/or sophomore-level physics. Its primary target was faculty in their first 5 years of teaching physics. Ultimately, participants included 6 senior faculty and 18 faculty in their first 5 years. The project paid for participants' lodging and gave them a stipend for meals.

Project Impact

At the workshop, most participants who were interviewed stated that they expected to incorporate the experiments they had learned during the workshop into their courses the following fall. Interviewees said that part of their motivation was to rekindle students' interest in physics, which was so low at their schools that the very existence of their departments was threatened. Given the low level of demand for physics courses and the fact that many faculty came from departments where physics merely served the needs of other departments, most participants anticipated incorporating the experiments into existing courses rather than developing new physics courses.

The precise number of participants who actually went on to revise their courses is not known; however, 2 years after the workshop, the PI reported having received unsolicited communications from approximately 12 participants indicating that they had incorporated some experiments into their courses.

Exhibit F-7
SCHEDULE FOR WORKSHOP ON INNOVATIVE PHYSICS EXPERIMENTS

July 26, 1998		
7:00 - 7:30 p.m.	Introduction to Workshop	Dr. Sharma
7:30 - 8:30 p.m.	How to Make Physics Fun?	Dr. Ronald Edge-Past President of AAPT
8:30 - 9:00 p.m.	Questions and answers	
July 27, 1998		
9:00 - 10:15 a.m.	Introductions/Distribution of Materials, Discussion of Workshop Agenda	Dr. Sharma
10:30 - Noon	String and Sticky Tape Experiments	Dr. Ronald Edge, USC - Columbia
1:00 - 2:30 p.m.	Review of Existing Experiments	Dr. Sharma and Mr. Van Swearingen
2:45 - 5:00 p.m.	Research in Physics Education and Its Effect on the Classroom and Lab	Ms. Lisa Grable
July 28, 1998		
8:30 - 10:15 a.m.	Innovative Physics Teaching Projects Using Web Lab	Ms. Lisa Grable
10:45 - Noon	Focus on Physics Demonstrations	Ms. Lisa Grable
1:00 - 2:30 p.m.	Some Criteria for Good Demonstrations Leading to Classroom Exercises and Laboratory Experiments	Dr. John Hubisz, NCSU, Raleigh
2:45 - 5:00 p.m.	Begin Development of New Experiments	Group sessions
July 29, 1998		
9:00 - 10:30 a.m.	How to Build and Maintain an Inexpensive Laboratory	Dr. John Hubisz
10:45 - Noon	Development of New Experiments	Group sessions
1:00 - 2:30 p.m.	Experimental Aspects of Physics Through Lecture Demonstrations	Dr. Mike Ruiz, Appalachian State University, NC
2:45 - 5:00 p.m.	Development of New Experiments	Group sessions
8:30 - 9:30 p.m.	WSSU Observatory (Optional - weather dependent)	
July 30, 1998		
9:00 - 10:30 a.m.	Presentation of New and Home Experiments	Participants in Physics Lab
10:45 - Noon	Optical Illusions and Experiments	Dr. Ruiz, UNC, Asheville
1:00 - 2:30 p.m.	Physics Demonstrations	Dr. Chowdhury and Keeth Willingham
2:45 - 3:45 p.m.	Error Analysis	Dr. Sharma
4:00 - 6:00 p.m.	Giggs Gallery and Reynolds Gardens Tour (Optional)	
July 31, 1998		
9:00 - 10:30 a.m.	Physics Demonstrations by Participants	
10:45 - Noon	Summary Session: Evaluation, Web Site and Follow-up Activities	
1:00 - 2:00 p.m.	Certificates, Stipends, Goodbyes	

(8) IMAGE PROCESSING APPLIED TO CLASSROOM TEACHING (IMPACT)

Principal Investigator:	Roxanne Baxter Mendrinos
Organization:	Foothill College/Community Colleges for Innovative Technology Transfer, Inc. (CCITT)
Workshop dates:	August 10-14, 1998
Workshop location:	Foothill College, Los Altos, CA

Sources of Data

An SRI researcher visited the IMPACT workshop on August 12-14, 1998. On August 12 and 13, the researcher was accompanied by an outside content expert. The project proposal was read before the visit. All workshop activities were observed, and interviews were conducted with the project PI, 2 workshop instructors, and 11 participants. In the spring of 2000, an SRI researcher examined the project's Web sites. Written updates were provided by the PI in June 2000.

