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ABSTRACT

The purpose of the National Science Foundation's Research Experiences for Undergraduates (REU) program is to provide undergraduate students with hands-on research experiences. Two kinds of grants are provided: Sites, in which groups of students participate in various organized activities with several researchers; and Supplements, where one or more undergraduates participate in the ongoing research of investigators with active National Science Foundation awards. This report summarizes an evaluation of the first 3 years of the program, covering program history, student profiles in terms of gender and race/ethnicity, changes in students' educational and career plans, characteristics of site and supplement awards, student characteristics, achievement of awardee, and participant satisfaction. The program evaluation found that the program helped uncertain students to clarify their preferences regarding graduate school attendance, field of specialization, and career path; and the program bolstered the certainty of highly interested students about their initial decisions in these areas. Students' expected graduate school majors differed by gender and race/ethnicity. Graduate school majors did not change appreciably as a result of REU. Suggestions are offered for program improvements, and an appendix outlines the survey and sampling strategy. Includes two references. (JDD)

National Science Foundation
Report 90-58

May 1990

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A Report By
NSF's Program Evaluation Staff

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TABLE OF CONTENTS

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## I. INTRODUCTION AND PURPOSE

This report summarizes an evaluation of the first three years of the Research Experiences for Undergraduates (REU) program. The purpose of the program, begun in Fiscal Year 1987, is to provide undergraduate students with hands-on research experiences. NSF makes two kinds of grants: Sites, in which groups of students participate in various organized activities with several researchers, usually during the summer; and Supplements, where one or more undergraduates participate in the ongoing research of investigators with active NSF awards. Approximately 450 Site awards and over 2,700 Supplements were made in the first three years of program operation, involving about 11,000 students. In FYs 1987 through 1989, $17.0 million was spent on Sites and $21.3 million was spent on Supplements.

The evaluation was intended to examine the short-term impact of the program on the students and identify areas in which program management can be improved. The study examined the program's objectives of: (1) attracting talented undergraduates to science or engineering careers; (2) encouraging undergraduates to attend graduate school in science or engineering; and (3) enhancing undergraduate education. To assess the degree to which these objectives were met in the near term, survey responses from 1,028 REU awardees (Site Project Directors [PDs] and Supplement Principal Investigators [PIs]) and 1,953 students were analyzed. Details of the survey, and sampling strategy, are provided in Appendix A.

This report is based on a study that was designed and overseen by NSF's Program Evaluation Staff, and conducted by Abt Associates Inc. of Cambridge, Massachusetts. Information about the availability of the detailed study may be found on page 19.

## II. PRINCIPAL FINDINGS

### A. Types of Students Served

- Two types of students participate: Those who are deeply interested in a particular field of science or engineering (S/E) and wanted to do research in it, and those who had a definite interest in S/E but are to varying degrees uncertain about pursuing graduate study in an S/E major or working in S/E. Students of these two types differ in reasons for participating, satisfaction with particular aspects of their REU experience, pre-REU educational and career aspirations, certainty of graduate school major, and the likelihood of going to graduate school.

- Two-thirds of students participated during or immediately after their junior year, 21% after sophomore year; 6% were seniors, and 4% freshmen. Sophomores were more likely to participate in Site awards.

- Thirty-nine percent of Supplement and 43% of Site participants were female, while 9% of Supplement and 10% of Site students were from racial/ethnic groups that are underrepresented in science and engineering. These percentages are much higher than the general involvement of these groups in science and engineering. Site awardees, whose complement of minority students went from 7% in FY 1987 to 13% in FY 1989, were more likely to recruit minority and female participants actively than Supplement awardees.

- Fifty-nine percent of students came from Predominantly Undergraduate Institutions (PUIs) (See Note 1 for definition). More than two-thirds of students from PUIs participated in REU awards at non-PUI institutions.

- Slightly more than one-half of all students visited another institution to participate in REU.

- Chemistry and biology majors were most likely to participate because they wanted to know if science or engineering, or research, was appropriate for them, while computer science majors, and to a lesser extent engineering, physics, and astronomy majors were more likely to be certain of their future plans.

- Behavioral science majors, and to a lesser extent geoscience and chemistry majors, were more likely to participate because of the PI/PD's reputation, or the reputation of the institution, than students with other majors.

B. Effects on Educational and Career Decisions

- The short-term program impact is best characterized as (1) helping the uncertain students to clarify their preferences regarding attending graduate school, field of specialization, and career path; and (2) bolstering the certainty of the highly interested students about their initial decisions in these areas.

  - Before participation in REU, nearly 75% of students anticipated acquiring either a masters or doctorate; after REU 92%, reported their intention to do so; the percentage planning to acquire a PhD or DSc rose from 45% to 57%.

