A Draft Report to the National Science Foundation

RESEARCH EXPERIENCES FOR UNDERGRADUATES (REU) IN THE DIRECTORATE FOR ENGINEERING (ENG): 2003-2006 Participant Survey

Prepared under Contract GS10F0554N/06D1403

Prepared by
Mary P. Hancock
Susan H. Russell
SRI International
333 Ravenswood Avenue
Menlo Park, CA 94025

Prepared for
The National Science Foundation
Directorate for Engineering

August 2008

The data collection, analysis, and reporting of this material were conducted in accordance with OMB No. 3145-0121.

ABOUT THE NATIONAL SCIENCE FOUNDATION

The National Science Foundation (NSF) funds research and education in most fields of science and engineering. Awardees are wholly responsible for conducting their project activities and preparing the results for publication. Thus, the Foundation does not assume responsibility for such findings or their interpretation.

NSF welcomes proposals from all qualified scientists, engineers and educators. The Foundation strongly encourages women, minorities and persons with disabilities to compete fully in its programs. In accordance with Federal statutes, regulations and NSF policies, no person on grounds of race, color, age, sex, national origin or disability shall be excluded from participation in, be denied the benefits of, or be subjected to discrimination under any program or activity receiving financial assistance from NSF (unless otherwise specified in the eligibility requirements for a particular program).

Facilitation Awards for Scientists and Engineers with Disabilities (FASED) provide funding for special assistance or equipment to enable persons with disabilities (investigators and other staff, including student research assistants) to work on NSF-supported projects.

The National Science Foundation has Telephonic Device for the Deaf (TDD) and Federal Information Relay Service (FIRS) capabilities that enable individuals with hearing impairments to communicate with the Foundation about NSF programs, employment or general information. TDD may be accessed at 1-800-281-8749, FIRS at 1-800-877-8339.

The National Science Foundation is committed to making all of the information we publish easy to understand. If you have a suggestion about how to improve the clarity of this document or other NSF-published materials, please contact us at plainlanguage@nsf.gov.

ACKNOWLEDGMENTS

We would like to thank the Directorate for Engineering, REU Program Manager, Esther Bolding and Mary Poats, Program Manager, Engineering Research Centers (ERC) Supplements program, Joanne Culbertson, ENG Staff Associate for Planning and Evaluation, Linda Parker, Engineering Program Evaluation Director (retired), and Allen L. Soyster, Division Director, Engineering Education and Centers (EEC) for their helpful guidance and assistance throughout the project. We also would like to extend a special note of thanks to all of the individuals who responded to our surveys. Clearly, the study could not have been done without their willingness to devote time to answering our questions.

How to cite this report:

National Science Foundation, Directorate for Engineering, *Research Experiences for Undergraduates (REU) in the Directorate for Engineering (ENG): 2003-2006 Participant Survey,* NSF 08-XXX (Arlington, VA, 2008).

CONTENTS

APPENDICES

A. Study Design and Methods

B. Survey Questionnaires and Overall Results

1. Undergraduate questionnaire
2. Faculty mentor questionnaire

C. Survey Results (bound separately)

1. Undergraduate responses by NSF award type
2. Undergraduate responses by time of year of research (summer vs. academic year)
3. Undergraduate responses by race/ethnicity
4. Undergraduate responses by sex
5. Faculty mentor responses by NSF award type

I. OVERVIEW

INTRODUCTION

The United States depends on technological leadership to sustain economic growth and national security. It is thus essential to the nation to assure the availability of well-trained scientists and engineers. Critical to providing this assurance is the need to encourage undergraduates to pursue graduate degrees in science, technology, engineering, and mathematics (STEM) and, subsequently, careers in those fields. Recent studies, including others conducted by SRI International,[1] have shown that undergraduate research experiences are effective in encouraging college undergraduates to pursue advanced degrees and to obtain STEM-related jobs.

Chief among the programs intended to increase graduate-degree production in fields covered by the National Science Foundation (NSF) is the Research Experiences for Undergraduates (REU) program, which has been in existence for more than 20 years. Several studies were done specifically about the REU program in 1989 and the early 1990s. These early studies included surveys of former REU students and principal investigators (PIs). In 2002, NSF's Division of Research, Evaluation, and Communication (REC) commissioned a nationwide study titled Undergraduate Research Opportunities (URO). The main part of the study was an examination of all of NSF's mechanisms that support undergraduate research, including the two types of REU awards, Sites and Supplements. The URO study covered a wide range of NSF programs and directorates but did not obtain detailed information about any of them. Accordingly, NSF's Directorate for Engineering (ENG) wanted to obtain information about its REU program that is comparable to that provided by the earlier and broader studies. This is the first study in many years to examine the activities, outcomes, and impacts of REU awards made in a single directorate.

NSF contracted with SRI International (SRI) to conduct surveys of participants in the REU program in the Directorate for Engineering (ENG). The ENG REU program officers wanted to obtain in-depth information about the activities, outcomes, and impacts of REU Site and Supplement awards from the perspectives of the former REU students, PIs, co-PIs, and other faculty mentors, in order to better understand the components and characteristics of effective REUs and thus provide direction to ENG REU program officers in their reviews of REU proposals and in the advice they give to REU PIs.

ENG wanted a comparison of REU Sites funded by the Division of Engineering Education and Centers ("EEC Sites"), REU Supplements funded by Engineering Research Centers ("ERC Supplements"), and REU Supplements funded by other divisions within ENG ("ENG Supplements"). In addition, ENG wanted the study to assess differences among respondent groups (undergraduates and faculty mentors) and, for undergraduates, differences by sex and race/ethnicity.

The study is being conducted through two surveys. This report describes the initial survey of faculty and undergraduate participants in all ENG Sites and ERC Supplements during fiscal year

---

[1] Five reports on SRI's recent studies about undergraduate research programs are available on SRI's Web site at http://www.sri.com/policy/csted/reports/university/.