Project Goals

The project sought to provide faculty with training in four technologies: remote sensing/image processing (RS/IP) and geographic information systems/geographic positioning systems (GIS/GPS). The project's principal objectives were to:

- Train undergraduate faculty in the use of RS/IP and GIS/GPS, using curriculum modules developed by CCITT.
- Develop additional curriculum modules integrating the four technologies into each participant's instructional area.
- Instruct faculty in the use of the Internet and its resources to develop curriculum using the four technologies.
- Assist faculty in developing an awareness of leading-edge ideas and applications that are reshaping the disciplines through the four technologies.
- Adapt and disseminate the curriculum modules developed by the undergraduate faculty participants on the national, regional, and local levels.
- Increase the level of communication and cooperation among participants while developing curricula at their home institutions.

Project Description

Foothill College received the UFE grant on behalf of CCITT, a national coalition of 12 community colleges with government and industry partners including the National Aeronautics and Space Administration (NASA) and NASA contractors, the Universities Space Research Association, the National Center for Advanced Technologies, and the Environmental Systems Research Institute. The grant was used to fund one planning workshop and seven regional summer workshops in 1998 and 1999 at Foothill College (California), Brevard Community College (Florida), Prince George's Community College (Maryland), University of Houston (Texas), and College of the Mainland (Texas). The 1998 workshops focused on RS/IP, and the 1999 workshops focused on GIS/GPS.

Activities

The majority of the 5-day workshop was devoted to demonstrations of RS/IP and related hands-on activities. Faculty and guest lecturers were experts not only in the technologies but also in their substantive fields. For example, a session on remote access microscopes was given by a professor of genetics, and a session on multispectral images was given by a researcher from the NASA Ames Research Center. A half-day field trip to NASA Ames was also scheduled for participants to observe the use of RS/IS in a real-world setting.

Following each demonstration, the workshop included time for participants to engage in structured hands-on activities. A binder containing all lecture notes, training activities, and a CD-ROM containing interactive activities and data was given to participants at the beginning of the workshop. Some of the activities and curriculum materials had been developed under an earlier NSF Advanced Technological Education (ATE) grant received by CCITT. These resources were expanded, and new materials were developed, under the current grant.

In the last 2 days of the workshop, 5 hours were allocated for participants to work on modules for their own courses. Sessions were held in a classroom equipped with sufficient computers for all participants. Thus, participants were able to work on their modules individually, although a few worked in small groups. During the hands-on sessions, project staff circulated around the room, discussing participants' work and offering assistance as needed. The last afternoon was dedicated to participants' presentations of their modules, including how the modules would be integrated into their courses. Each presentation was followed by feedback and suggestions from other participants and staff.

An interesting feature of this workshop was that it was multidisciplinary, including topics from a broad range of disciplines, including life sciences, earth sciences, physical sciences, social sciences, and dentistry. Although participants tended to interact mainly with others from similar disciplines, there also was considerable interaction across disciplinary areas. The field trip, a dinner, and scheduled breaks allowed for considerable and fertile exchange of ideas.

Over the course of the grant, the project continued to develop CCITT's existing Web site. A second Web site exclusively for the 1998 Foothill workshop was also developed so that participants could share their curriculum training materials, curriculum abstracts, and lesson plans. As of June 2000, both Web sites still existed, at http://earth.fhda.edu/ and http://impact.fhda.edu/, respectively.

Leadership

The project's PI, Dr. Roxanne Baxter Mendrinos, is Professor and Library Systems Administrator at Foothill College. She has had a long-standing interest in technology in the classroom and is author of *Using Educational Technology with At-Risk Students* (Greenwood Press). Dr. Mendrinos has been involved with technology at Foothill College in a variety of capacities, for example, working with a geology instructor to set up the college's Image Processing and Digital Mapping Center. Dr. Mendrinos organized the Foothill workshops, bringing together a team of instructors. In addition, she worked with a team in the design of the CCITT Web site, virtual classroom, and listserv, and arranged for all guest instructors.

Workshop instructors and guest lecturers included the head of Foothill College's Earth Science Department, a faculty member from the College's Microbiology and Environmental Science Department, two researchers from NASA Ames Research Center, and an Associate Professor of Genetics from California State University, Stanislaus.

Participants

Twenty-one undergraduate faculty attended, 15 males and 6 females. None were from underrepresented minority groups. Fifteen were from the California State Community College system, three were from comprehensive universities, and three were from doctoral institutions. Most participants taught either life sciences or earth sciences, exceptions being an anthropologist, a mathematician, a physical scientist, and an instructor from a dental program. Most participants had tenure.