  - Regardless of type of specific impact experienced, 80% of students indicated that REU increased their interest in science and engineering.

- Students' expected graduate school majors differed by gender and race and ethnicity, but did not change appreciably as a result of REU. Chemistry was the only major in which all groups were strongly represented.

  - Males were far more likely to select engineering, physics, and computer sciences, while females were more apt to choose biological and social science majors. There were no marked gender differences with regard to preferences for majors in astronomy, mathematics, and the geosciences.

  - Asians were overrepresented in engineering compared to their numbers in the general population, but somewhat less likely than others to choose computer science majors. Blacks and Hispanics selected physics and engineering majors less frequently than other students, but chose biological and behavioral science majors more frequently.

  - Blacks were also less likely to anticipate mathematics and earth sciences as graduate school majors, while Hispanics were less likely than others to elect majors in computer sciences.

- Sixty-eight percent of all early participants who could be in graduate school as of September 1989 had enrolled in graduate S&E programs. Those in graduate school at the time of the survey who had attended REU because of their high interest in a particular field were more likely than those who were uncertain about educational and career plans to indicate that REU caused them to be more, or much more, confident in their choice of graduate major.

C. Student Satisfaction with REU Participation

- Students and PIs/PDs alike judged the same activities as beneficial: seeing how research is done, working on independent projects, and conducting experiments independently.

- Of the four educational objectives cited by PIs/PDs as having been achieved during the course of their REU project, students indicated a high level of satisfaction with the achievement of three: discovering the nature of the job of a researcher, learning specific research techniques, and exploring the basics of the scientific method. The objective on which there was not agreement was that of obtaining substantive knowledge of the field.

- Students participating because they loved a particular field and wanted to do research in it were generally more satisfied with their REU experience overall than those who wanted to "test the waters"; the latter were more likely to be very satisfied with the specific aspects of learning about the job of a researcher.

- The more contact that students of both types had with their REU advisor, the greater the likelihood that they felt that their objectives in attending had been met, pointing up the mentorship role of REU advisors.

- Students enrolled at PUIs who were involved with REU awards at PUIs were less satisfied with the availability of opportunities to discuss graduate school and related topics with graduate students and postdoctoral fellows than students who had REU experiences at institutions with a greater level of research activity.

- Students working for PIs on Supplements were somewhat more likely to be very satisfied with individual aspects of their REU experience than Site students, yet a greater percentage of Supplement students suggested that the quality or appropriateness of individual student projects could have been improved.

D. Institutional and Award Characteristics

- In terms of average size and activities offered, Sites and Supplements differed in a variety of ways. Sites had an average of 11.3 students, while Supplements had an average of 2.2 students. Sites generally took place during the summer, while most Supplements were either combined summer and academic year operations, or took place exclusively during the summer. Sites were likely to offer opportunities

to present project results to other students and project directors and to attend REU seminars, while Supplements were more likely to provide opportunities for participants to get to know graduate students.

- Over one-third of REU Site awards were used to augment or replace existing departmental or institutional undergraduate research programs. Site awards were also leveraged such that between 21% and 29% of Site students received stipends from sources other than NSF's Site award.

- Site and Supplement awards were distributed differently among institutions. Universities receiving 60 or more NSF research awards in FY 1988 (called first-tier institutions in this report) received 16% of Site and 29% of Supplement awards, while Predominantly Undergraduate Institutions (PUIs) (See Note 1 for definition) received 21% of Site and 12% of Supplement awards. More than half of the Site and Supplement awards went to doctoral institutions that were neither PUIs nor first-tier; in this report they are called second-tier institutions.

- In general, REU awardees were most likely to be located at public colleges and universities. They were also most likely to be at second-tier doctoral institutions. There was a greater tendency for Supplements to be awarded to first-tier institutions, while Sites were somewhat more likely to be awarded to PUIs.

E. Program Improvement

- In terms of the optimum point for REU participation during the undergraduate years, nearly two-thirds of the awardees and half of the students preferred participation after the junior year. Forty percent of students said that the best point for participation is following sophomore year; this was especially true for those who were uncertain about attending graduate school -- the more uncertain they were, the earlier they recommended REU participation.

- Forty percent of Site Directors and 20% of Supplement PIs suggested that NSF make its award decisions much earlier, to improve participant recruiting. Supplement PIs indicated that roughly four weeks are necessary for recruitment, while Site PDs need between 9 and 16 weeks lead time for recruiting. More than a quarter of Site awardees suggested that multi-year funding be expanded.

## III. PROGRAM HISTORY

The predecessor to REU, a program titled "Undergraduate Research Participation" (URP), commenced in 1958. Designed as a vehicle to encourage the development of able undergraduates into independent investigators, URP supported undergraduate research projects that were conducted either during the summer on a full-time basis, or during the academic year on a part-time basis. Typically, the same student worked on the same problem for one summer and one academic year. Most of the participants were either in their junior or senior year of undergraduate study. The program was discontinued in FY 1979.