(FY) 2003 through FY 2006 and ENG Supplements during FY 2006, which was conducted during fall 2007. A follow-up survey of the FY 2006 undergraduate participants is planned for fall 2009 to measure the longer-term impact of their REU experiences. The initial survey focused primarily on specific REU experiences during the summer or the academic year but also asked about other undergraduate research experiences and about academic and career decisions. The follow-up survey will cover all undergraduate research experiences, as well as academic and career decisions and experiences since the initial survey.

The study addressed the following research topics:

- Students' motivations for participating in research.
- Students' REU research activities.
- Students' satisfaction with various aspects of their REU research experiences.
- Students' gains in research-related awareness, confidence, skills, and understanding.
- Importance of research experiences in students' academic and career decisions and interests.
- Changes in students' interest in STEM-related careers.
- Students' expectations of academic degree attainment.
- Mentors' reasons for mentoring.
- Mentors' selection criteria for students.
- Mentors' mentoring experiences.
- Mentors' reports of students' gains in awareness, confidence, skills and understanding.
- Mentors' perceptions of barriers to increasing the number of undergraduates involved in research.

SRI drew heavily on the questionnaires developed for the URO studies, the objectives of which corresponded closely to those of this study. Questions were adapted to engineering programs, and other questions of particular interest to REU program officers were added.

STUDY METHODS

Pretests

To refine development of the survey questionnaires, eight pretests were conducted for each of the survey instruments. Both summer and academic-year (fall to spring) undergraduate and faculty mentor participants were included in the pretests. Only minor changes and additions were made to the questionnaires as a result of the pretests.

Survey Data Collection

All EEC Site and ERC Supplement awards granted during FY 2003 through FY 2006 were initially included in the survey. At NSF's request, all ENG Supplement awards granted during 2006 were later added to the survey. The PI of each award was contacted by e-mail and/or telephone to obtain names and contact information for undergraduates who had participated in faculty-mentored research between summer 2003 and spring 2007. Names and contact information for these students' faculty mentors also were obtained. Participant names and contact information were obtained from 88% of the award PIs. The numbers of awards by year, ENG division and award type are shown in Appendix A, Table A-2. In total, 3,936 students and 2,037 PIs and faculty mentors were included in the survey.

The next step in the data collection process was to e-mail a notification of the survey and its purpose to each sample member for whom we had an e-mail address. Sample members for whom a phone number was available were phoned to obtain an e-mail address, if necessary. Those for whom only a postal address was available were surveyed by mail. As an incentive, undergraduates were offered a $20 Amazon.com gift certificate in return for their participation and all respondents were promised a summary of the survey results. Each cover letter contained a URL hyperlink, embedded with a respondent ID number and year of participation, to the Web-based survey questionnaire. Reminders to complete the questionnaire were sent by e-mail at approximately weekly intervals over an 11-week period. Reminder phone calls were made and postal mailings were sent to all nonresponding undergraduate students for whom phone and postal information was available.

Completed questionnaires were obtained from 67% of the undergraduates (n = 2,619) and 69% of the PIs/faculty mentors (n = 1,319). The number of participants and response rate for each group are shown in Appendix A.

Students with e-mail addresses were later recontacted to ask "Do you have a disability or handicap that limits a major life activity?" Of the 2,416 student respondents who had e-mail addresses, 75% responded to the additional question (n = 1,812).

Student survey responses were weighted to represent the total estimated number of participants by year and award type. All student survey results presented here are based on weighted data. Weighting is described in detail in Appendix A. All group differences described in this report are significant at the $p < .05$ level, based on *t* tests comparing each group with all other groups combined.

REPORT FOCUS AND ORGANIZATION

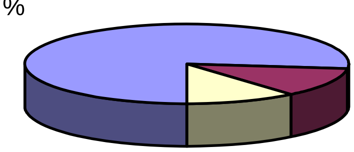
This report focuses on what we consider to be the major findings[2] from the undergraduate and faculty mentor surveys. The report is organized in a generally chronological sequence, starting with background information on the NSF award types and the undergraduate researchers themselves and then moving from pre-research events (motivations, selection criteria) to the research experiences themselves, perceptions of the experiences, and effects of the experiences (what has been learned/gained, interest in various careers, academic degree expectations). The report concludes with sections summarizing the undergraduate student and faculty responses to several open-ended questions asking how to improve the REU experience. All data shown in figures and tables are derived from the REU survey conducted in 2007 by SRI International, unless noted otherwise.

[2] We recognize that others' conceptions of "major findings" might well differ from ours, in terms of both what we chose to include and what we did not include. It is possible that subsequent reports can cover additional topics or that the data can be made available to others to pursue analyses of their choosing.

II. REU AWARD TYPES INCLUDED IN THE STUDY

SRI estimates that at least 4,780 undergraduates[3] participated in hands-on faculty-mentored research in the ENG REU programs during the years included in the study (FY 2003 through FY 2006 for EEC Sites and ERC Supplements and FY 2006 for ENG Supplements). As shown in Figure II-1, by far the largest number of undergraduate participants were supported through EEC Sites, which supported 77% of the total ENG undergraduate participants. ERC Supplements supported 12% of participants and FY 2006 ENG Supplements supported 11%.

Figure II-1
Distribution of Undergraduate Researchers, by REU Award Type



In this section, we describe each type of NSF award whose participants were included in the 2007 survey, interweaving general portrayals of the award types with some of the data gathered about them in this study.