The workshop recruited participants by sending a brochure and application form to the deans of instruction, science and mathematics department chairs, and faculty members at 2-year and 4-year institutions throughout California. Announcements were posted to newsgroups serving minorities and women in science education. Applicants were required to indicate what they hoped to achieve as a result of the workshop and describe a curriculum module to be developed. A written endorsement from each applicant's department chair or dean was also required. Preference was given to applicants who had been teaching less than 5 years.

All participants received a stipend to cover subsistence for the days of the workshop, and participants from outside the local area also received a subsidy for lodging.

Project Impact

About two-thirds of participants indicated that they would have their students work directly with the technologies they had learned. Examples of anticipated projects included:

- Working in small groups, students would learn problem-solving and critical-thinking skills by making *a priori* hypotheses regarding relationships and then taking measurements to test their hypotheses.
- In a general education natural disasters course, students would use images to interpret the potential for landslides in the San Francisco Bay area, given slope, rock, types of vegetation, and precipitation.
- In a geology class, students would study earthquakes by examining the San Andreas fault as observed from space.

The remaining third of the participants did not anticipate having their students work directly with the technologies, either because of lack of equipment or because their courses had no lab component. However, most of them were looking forward to using the technologies to develop presentations for their classes.

Exhibit F-8
SCHEDULE FOR IMPACT WORKSHOP

Monday, August 10, 1998

9:00 a.m.	Introductions	Dr. Roxanne Baxter Mendrinos
9:15 a.m.	Welcome	Dr. Leo Chavez
9:30 a.m.	Imaging the Earth System; An Introduction to Imaging Systems and Software. Presentation will include using VISTA Archive.	Chris Di Leonardo

10:45 a.m.	Welcome	Dr. Bill Patterson
11:00 a.m.	Get the Picture - An Introduction to Digital Images, Data, Image Enhancement and Histograms	Hands-on activity appropriate for all science disciplines.
1:00 p.m.	Seeing is Believing: Working with Measurements as Calibration of Images and Temporally Registered Data	Hands-on activity appropriate for all science disciplines.
3:00 p.m.	End of Session	

Tuesday, August 11, 1998

9:00 a.m.	Introduction: Issues in Creating an Image Processing Lab	
9:15 a.m.	Features of the Seafloor: Evidence of Plate Tectonics	Discipline areas: Earth, Marine, Environmental, and Biological Sciences
10:45 a.m.	Aerial Waterfowl Counts	Discipline areas: Biology, Environmental Science, Ecology
1:15 p.m.	Relationships Between Trees: Molecular Taxonomy	Discipline areas: Botany Molecular Biology, Evolutionary Biology, Forestry, General Biology
2:10 p.m.	Seeing the Forest Through the Trees: Consideration of Scale, Resolution, and Multispectral Data in Image Analysis	Discipline areas: Forestry, Biological, Environmental Ecosystem Sciences
3:00 p.m.	End of Session	

Wednesday, August 12, 1998

9:00 a.m.	Introduction	
9:15 a.m.	Image Classification using Multi-Spec	Dr. Jay Skiles, Ph.D.-PI with the SETI Institute
12:20 p.m.	Bus leaves for field trip to NASA/Ames Research Center	
1:00 p.m.	Arrive at NASA/Ames Research Center	
4:30 p.m.	Return to Foothill College	
6:00 p.m.	Banquet dinner at the Hyatt Rickey's. Reconstructing Past Environments with Pollen Analysis	Hector L. D'Antonio, Ph.D., Assistant Branch Chief in the Ecosystem Science and Technology Branch, NASA/Ames Research Center

Thursday, August 13, 1998

9:00 a.m.	Remote Access Microscopes in the Curriculum	Dr. Janey Youngblum, Ph.D., Associate Professor of Genetics California State University, Stanislaus
10:30 a.m.	Scanning Demonstration, Video Capture, Flat Bed Scanner, Imaging Microscopy	
11:30 a.m.	Geographic Information Systems and Urban Development	Dr. Len Gaydos, Ph.D., USGS and NASA/Ames Research Center
1:00 p.m.	Work on curriculum integration and the development of plans to be used in one's teaching	
2:10 p.m.	Continuation of group and individual projects	
3:00 p.m.	End of Session	

Friday, August 14, 1998

9:00 a.m.	Introduction
9:15 a.m.	Work on curriculum integration and the development of plans to be used in one's teaching
10:45 a.m.	Work on curriculum integration and the development of plans to be used in one's teaching
1:00 p.m.	Presentation of group and individual projects
3:00 p.m.	End of Session

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