Concern about the adequacy of undergraduate education in science, mathematics, and engineering led the National Science Board (NSB) to convene a Task Committee on Undergraduate Science and Engineering Education in 1985. The final report of the Task Committee, known as the Neal Report (see Note 2), outlined a series of undergraduate programs that the members concluded were necessary for NSF to establish. One proposed program, given the same name as the original initiative, was intended to provide undergraduates with the opportunity for active involvement in research. Following Board acceptance of the Neal report in March 1986, guidelines were developed for an undergraduate research program. In November 1986, the NSB approved the proposed activity, which was then named Research Experiences for Undergraduates.

REU began operations in FY 1987 as one of the programs constituting the newly-established Office of Undergraduate Science, Engineering, and Mathematics Education. Intended to intervene in the trend of decreasing annual production of PhDs in science and engineering, REU was designed to give undergraduate students an opportunity to experience academic research first-hand and learn about graduate school at a point during their study at which they needed to make decisions about their future. From the beginning, REU emphasized the inclusion of women and minorities that are underrepresented in science and engineering as participants in REU awards. Two of the fundamental differences between the URP and REU programs are that URP did not have a focus on underrepresented groups and that it was operated exclusively in a mode akin to the current Sites, but with participants coming exclusively from the awarded institution.

## IV. STUDENT PROFILES

### A. Deriving the Profiles

Students were asked to rank the importance of nine reasons for participating in REU. The reasons most frequently labeled important or very important were: (1) wanting to know if doing research was for them (mentioned by 76% of respondents); (2) wanting to know if a particular field of research was for them (60%); (3) wanting to know if studying science or engineering in graduate school was for them (60%); and (4) loving a particular field of research and wanting to do some real work in it (45%).

Analysis of their reasons for participating showed that the students could be categorized in two groups. Those finding the first three items to be important were looking to the REU experience to help clarify their educational and career plans. In contrast, a smaller proportion were motivated to participate by the fourth reason. These students already had substantial interest in a specified field of research and wanted to "jump right in".

In order to test the validity of these groupings, an analysis was conducted that examined how those indicating that each of the four reasons for participating was important or very important responded to another question -- one that asked them to rank the importance of seven learning objectives for their REU experience.

This second analysis verified that two types of students could be differentiated. Interested but uncertain students were categorically most interested in learning about the nature of the job of a researcher, followed by obtaining substantive knowledge in a particular field. Their third and fourth learning objectives were gaining familiarity with specific techniques or procedures, and learning how to plan a research project. In contrast, more committed students wanted first and foremost to gain substantive knowledge of a particular field, while the next most important thing for them to learn was the nature of the job of a researcher.

### B. Gender and Race/Ethnicity Differences

Among the interested but uncertain group, some differences existed between male and female students. Females were more likely to have indicated that determining whether the following items suited them was very important, as compared with important, in their decision to participate: (1) science or engineering in general; (2) being a researcher; (3) a particular research field; or (4) graduate study in science and engineering. Similarly, males were more likely than females to indicate that "wanting to know" if science or engineering was for them had little bearing on their participation. Among the more committed students, no

differences existed in percentage of males and females for whom being strongly attracted to a particular field of research and wanting to do real work in it was either important or very important in their decision to participate.

In terms of learning objectives, the two most notable differences between males and females was that females were somewhat more likely to indicate that learning about the nature of the job of a researcher and the basics of the scientific method were very important to them.

Profound differences existed in terms of race/ethnicity group membership. While whites and Asians and Pacific Islanders were remarkably similar in terms of the relative importance of various reasons for participating, blacks were much more likely to indicate that the opportunity to gain experience that would help them to clarify educational and career plans was very important in their decision to participate. In most cases, Hispanics' views resembled those of whites and Asians and Pacific Islanders, but, like blacks, Hispanics were more likely to indicate that either the PI/PD's or the awarded institution's reputation and the stipend were also considerations.

## V. CHANGES IN STUDENTS' EDUCATIONAL AND CAREER PLANS

### A. Educational Plans

Eighty percent of the students indicated increased interest in science and engineering as a result of their REU participation. The proportion of students intending to attend graduate school in science or engineering was greater after REU involvement than before REU. As Table 1 indicates, Site and Supplement students report marked increases in: (1) their likelihood of attending graduate school; (2) the likelihood of their doing so immediately after completion of a baccalaureate degree; and (3) their aspirations to a masters, PhD, or DSc degree.