EEC SITES

EEC Sites, funded by the Division of Engineering Education and Centers, are independent awards to conduct projects that engage students in research. They may be focused on a single discipline/academic department or on related interdisciplinary/multi-department research. EEC Site participants, a significant portion of whom must attend an institution other than the one hosting the Site, typically participate for 8 to 10 weeks in a full-time, hands-on research experience during the summer. Each Site uses REU funds to host six or more students who conduct research within the engineering discipline or research area around which the Site is organized. The Site may be hosted by an academic or non-academic institution (e.g., government lab or research institution), either in the United States or at a foreign location.

During FY 2003-2006, an average of 84 EEC Site awards were made per year, for a total of 337 EEC Site awards. Of these, 263 (78%) provided participant contact information.

During FY 2003-2006, EEC Sites each hosted an average of 11 students. Ninety-eight percent of EEC Site participants were located at an academic institution, 7% were at a non-

[3] This number is derived from the number of students whose names and contact information were provided to SRI. Using the average number of students per award type, we then estimated the number of students in the awards for whom we did not receive names and contact information.

academic institution, and 5% were located at least part of the time in another country[4] (Table II-1). All but one Site conducted its research during the summer. The exception was a full-time research experience, similar to summer-run Sites, but conducted outside the United States during the fall semester. Nearly three-quarters of EEC Site students (74%) came from campuses other than the institution hosting the Site.

Table II-1

Selected Characteristics of Undergraduate Researchers, by REU Award Type: Percentage with Each Characteristic

	ERC Supplements	EEC Sites	ENG Supplements	All
Number of respondents:	*363*	*1,893*	*363*	*2,619*
Did research at home institution	20%*	26%*	77%**	31%
Did research at another academic institution	83**	72**	15*	67
Did research at non-academic institution	1*	7	12**	7
Did research in another country	1	5	1	4
Did research during the summer	100**	99**	67*	96
Received stipend	99	99	96	99
Received academic credit	6*	18**	14	16
Enrolled in classes while involved in research	9*	11*	51**	15
Female	47	43	30*	42
Have a disability or handicap that limits a major life activity	2	2	1	2
Race/Ethnicity				
American Indian	1	< 1	0	<1
Asian	14	11	12	11
Black or African American	17**	10	5*	10
Pacific Islander	<1	<1	1	<1
Hispanic	17**	11	7*	11
Non-Hispanic white	48*	66**	71**	65
More than one non-Hispanic race	4	2	4	2
Average hours per week spent on research	38.2**	38.0**	28.0*	36.9

This table shows, for example, that 20% of undergraduate respondents who participated in ERC Supplements did so at their home institution.

Note: Research location columns sum to more than 100% because respondents could select more than one location.

*This group's percentage is reliably lower than that of all other groups combined (p < .05).

**This group's percentage is reliably higher than that of all other groups combined (p < .05).

[4] These percentages sum to more than 100 because some undergraduates worked in more than one location.

The EEC Site research experience is typically a full-time responsibility, and students generally do not have other work obligations outside of the laboratory, library, or field research that they are conducting. The host institution provides students with stipends and, for non local students, with housing for the summer. Only 11% of EEC Site students were enrolled in classes during the time they participated in the REU research, 18% received academic credit for their research activities, and, on average, they spent 38 hours per week engaged in research-related activities.

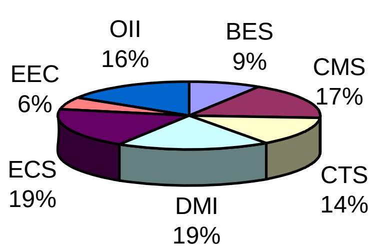
Slightly less than half of FY 2003-2006 EEC Site undergraduate participants (43%) were female, and 66% were non-Hispanic white.

ENG SUPPLEMENTS

REU Supplements may be requested for ongoing NSF-funded research awards or may be included as a component of proposals for new or renewal NSF grants or cooperative agreements to involve undergraduates in research. NSF-wide, most REU Supplements support one or two students and take place during the academic year.

SRI estimates that ENG awarded 248 REU Supplements that involved undergraduate research during FY 2006. Of these, 229 (92%) provided participant contact information. The former ENG Division of Design and Manufacturing Innovation (DMI, now part of the ENG Division of Civil, Mechanical and Manufacturing Innovation, or CMMI) and the former ENG Division of Electrical and Communications Systems (ECS, now the ENG Division of Electrical, Communications and Cyber Systems or ECCS) funded the largest number of these awards with 19% each (Figure II-2). Other ENG divisions included in the survey are Bioengineering and Environmental Systems (BES, now part of CBET), Civil & Mechanical Systems (CMS, now part of CMMI) , Chemical and Transport Systems (CTS, now part of CBET), Engineering Education and Centers (EEC, still EEC), and the Office of Industrial Innovation (OII, now IIP).

Figure II-2
Funding Source for
FY 2006 ENG REU Supplement Awards



ENG Supplements each supported an average of two undergraduates during FY 2006. ENG Supplement-funded students were more likely than either EEC Site or ERC Supplement students to have participated in research at their home institution (77% vs. 26% and 20%, respectively) or at a non-academic institution (12% vs. 7% and 1%, respectively).

Very few participated in another country (1%). Most (96%) received a stipend but few (14%) received academic credit.

ENG Supplement participants were also more likely than either EEC Site or ERC Supplement students to be male (70% vs. 57% and 53%, respectively) and non-Hispanic white (71% vs. 66% and 48%, respectively).

The survey found that only one-third (33%) of the ENG Supplement-sponsored undergraduates participated in research during the 2006-07 academic year, most often at their home institution (94%). The majority (67%) participated during the summer at their home institution (69%). (Note that this is very different from the typical REU Supplement award. SRI's 2002 URO study found that, NSF-wide, 90% of REU Supplement participants' experiences took place during the academic year.) For the academic-year ENG Supplement participants, the experience was less intensive (17 hours per week vs. 33 hours per week for summer participants). Academic-year participants were more likely than summer participants to have received academic credit for their research work (26% vs. 9%) and more likely to be enrolled in classes while involved in research (99% vs. 28%).