Clearly, aspirations shifted: before REU, 75% said that they were likely to go to graduate school; after REU, 92% said so. However, while certainty about attending graduate school increased, the extent of certainty differed among those who were still undergraduates at the time of the survey. Students who participated because they wanted to find out whether science or engineering suited them were still more likely after REU to be somewhat uncertain about choosing a science or engineering graduate school major. Conversely, those who participated because they wanted to do research in a field that they already loved were more likely to be confident or very confident in their choice of a science or engineering graduate major.

Table 1

Pre- and Post-REU Graduate School and Highest Degree Plans

| | Sites | Supps | Total |
|---|---|---|---|
| **Grad. School Likely** | | | |
| Pre-REU | 77% | 71% | 75% |
| Post-REU | 93 | 90 | 92 |
| **Grad. School Right After BA or BS** | | | |
| Pre-REU | 70 | 61 | 66 |
| Post-REU | 79 | 65 | 73 |
| **Highest Degree Aspirations** | | | |
| Bachelors: Pre-REU | 18 | 26 | 21 |
| Post-REU | 3 | 5 | 4 |
| Masters: Pre-REU | 16 | 17 | 16 |
| Post-REU | 19 | 19 | 19 |
| PhD or DSc: Pre-REU | 48 | 41 | 45 |
| Post-REU | 58 | 55 | 57 |
| MD: Pre-REU | 10 | 8 | 9 |
| Post-REU | 10 | 8 | 9 |
| MBA: Pre-REU | 4 | 5 | 4 |
| Post-REU | 4 | 7 | 5 |
| Other: Pre-REU | 4 | 4 | 4 |
| Post-REU | 5 | 7 | 6 |

Participants indicated little change in their choice of major field as a result of REU. The most likely majors before and afterwards were: Chemistry (15%), Physics (10%), Biological Sciences (10%), and Medicine (9%). The main exception was that participants with Geoscience majors were more likely than others to indicate that REU caused significant change in their certainty; the REU experience either caused them to doubt their choice of graduate major, or caused them to feel more confident about it.

Chemistry was the only major in which all race and ethnic groups were strongly represented. Males were far more likely to select engineering, physics, and computer sciences, while females were more apt to choose biological and social science majors. There were no marked gender differences with regard to preferences for majors in astronomy, mathematics, and the geosciences.

Asians were overrepresented in engineering, but somewhat less likely than others to choose computer science majors. Blacks and Hispanics selected physics and engineering majors less frequently than other students, but chose biological and behavioral science majors more frequently. Viewed separately, blacks were also less likely to anticipate mathematics and earth sciences as graduate school majors, while Hispanics were less likely than others to elect majors in computer sciences.

Sixty-eight percent of all early participants who could be in graduate school as of September 1989 had enrolled in graduate S/E programs. Those in graduate school at the time of the survey and had attended REU because of their love for a particular field were more likely to indicate that REU caused them to be more, or much more, confident in their choice of graduate major. The same was true for participants who had found conducting experiments and presenting research results to be beneficial, or were very satisfied with what they had learned about conducting research and being a member of a research team.

B. Career Plans

REU participants were fairly consistent in their preferences of graduate school major and field of employment; 19% of participants indicated that REU caused them to change their mind or doubt their initial choice. Despite noticeable differences between Site and Supplement students, overall their most frequent field preferences were: chemistry (15%); physics (10%); biological sciences (10%); and medicine (9%). A greater proportion of Supplement students intended to pursue engineering or biological sciences graduate majors, while Site students were more likely to opt for physics, chemistry, and medicine.

As with academic plans, the REU experience seemed to bolster their original ideas. While this was particularly true with students who were satisfied with their REU experience, the bolstering effect was most evident among those who participated because they wanted to obtain substantive knowledge in a particular field, learn specific techniques or procedures, or learn how to plan a research project. It was also notably true for those who were satisfied with what they had learned about research techniques and the technical guidance that they had received. Bolstering was less evident among those who had participated because they wanted to learn about what was involved in being a researcher.

While 45% preferred to be employed in academia, 39% were headed toward the industrial sector, or were already there. Site and Supplement students did not differ, but engineering and computer science participants were much more likely to opt for industry, and much less likely to select academia, than students with other

majors. Further, those who had decided that their highest degree would be a baccalaureate or that they did not intend to pursue a PhD or DSc degree were also more likely to select industrial employment.

C. Subsequent REU Staff Contact with REU Participants

Nearly two-thirds of REU students were contacted at least once after the conclusion of their REU experience by a faculty member with whom they worked; of these, 81% of the participants were contacted by their REU advisor. Additionally, while 34% had contact with the REU awardee or the project's assistant director, this was reported more frequently by Site participants (41%) than Supplement participants (25%).