ERC SUPPLEMENTS

Although funded as Supplements, Engineering Research Center Supplements support an average of about 10 students and take place during the summer. Thus, from a functional perspective, ERC Supplements are more similar to EEC Sites than to "typical" Supplements. A total of 67 ERC Supplement awards were funded during FY 2003-2006 (14 in 2003, 16 in 2004, 20 in 2005, and 17 in 2006). All provided participant contact information for the survey.

The ERCs reported supporting an average of nine undergraduate researchers per year during FY 2003-2006. Essentially all ERC undergraduates (99%) received a stipend, but few (6%) received academic credit. All participated during the summer and almost all (99%) were located at an academic institution. More than 8 in 10 (83%) came from schools other than the institution hosting the ERC.

Undergraduate participants in ERC Supplements during FY 2003-2006 were more likely than those in EEC Sites or ENG Supplements to be minorities (52% vs. 34% and 29%, respectively). For example, 17% of ERC participants were black or African American, compared with 10% in EEC Sites and 5% in ENG Supplements. About half of ERC participants (47%) were female.

III. PROFILE OF UNDERGRADUATES WHO PARTICIPATE IN ENG REU-FUNDED RESEARCH

This section provides a broad description and discussion of the kinds of undergraduates who were engaged in ENG REU-funded research during FY 2003-2006. Understanding who is served by undergraduate research programs is important to assessing the programs' overall role in engineering education.

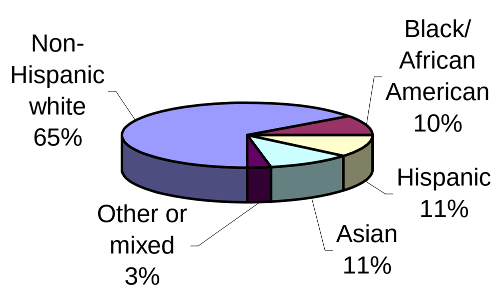
GENERAL CHARACTERISTICS

Almost all (96%) of the approximately 2,600 survey participants responded regarding summer programs. In this report, these are referred to as "summer undergraduates/students/ researchers." Only 4% (136 individuals) responded regarding academic-year (fall to spring) programs; these respondents are referred to as "academic-year undergraduates/ students/researchers."

Overall, 67% of undergraduate researchers participated in research at a school other than their home school, 31% did so at the college they were already attending, and 7% did so at a non-academic institution.[5] Predictably, a large majority of academic-year researchers (79%) participated in research at their home school, but only slightly more than a quarter (28%) of those in summer programs did so. EEC Site and ERC Supplement researchers were much more likely to participate at another college than were ENG Supplement researchers (72% and 83% vs. 15%, respectively), and ENG Supplement researchers were slightly more likely to participate at a non-academic institution than were EEC Site or ERC Supplement researchers (12% vs. 7% and 1%, respectively).

DEMOGRAPHIC CHARACTERISTICS

Figure III-1
Distribution of Undergraduate Researchers, by Race/Ethnicity



Undergraduate researchers in FY 2003-2006 were more often men (58%) than women (42%) (Table II-1), 2% reported a disability or handicap that limits a major life activity, and about two-thirds were non-Hispanic white (Figure III-1).

According to the U.S. Department of Education (ED), 80% of engineering bachelor's degrees in 2004-2005 were awarded to men.[6] The ED and REU numbers are not precisely comparable, but it appears that women were proportionally well represented among REU undergraduate researchers in engineering. The situation was similar for minority researchers. Excluding nonresident aliens, 73% of engineering bachelor's degrees in 2004-2005 were awarded to non-Hispanic whites, 6%

---

[5] These percentages sum to more than 100 because some undergraduates worked in more than one location.
[6] U.S. Department of Education, National Center for Education Statistics, *Digest of Education Statistics*, 2006, Table 258: http://nces.ed.gov/programs/digest/d06/tables/dt06_258.asp.

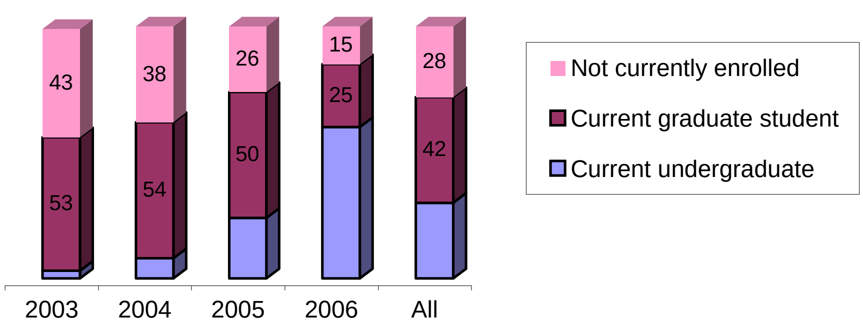
to black or African Americans, and 6% to Hispanics.[7] These numbers suggest that, overall, historically underrepresented minorities also were well represented as undergraduate researchers in engineering.

ACADEMIC CHARACTERISTICS

Academic Status

As expected, the vast majority of the earlier-year (FY 2003-2005) participants (89%) had graduated or left school by the time they were surveyed. About half of these earlier-year students (52%) had been accepted or were currently enrolled as graduate students, 12% were enrolled as undergraduates, and 36% were no longer enrolled in college (Figure III-2). The planned follow-up survey of 2006 participants will give us a longer-term perspective of their degree and career expectations. Extrapolating from the current academic status of 2006 participants, approximately 41% of participants were rising seniors and 45% were rising juniors at the time they participated in REU research. Only 14% were sophomores or freshmen. Faculty who were involved in selecting undergraduates to participate in summer REU programs were asked which academic class or classes they preferred. A majority of the faculty preferred juniors or seniors (59%), and a large majority of FY 2006 student participants (86%) were estimated to be juniors or seniors.

Figure III-2
Current Academic Status of Undergraduate Researchers by Year of REU Participation: Percentage



Grade Point Averages (GPAs)

More than 8 in 10 faculty reported that overall GPA (82%) and GPA in the student's major (88%) were fairly important or extremely important. Consistent with faculty attitudes, the mean self-reported cumulative undergraduate GPA was 3.56,[8] with 45% reporting GPAs of 3.7 or higher. Only 5% had GPAs lower than 3.0.

[7] U.S. Department of Education, National Center for Education Statistics, *Digest of Education Statistics*, 2006, Table 268: http://nces.ed.gov/programs/digest/d06/tables/dt06_268.asp.
[8] All GPAs were converted to a 4.0 scale.

EEC Site participants had the highest GPA (3.57), on average, but ERC and ENG Supplement participants had only slightly lower GPAs of 3.53 and 3.51, respectively.

Academic Major and Its Relationship to the Research Conducted

Many students use research experiences to explore new areas. Slightly more than half (56%) said the research experience was in an academic field different from their undergraduate major, but about half (52%) also reported that the research was somewhat related to courses they had taken in their major, and more than a third (36%) said it was closely related to their course work. ENG Supplement students were slightly more likely to say their REU research was closely related to courses they had taken in their major than were ERC Supplement or EEC Site students (43% vs. 36% and 35%, respectively). There were no appreciable differences between summer and academic-year undergraduate researchers in these percentages.

Surprisingly, 9% of undergraduates reported that their research was in a non-engineering field (such as biology, chemistry, mathematics, or physics), and another 6% reported their research involved both engineering and non-engineering fields. Likewise, 8% of faculty reported that their own research was in a non-engineering field, and 7% said their research involved both engineering and non-engineering fields. EEC Site and ENG Supplement students were slightly more often involved in non-engineering research than were ERC Supplement students (15% and 16% vs. 9%, respectively).

Opportunities for Research

About 9 in 10 students (93%) reported that there were research opportunities for undergraduates in their major at the school they attended, and about 8 in 10 (83%) indicated that they did in fact participate in research at their home school at some time during their undergraduate career. Slightly fewer EEC Site students than ERC and ENG Supplement students participated in research at their home school (81% vs. 87% and 91%, respectively). All academic-year researchers had opportunities to do research at their home school (100% vs. 93% of summer researchers), and almost all did participate (96% vs. 82% of summer researchers).

OTHER RESEARCH EXPERIENCES AND INTERESTS

A majority of respondents participated in research during both the summer and the academic year. Sixty-one percent of the summer undergraduates had participated in research during the academic year, and 60% of the academic-year undergraduate researchers had participated in summer research. Overall, 26% reported they had also participated in an intern or co-op research program, and 32% said they had completed a junior or senior thesis that involved hands-on research. ENG Supplement students were less likely to have completed a junior or senior thesis than were EEC Site or ERC Supplement students (22% vs. 35% and 33%, respectively).

Approximately three-quarters (77%) of the students had done some kind of undergraduate research other than the experience they reported on in the survey, and 35% had participated in science or math fairs while in high school. One fifth said they had been interested in engineering ever since they were a child and about half (49%) became interested in engineering during high school; another fifth became interested during college. ENG Supplement students were the least likely to have become interested in engineering during college (13% vs. 20% each for EEC Sites and ERC Supplements) and the most likely to have been interested ever since they were a child (27% vs. 19% and 17%, respectively).

Before they participated in any undergraduate research, about half of the students (55%) were already planning to get some kind of advanced degree, and a quarter planned to get a PhD. ENG Supplement students less often expected a PhD than did EEC Site or ERC Supplement students (21% vs. 27% of each), and black or African American students more often expected a PhD than did non-Hispanic white or Hispanic students (34% vs. 24% and 25%, respectively). There were no appreciable differences between summer and academic-year researchers.

IV. UNDERGRADUATE SELECTION CRITERIA

In this section, we discuss the preferences and criteria used by faculty mentors in selecting undergraduates for their REU research programs. Faculty of summer and academic-year programs were asked slightly different sets of questions about selection criteria because of the different structures of undergraduate research programs offered at these two times. That is, summer programs have a specific time schedule, with formal applications from undergraduates in all parts of the country, most of whom have no personal acquaintance with the faculty. In contrast, academic-year programs tend to be more informal, based on personal contacts between the student and the faculty, and with students beginning work at different times and working on individual schedules. Therefore, for example, only summer faculty were asked about the importance of letters of recommendation and the student's essay, whereas only academic-year faculty were asked about the importance of whether the student has sufficient time available, the student's interest in research as a career, and the student's dependability.

Questions about selection criteria were asked only of those who indicated they were involved in selecting undergraduates to participate, which included 78% of academic-year mentors and 53% of summer faculty mentors. Fifteen percent of academic-year faculty mentors indicated that they "take pretty much anyone who wants to participate." In total, 55% of faculty mentors answered questions about selection criteria.

The most important criterion for all faculty was the student's apparent motivation or enthusiasm—rated extremely important by 70% of all faculty. All other criteria were rated as extremely important by half or less of the faculty. Whether the student's interests matched faculty interests was rated extremely important by 51% of all faculty. For summer faculty, letters of recommendation were next most important; for academic-year faculty, dependability was rated next most important (each was rated extremely important by 49% of the respective faculty).

There was substantial variation among award types in what faculty thought was important in selecting undergraduate researchers (Table IV-1). Generally, the largest differences were between faculty of EEC Sites and ENG Supplements. EEC Site faculty tended to rate more criteria higher than did ENG Supplement faculty, with ERC Supplement faculty often in the middle. Only one of the criteria listed was rated as extremely important by more than half of the ENG Supplement faculty (motivation/enthusiasm, at 76%), but the top three criteria were all rated as extremely important by more than half of the EEC Site faculty.