Subsequent contact between REU staff and participants related to the student's future career or educational plans (61%) or an individual research project on which the student worked (55%). Black students were more likely to have had been contacted by an REU faculty member and more likely to discuss future career or educational plans than was the case for other students.

VI. CHARACTERISTICS OF SITE AND SUPPLEMENT AWARDS

A. Institutions

In general, REU awardees were most likely to located at public colleges and universities. They were also most likely to be at second tier doctoral institutions. There was a greater tendency for Supplements to be awarded to first tier institutions, while Sites were somewhat more likely to be awarded to PUIs. Over one-third of Site awardees reported that their REU award augmented or replaced an existing summer undergraduate research program, the majority of which had commenced within the past several years. first tier institutions received 16% of Site and 29% of Supplement awards, while PUIs received 21% of Site and 12% of Supplement awards.

Nearly 60% of participants were enrolled in PU__. Slightly more than one-half of all students went to another institution to participate in REU. Of those who did, a small percentage went to institutions in the same category as their home institution. Students from PUIs were somewhat more likely to go to a different type of institution, as 69% of them were REU participants at either First or Second Tier Institutions.

B. Activities

In terms of average size and activities offered, Sites and Supplements differed in a variety of ways. Sites had an average of 11.3 students, while Supplements had an average of 2.2 students. Sites generally took place during the summer, while

most Supplements were either combined summer and academic year operations, or took place exclusively during the summer. Eighty-seven percent of students worked in laboratories of individual faculty members. Nearly three-quarters of Supplement awardees used their awards to hire additional research assistants. Site participants worked with a significantly greater number of research personnel than Supplement students, especially faculty members and postdoctoral fellows. A higher proportion of part-time students was involved with Supplement awards. Two-thirds of REU students participated during or immediately after their junior year.

The activities available for Site and Supplement students differed. Both types of awards were likely to provide opportunities for students to see how research is conducted, to work on independent research projects, and to conduct experiments themselves. In addition, Sites were likely to offer opportunities to present project results to other students and project directors and to attend REU seminars, while Supplements were more likely to provide opportunities for participants to get to know graduate students.

Awardees mentioned relatively few problems related to the success of activities. The most frequently discussed item was that having students write articles with faculty members either took more time than was available or was too advanced for the students. In general, lack of time, and students not being as advanced as awardees would have liked, were obstacles to carrying out activities as planned by awardees.

C. Leveraging of REU Site Awards

Over the first three years of program existence, REU Site funds were leveraged between 21% and 29%. Thus, for every 7 to 8 students supported by Site stipends, an additional 2 to 3 participants received stipends from another sources, which included other NSF grants, plus other Federal and non-Federal sources of support for participating faculty members. On average, 20% of faculty members associated with Sites supported REU stipends out of their own NSF grants. This meant that some portion of Supplement students, as well as students supported by non-Site funds, were actually Site participants and received the benefits of the breadth of Site activities, while incurring no direct costs for the Site. Using the REU-supported students as the base number, the leverage ranges between 27% and 41% in terms of the number of additional students supported over the REU base. The dollar of the leverage is roughly $9.5 million over the 1987-89 period. An important additional form of leverage came from the labor contributed by other faculty and researchers who were involved with the REU awards but received no monetary support from them.

## VII. STUDENT CHARACTERISTICS

### A. Underrepresented Groups

Based on information obtained from awardees, roughly one in ten students was from an ethnic or racial group that NSF has designated as underrepresented in science and engineering. Table 2 shows the percentage distribution of participants by gender and race or ethnicity.

Table 2

PI/PD Reports of Percentage of REU Students in Underrepresented Groups

| | 1987 | | 1988 | | 1989 | | Total[1] |
|---|---|---|---|---|---|---|---|
| | Site | Supp | Site | Supp | Site | Supp | |
| Female | 42.8 | 38.1 | 42.2 | 40.7 | 43.3 | 39.0 | 41.3 |
| Native American or Alaskan Native | .5 | .7 | .6 | .6 | .9 | .1 | .7 |
| Hispanic | 1.3 | 2.3 | 3.1 | 4.7 | 4.9 | 3.4 | 3.5 |
| Black | 4.8 | 4.3 | 7.4 | 5.5 | 6.7 | 4.7 | 5.8 |
| Total[1] | 6.6 | 7.3 | 11.2 | 10.9 | 12.6 | 8.3 | 9.9 |
| Disabled | 1.7 | 1.6 | 1.3 | .9 | .7 | .5 | 1.1 |

Awardee information on the demographic characteristics of their student participants differed in slight but noticeable ways from the demographic characteristics of the students who responded to the survey. The most obvious difference is in the higher proportion of students reporting that they have a disability.

Table 3

Percentages of Students Indicating That They Are From Underrepresented Groups

| | Sites | Supplements | Total[1] |
|---|---|---|---|
| Female | 39.6 | 43.9 | 41.5 |
| Native American or Alaskan Native | .7 | .2 | .5 |
| Hispanic | 3.2 | 3.1 | 3.2 |
| Black | 5.6 | 2.8 | 4.4 |
| Total[1] | 9.5 | 6.1 | 8.2 |
| Disabled | 2.5 | 3.9 | 3.1 |

[1] Totals may not equal the sum of component parts due to rounding.

Students were most likely to find out about the REU award from their advisors or instructors. While this was especially the case for Supplement students, black participants were more likely to hear about an REU opportunity in this manner than Hispanic students, who learned about REU more frequently from a friend. Disciplinary differences also existed, possibly because of differences in preferred recruitment methods and norms of professional communication. Slightly more than one-quarter of all participants had also applied to other non-REU programs.

Regardless of whether they were involved with Sites or Supplements, students were most likely to participate in REU because they wanted to know if: (1) being a researcher was for them; (2) the specific field of research was for them; or (3) if graduate study in science or engineering was for them. Site students were somewhat more likely to indicate wanting to learn about the nature of the job of a researcher was a very important reason for participating. Female, black, and Native American or Alaskan Native participants were more likely than others to choose to participate because they wanted to know if science or engineering, or research, was appropriate for them. Similarly, students with chemistry and biology majors were most likely to participate for these reasons, while computer science majors, and to a lesser extent engineering, physics, and astronomy majors were unlikely to participate to clarify future plans. Behavioral science majors, and to a lesser extent geoscience and chemistry majors tended to participate because of the PI/PD's reputation, or the reputation of the institution.

B. Recruitment Strategies

Nearly three-quarters of REU awardees actively recruited students; however, Site awardees were much more likely than Supplement awardees to do so. The range of techniques was broad, but the most common were posting announcements in their department and having fellow faculty members announce the research opportunity to their students. Site awardees were much more apt to send announcements to other institutions or contact colleagues at other institutions. Conversely, Supplement awardees were more likely than Site awardees to contact individual students directly.

Awardees who placed a high value on recruiting minority and female students were generally successful. While about 25% of awardees overall reported that a potential participant's gender, race, or ethnicity was not important or not considered, Site awardees were significantly more likely than Supplement awardees to recruit female, minority, and disabled students actively, and had higher overall percentages of participants from these groups than did Supplement awardees. Contacting colleagues at other institutions and making announcements in their own classes were the techniques most frequently used by Site awardees, while Supplement awardees were most likely to contact students in these groups directly or have fellow faculty members announce the opportunity for conducting research to their students. The singularly most successful method for recruiting minority students was awardee visits to campuses with significant numbers of minority science and engineering majors. Direct contact with the students was far more effective than any other method.

The differences between Sites and Supplements in recruitment patterns vis-à-vis underrepresented groups in science in engineering is also evident in participant selection criteria preferences. Overall, the most important criteria were major, grade point average, courses taken, and advisor's recommendation; Site awardees indicated that advisor's recommendation, grade point average, and belonging to an underrepresented group were noticeably more important than did Supplement awardees. Differences across disciplines resulted in Engineering and Computer Sciences awardees emphasizing underrepresented group status more so than awardees in the Geosciences, Behavioral and Social Sciences, and Mathematics. In general, those who judged this criterion to be very important were most successful in recruiting participants from underrepresented groups.

Awardees expressed concerns about the difficulties in recruiting students. Overall, the most frequent problem was that they had been notified of their award too close to the scheduled commencement of research activities to permit adequate recruiting. Two the consequences of this were that interested students had already finalized their summer plans by the time

awardees had selected participants and that too few students applied.

## VIII. ACHIEVEMENT OF AWARDEE AND PARTICIPANT SATISFACTION

### A. In General

The similarity in awardee and student objectives for their particular REU project extended to their judgments of the degree to which objectives were met. PIs and PDs felt that the objectives that were accomplished most successfully pertained to exposing students to: (1) the nature of the job of a researcher; (2) the basics of the scientific method; (3) specific techniques or procedures, and (4) how to plan research projects. Students basically agreed. Female and Hispanic participants were more likely than other students to be satisfied with being a member of a research team. In addition, female students tended to be more satisfied about objectives that were not ranked highly overall, such as familiarity with a particular instrument, technique, or procedure and learning how to plan a research project.

Over one-half of the students were very satisfied with their experiences working independently and learning research techniques. They were less satisfied with the adequacy of technical guidance and the degree to which they were working on important research. In general, more Supplement participants were very satisfied with specific aspects of their research experience than were Site students. Similarly, while respondents indicated that overall the three best aspects of REU were learning about and experiencing basic research, learning research skills and techniques, and obtaining substantive knowledge, a larger percentage of Supplement participants cited these three aspects than their Site colleagues.