Some of the response differences reflect differences among the award types in how students are recruited. For example, EEC Site awards are almost entirely group summer programs with many participants from campuses other than the Site location. Accordingly, a majority of EEC Site faculty (54%) rated letters of recommendation as extremely important. Letters are less important for ENG Supplements (31% rated them extremely important), which involve mostly students from their own campus. Likewise, a larger proportion of EEC Site faculty than ENG Supplement faculty rated students' essays as extremely important (36% vs. 13%). Conversely, interviews and other prior personal contact with potential researchers were much more important to faculty in ENG Supplements than they were to those in EEC Sites (45% vs. 20%).

Table IV-1

Faculty Mentors' Selection Criteria for Undergraduate Researchers, by Award type: Percentage Extremely Important

(Listed in descending order of the "All" percentage)

	ERC Supplements	EEC Sites	ENG Supplements	All
Number of respondents:	*83*	*473*	*164*	*720*
Motivation, enthusiasm	77%	67%*	76%**	70
Student's interests match faculty interests	59	53	42*	51
Letters of recommendation (S)	41	54**	31*	49
Dependability (AY)	na	na	48	49
Major	37	41	46	42
Have sufficient time available (AY)	na	na	42	42
Grade point average in major or selected courses	31	40	34	38
Student's essay (S)	28	36**	13*	32
Obtaining a racially/ethnically diverse group	26	36**	19*	31
Including a good mix of male and female students	21	35**	18*	29
Courses taken	27	27	32	28
Interview or other personal contact with student (S) or prior contact with student (AY)	31	20*	45**	27
Overall grade point average	19	30**	20*	26
Including students with disabilities	8*	19**	8*	15
Interest in research as a career (AY)	na	na	14	13

This table shows, for example, that 77% of ERC Supplement faculty rated motivation or enthusiasm as extremely important in selecting undergraduates to participate in their research.

Notes: na = not asked of this group.
S = summer faculty only (n=659). Summer faculty were asked the importance of "interview or other personal contact with student."
AY = academic-year faculty only (n=61). Academic-year faculty were asked the importance of "prior contact with student."

*This group's percentage is reliably lower than that of all other groups combined ($p < .05$).

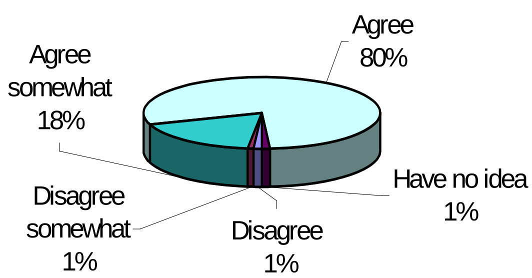
**This group's percentage is reliably higher than that of all other groups combined ($p < .05$).

One might expect that including a good mix of male and female students who are racially/ethnically diverse would be more important to faculty of both ERC Supplements and EEC Sites, which recruit larger groups for their summer programs, than to faculty of ENG Supplements, which typically involve only one or two students. Indeed, these issues were less important to ENG Supplement faculty, but they were, surprisingly, also less important to ERC Supplement faculty than they were to EEC Site faculty. Thirty-five percent of EEC Site faculty rated a good mix of male and female students as extremely important, compared with 18% of ENG Supplement faculty; and 36% of EEC Site faculty rated a racially/ethnically diverse group as extremely important, compared with 19% of ENG Supplement faculty. Similarly, including students with disabilities was more important to EEC Site faculty than to ERC or ENG Supplement faculty (19% vs. 8% and 8%, respectively).

In all three award types, most faculty indicated that they preferred a mix of backgrounds and interests for their undergraduate researchers rather than any one type. For example, asked whether they tended to prefer those with few research opportunities or those with many, 74% responded “some of both” or “no preference.” (It is noteworthy, however, that few (5%) stated a preference for students with many research opportunities.) Similarly, 68% indicated “some of both” or “no preference” regarding their preference for those with or without research experience. And asked whether they tended to prefer those who were committed to graduate school or those who were undecided, 74% of faculty responded either “some of both” or “no preference.”

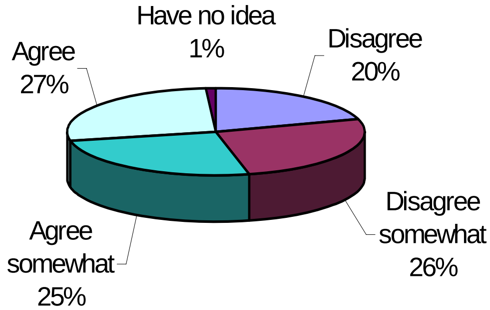
This desire for a mix of students also was reflected in two other findings:

Figure IV-1
"Research is a good experience for undergraduates, regardless of their decisions about career or advanced degrees": Percentage with Each Response



- Ninety-eight percent of faculty agreed, at least somewhat, that “research is a good experience for undergraduates, regardless of their decisions about career or advanced degrees” (Figure IV-1).

Figure IV-2
"Research experiences are more valuable for students who will pursue research or teaching careers than for those who will not": Percentage with Each Response



- Faculty were almost equally divided among the four points of an agreement scale on the statement "Research experiences are more valuable for students who will pursue research or teaching careers than for those who will not" (Figure IV-2).

V. UNDERGRADUATE MOTIVATIONS FOR PARTICIPATION

Based on our URO survey experience, we developed a list of potential reasons for participating in research in general and for choosing a particular REU research project. Undergraduates were asked to rate the importance of each reason on a 4-point scale: 1 = not important, 2 = somewhat important, 3 = fairly important, 4 = extremely important. The reasons, percentage distribution of responses, and mean ratings are shown in Table V-1. The top five reasons overall for participating in research were:

- I wanted to learn more about what it's like to be a researcher.
- I wanted hands-on experiences to reinforce what I learned in class.
- I thought it would be fun.
- The research project(s) sounded interesting.
- I wanted to know if going to graduate school in engineering was for me.

The first four were the top-rated reasons for students in each award type. ERC Supplement students' fifth reason was "I thought it would help me get into graduate school or get a job," and ENG Supplement students' fifth reason was "Doing research was more appealing than other kinds of jobs available." The top five reasons were also among the top-rated reasons for both summer and academic-year research participants, males and females, and most racial/ethnic groups.

Factor analyses of the items asked of both summer and academic-year researchers were conducted to facilitate analysis of these many items.[9] The analyses showed that most of the items clustered into four types of motivations. Indices were created by calculating the combined mean of the items in each cluster, which we have termed "decision help," "research enthusiasm," "meet requirements," and "personal contacts." The items comprising each index are as follows:

Decision help

- I wanted to know if engineering was for me.
- I wanted to learn more about what it's like to be a researcher.
- I wanted to know if going to graduate school in engineering was for me.
- I wanted to know if this field of research was for me.

Research enthusiasm

- Doing research was more appealing than other kinds of jobs available to me.
- I thought it would be fun.
- I like this field of research and wanted to work in it.
- The research project(s) sounded interesting.

[9] Factor analyses identify groups of items that are correlated with one another. For example, if several items are correlated with one another, respondents who rate one item as extremely important are also likely to rate other items in that group as extremely important.

Table V-1

Undergraduates' Motivations for Participating in Research

(Listed in descending order of mean rating)

	No. of Resp.	**Not Important**	**Somewhat Important**	**Fairly Important**	**Extremely Important**	**Mean Rating**
I wanted to learn more about what it's like to be a researcher.	*2,610*	2%	5%	24%	70%	3.6
I wanted hands-on research experiences to reinforce what I learned in class.	*2,609*	3	11	28	57	3.4
I thought it would be fun.	*2,602*	2	10	41	48	3.3
The research project(s) sounded interesting.	*2,601*	3	11	37	48	3.3
I wanted to know if going to graduate school in engineering was for me.	*2,594*	11	10	24	55	3.2
I thought it would help me get into graduate school or get a job.	*2,612*	6	14	31	49	3.2
I wanted to do something different than what I've done before.	*2,602*	8	12	33	46	3.2
I wanted to know if this field of research was for me.	*2,610*	7	15	37	40	3.1
Doing research was more appealing than other kinds of jobs available to me.	*2,582*	10	18	30	42	3.0
I like this field of research and wanted to work in it.	*2,605*	9	22	36	33	2.9
Personal interaction with the program coordinator, director, or other faculty member or researcher.	*2,602*	18	16	29	36	2.8
The living arrangements for this program. (S)	*2,472*	13	22	37	27	2.8
The amount of the stipend and support package (housing, meals, etc.). (S)	*2,463*	20	23	34	22	2.6
The reputation of the host institution. (S)	*2,463*	24	22	30	24	2.5
I wanted to know if engineering was for me.	*2,602*	27	21	28	24	2.5

(Continued)

Table V-1 (Concluded)

Undergraduates' Motivations for Participating in Research

(Listed in descending order of mean rating)

	No. of Resp.	**Not Important**	**Somewhat Important**	**Fairly Important**	**Extremely Important**	**Mean Rating**
The social/cultural activities for this program. (S)	*2,465*	29	23	29	20	2.4
This was the first program/project that accepted me for [REU time period].	*2,605*	39	19	25	17	2.2
I wanted to be close to home. (S)	*2,463*	32	26	26	15	2.2
Someone I knew recommended it.	*2,598*	47	15	18	18	2.1
This was the only research program/project that accepted me for [REU time period].	*2,607*	51	13	16	16	2.0
Personal interaction with other undergraduates, grad students, or K-12 teachers	*2,605*	58	9	12	17	1.9
I wanted to be far from home (S)	*2,476*	68	11	12	9	1.6
Geographic location of the project (not the distance from home per se) was appealing (S)	*2,468*	72	13	9	6	1.5
I needed/wanted the academic credit I could get from doing research	*2,599*	77	11	7	5	1.4
I needed to fulfill my school's or scholarship's requirements for research	*2,593*	85	7	4	4	1.3

This table shows, for example, that 2% of undergraduate researchers rated "I wanted to learn more about what it's like to be a researcher" as not important in their decision to do research.

Notes: Mean ratings are based on a 4-point scale: 1 = not important, 2 = somewhat important, 3 = fairly important, 4 = extremely important.

Percentages answering "Don't remember" (4% or less on all items) are not shown.

(S) = asked only of summer researchers.

Meet requirements

- I needed to fulfill my school's or scholarship's requirements for research.
- I thought it would help me get into graduate school or get a job.
- I needed/wanted the academic credit I could get from doing research.

Personal contacts

- Someone I knew recommended it.

- Personal interaction with the program coordinator, director, or other faculty member or researcher.
- The reputation of the host institution (asked only of summer researchers).

The indices' mean ratings were compared by award type, research field, sex, and race/ethnicity. All groups rated "research enthusiasm" and "decision help" as the most important reasons for doing research. Comparing award types, we found that ENG Supplement students gave lower ratings to "decision help" than did EEC Site or ERC Supplement students (2.98 vs. 3.12 and 3.18, respectively) and EEC Site students gave "personal contacts" a lower rating than did the other two groups (2.46 vs. 2.60 and 2.63, respectively). Females gave slightly higher ratings to "decision help" and "personal contacts" than did males (3.15 vs. 3.09 and 2.55 vs. 2.45). Comparing across racial/ethnic groups, black or African Americans, Asians, and Hispanics tended to have relatively high ratings, whereas non-Hispanic whites tended to have relatively low ratings (3.2 and above vs. 3.06 on "decision help" and 2.6 and above vs. 2.4 on "personal contacts"). Hispanics tended to have the highest motivation index ratings of all racial/ethnic groups.