Two-thirds of the respondents had participated either during or immediately after their junior year. Nonetheless, slightly less than half of all participants indicated that this was the best point during the undergraduate years in which to do something like REU. Forty-percent cited the sophomore year as optimal. The earlier the respondent had participated, the earlier he or she thought that REU participation would be most worthwhile. Students from first-tier institutions were most likely to prefer sophomore year over junior year.

### B. Benefits of Particular Activities

Awardees and participants generally agreed about the degree to which REU activities were successful. In particular, both groups judged as most beneficial activities that were designed to let participants: (1) see how research is conducted; (2) work on independent research projects; and (3) conduct experiments independently. According to students, the least beneficial

activities were: (1) getting to know other undergraduate students; (2) getting to know graduate students; and (3) attending REU seminars. As many as 40% of the students were not involved in classes for REU students, writing articles with faculty members based on the REU research, and REU seminars.

Participants from underrepresented groups were likely to view certain activities as being more beneficial than did white males. For instance, women tended to rate activities designed to allow them to see how research is really done as being more beneficial than their male colleagues. In general, members from underrepresented groups were more likely to accrue benefit from activities that were not considered beneficial by a majority of students; each underrepresented group derived benefit from at least one activity mentioned above as being of least benefit to students overall.

Students obtained different benefits from REU activities depending on their field of study. Those with chemistry and biology majors were more likely to say that they derived particular benefit from conducting experiments themselves. Chemistry students were also more likely than others to value getting to know graduate students. Behavioral science, social science, and chemistry majors were more likely to assess attending REU seminars as beneficial or very beneficial. Mathematics majors tended to find classes for REU students valuable, while chemistry, biology, and mathematics majors were more likely to value working on independent research projects. Chemistry majors were particularly likely to obtain benefit from presenting project results to fellow students and awardees, while mathematics and computer science students expressed more satisfaction than others regarding writing articles with faculty members about REU research results.

Nearly three-quarters of participants indicated that the level of challenge of the activities with which they were involved was about right. Mathematics, engineering, and computer science majors and Hispanic students were more likely than other students to have found the challenge to be a little, or much too, challenging. Conversely, students from first-tier institutions were less likely than other students to view their activities as having the right degree of challenge, and more likely to believe that the activities were not challenging enough.

C. Contact with Research Staff

To varying degrees, participants were exposed to different types of research personnel. They had the greatest exposure with, in descending order: graduate students, other REU students, and their REU advisor. As a group, participants valued most highly their contact with, in descending order: their REU advisor, graduate students, and other faculty members. Overall, 17% of

Site PDs did not conduct the day-to-day management of the Site.

In conjunction with REU's aim of providing exposure to life in graduate school, participants indicated that they were most likely to obtain a wide variety of information about graduate school from their REU advisor and graduate students. Most of the students who attended REU Sites at PUIs missed the opportunity of discussing academic and career issues with graduate students or postdoctoral fellows, but they were more likely than colleagues at other types of institutions to have had such discussions with their REU advisor or another faculty member. About two-thirds of the students normally attending PUIs who were involved with REU awards at non-PUI institutions found getting to know graduate students to be a valuable part of their experience, while 16% of the participants from PUIs who were at a PUI for REU felt the same way. The latter were more likely to rate getting to know other undergraduates more highly instead.

## IX. SUGGESTIONS FOR PROGRAM IMPROVEMENTS

### A. PIs/PDs' Suggestions

Forty-three percent of Site awardees and 20% of Supplement awardees desire more time between notification of the award and start of the project in order to recruit students. Awardees pointed repeatedly to the shortage of recruitment time as the principal cause of recruitment problems, especially of minority students. Supplement PIs indicated that roughly four weeks are necessary for recruitment, while Site PDs need between 9 and 16 weeks lead time for recruiting. Six percent of Site awardees and 2% of Supplement awardees specifically requested assistance with minority recruitment. More than one-quarter of Site awardees and 11% of Supplement awardees also suggested that having longer award periods would be an improvement, in that recruiting could take place over a longer period of time.

### B. Students' Suggestions

Students made a variety of suggestions for improving either the REU award on which they worked or the REU program. The most frequent suggestion (made by 27% of Site and 36% of Supplement participants) was that the quality or appropriateness of the individual research projects be improved. This was followed by having one's REU advisor more accessible (21%), extending the length of the experience (14%), and providing more orientation (13%).

Addendum: Student and Parent Enthusiasm for REU

Respondents were provided with the contractor's "800" telephone number in case they had questions about the study or the instrument that they were to complete. Several hundred calls were received, often from students or their parents making certain that the instruments had been received. Regardless of the reason for calling, students expressed enormous enthusiasm about the program and felt that their experiences had been extremely valuable. Parents wanted to be certain that their child's survey had been received because they wanted NSF to know how beneficial the program was, and expressed great appreciation to the Federal Government for providing such a "wonderful program" for their children.

Copies of the 219-page comprehensive report upon which this document is based can be obtained without charge by writing to:

Dr. Stephen J. Fitzsimmons
Vice President and Director
Center for Science and Technology Policy Studies
Abt Associates Inc.
55 Wheeler Street
Cambridge, MA 02138

The comprehensive report contains detailed analyses of: (1) characteristics of students by field of science, type of home institution, and reasons for participating; (2) the types of activities in which students engaged; (3) conditions under which awardees judged activities to be successful; (4) factors that contribute to the success of an REU award; (5) interrelationships between selected student outcome measures and their reasons for participating; (6) the Site mode compared with the Supplement mode; (7) participation by students in groups that are underrepresented in science and engineering; and (8) areas for programmatic and management improvement. Samples of the survey instruments are also included.

Notes and References:

1. NSF defines Predominantly Undergraduate Institutions as those higher education institutions that awarded 20 or fewer doctorates in NSF-supported fields in the two years preceding the proposal submission. Institutional classifications are updated annually.

2. National Science Board. Undergraduate Science, Mathematics and Engineering Education. March 1986. NSB 86-100. This publication may be obtained by writing to NSF's Forms and Publications Unit (address on front cover of this report).

3. The most recent brochure describing Research Experiences for Undergraduates and related programs may be obtained by writing to NSF's Forms and Publications Unit (address on front cover of this report).

4. A summary of results of study of a similar undergraduate research program may be found in Vivo, Frank M. and Stevenson, Wayne, U.S. Department of Energy Student Research Participation Program: Profile and Survey of 1979-1982 Participants. Washington, DC: U.S. Department of Energy, January 1988.

The design of this project and of the survey, interpretation of the findings, and preparation of this report were done by Linda Parker of NSF's Program Evaluation Staff (PES), under the direction of Jim McCullough, Director, PES. Survey instrument refinement, student name collection, adminstration of the surveys, response analysis, and compilation of the comprehensive study report were performed under contract by a team lead by Steve Fitzsimmons of Abt Associates inc, Cambridge, MA. Jim Slaugh of NSF's Office of Information Services prepared tapes containing REU Supplement award data, and Delores Williams of PES compiled a database on Site awards.

## Appendix A

### SURVEY AND SAMPLING STRATEGY

One survey instrument was designed for awardees and one for students. Both instruments could be used by individuals involved with either Site or Supplement awards, and contained several series of comparable questions. The instruments were pretested with Site and Supplement awardees and students, after which modifications were made as necessary. (See page 19 for information on obtaining the survey instruments.)

At the beginning of the project, the number of awards was known, but each awardee had to be contacted in order to obtain the names of students supported under each award. Sample frame was based on population size. In the case of awardees, this was known. In the case of students, it was estimated. Given small numbers, all Site awardees were surveyed. The number of Supplement awardees in the sample was 50% of the total number of awards. Students involved with the selected Supplement awards were surveyed, as were the students in half of the Site awards. Awardees who did not return student names were excluded from the random selection of those who were to be surveyed. Thus, to obtain a sample that was half the size of the original awardee population, the proportion of individuals who were surveyed was somewhat greater than 50% of those who remained eligible to be surveyed as a result of providing student names.

As a side note, names and addresses of students continued to be submitted by awardees after the date on which the samples were taken. By November 1989 60% of awardees had submitted 6,820 names. Table A.1 summarizes the known and estimated populations when the samples were taken, sample sizes, and responses.

Table A.1

REU Population and Samples[1]

| | Population | Sample | Responses | Completion Rate |
|---|---|---|---|---|
| **Sites** | | | | |
| Awardees | | | | |
| Duplicated | 448 | 448 | 199 | 45% |
| Unduplicated | 290 | 290 | 199 | 68% |
| Students[2] | 4,480 | 2,035 | 1,125 | 55% |
| **Supplements** | | | | |
| Awardees[3] | 2,704 | 1,284 | 829 | 65% |
| Students[2] | 4,056 | 1,644 | 828 | 50% |

[1] Respondents classified by earliest known award year.

[2] Estimated student population.

[3] FY 1989 Supplement award list was compiled in June 1989, and therefore slightly understates the final total of FY 1989 awards.

Awardees and participants selected to be in the various samples were mailed survey instruments during July 1989. Respondents were assured of confidentiality. For analytical purposes only, individual participants were linked via a numerical code to the award with which they were associated. This allowed analysis of student responses by the NSF division that issued the award.

P.T.: 34,11
K.W.: 1000000
0600000



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