Almost half of undergraduate researchers (46%) applied to other research programs at the same time as they applied for REU research, and 18% applied for four or more programs. Participants in ENG Supplements were about half as likely to apply to other programs as were those in EEC Sites or ERC Supplements (23% vs. 48% and 51%, respectively). This difference reflects the relatively informal structure of ENG Supplements, in which students tend to work at their own college with a professor they already know, in contrast with the more formal group structure of ERC Supplements and EEC Sites.

In later sections, we discuss the relationships between various kinds of motivations and other survey issues, such as students' satisfaction with the research experience and the effects of the experience on them.

VI. ACTIVITIES AND CHARACTERISTICS OF UNDERGRADUATE RESEARCH EXPERIENCES

RESEARCH ACTIVITIES

Students' Report of Undergraduate Research Activities

The survey asked about undergraduate participation in many varied research activities. It found that three-quarters or more of the undergraduates supported by ENG REU programs participated in the following activities and experiences:

- Collected and/or analyzed data or information to try to answer a research question (reported by 88% of undergraduate researchers).
- Delivered an oral/PowerPoint presentation describing my research and results (86%).
- Understood how my work contributed to the "bigger picture" of research in this field (78%).
- Received training to use research tools (computer program/language, lab or field equipment, etc.) (75%).

Other activities in which at least half of the undergraduates participated were:

- Gained increasing independence over the course of the summer (72%).
- Decided or helped decide what to do next (70%).
- Prepared a final written research report describing my research and results (69%).
- I had primary responsibility for designing the research project that I worked on or I provided input (61%).
- Decided or helped decide what research techniques/materials were used (58%).
- Received training in written or oral communication skills (57%).
- Attended lectures/seminars on research ethics (56%).
- Was able to complete my research project (either then or later) (54%).
- Went on research-related field trip(s) (to other labs, universities, industry, etc.) (54%).

Less common activities were:

- Prepared/presented a poster presentation describing my research and results (45%).
- Had a choice of projects to work on when research activities began (45%).
- Wrote a proposal describing the research I planned to do (31%).
- Attended student conference(s) that included students from multiple colleges (26%).
- Authored or co-authored a paper that has been or will be submitted for publication in a professional journal (21%).
- Attended professional conference(s) (conferences not specifically for students) (20%).
- Mentored other students conducting research or led a student research team (9%).

Reassuringly, only 7% of ENG-funded undergraduate researchers felt that they "did little or nothing that seemed to be real research."

Percentages of students who reported the various research activities are shown in Table VI-1, broken out by award type. ENG Supplement students, on average, participated in fewer research activities than did EEC Site or ERC Supplement students (8.8 vs. 11.0 and 10.9, respectively). ENG Supplement students were much less likely than others to have delivered a formal presentation (oral, written, or visual) describing their research and results and were less likely to have received training in written or oral communication skills, attended lectures/seminars on research ethics, completed their research project, gone on research-related field trips, or attended student conferences. In each of these cases, the differences reflect the less structured, more individualistic nature of the research experiences of ENG Supplement participants, as opposed to the more structured, group experiences of EEC Site and ERC Supplement participants. All other activities had differences of 10 percentage points or less between the groups.

Table VI-1

Undergraduate Research Activities and Characteristics, by REU Award Type: Percentage Who Did Each Activity or Had Each Characteristic

(Listed in descending order of the "All" column)

	ERC Supplements	EEC Sites	ENG Supplements	All
Number of respondents:	*363*	*1,893*	363	*2,619*
Collected and/or analyzed data or information to try to answer a research question	86 %	89 %**	85 %	88%
Delivered an oral/PowerPoint presentation describing my research and results	93 **	90 **	51 *	86
Understood how my work contributed to the "bigger picture" of research in this field	79	77	80	78
Received training to use research tools (computer program/language, lab or field equipment, etc.)	71 *	77 **	68 *	75
Gained increasing independence over the course of the research	72	72	68	72
Decided or helped decide what to do next	68	71	67	70
Prepared a final written research report describing my research and results	79 **	71 **	46 *	69
I had primary responsibility for designing the research project that I worked on or I provided input	56 *	62	65	61
Decided or helped decide what research techniques/materials were used	53 *	58	63 **	58
Received training in written or oral communication skills	70 **	59 **	32 *	57
Attended lectures/seminars on research ethics	55	61 **	23 *	56

(Continued)

Table VI-1 (Concluded) Undergraduate Research Activities and Characteristics, by REU Award Type: Percentage Who Did Each Activity or Had Each Characteristic (Listed in descending order of the "All" column)	ERC Supplements	EEC Sites	ENG Supplements	All
Was able to complete my research project (either then or later)	55	56 **	41 *	54
Went on research-related field trip(s) (to other labs, universities, industry, etc.)	53	58 **	26 *	54
Prepared/presented a poster presentation describing my research and results	44	48 **	28 *	45
Had a choice of projects to work on when research activities began	41	46 **	41	45
Wrote a proposal describing the research I planned to do	26 *	32 **	27	31
Attended student conference(s) that included students from multiple colleges	39 **	26	15 *	26
Authored or co-authored a paper that has been or will be submitted for publication in a professional journal	19 %	20 %	24 %	21%
Attended professional conference(s) (conferences not specifically for students)	24	20	17	20
Mentored other students conducting research or led a student research team	8	9	14 **	9
Did little or nothing that seemed to me to be real research	9	7	6	7

This table shows, for example, that 86% of ERC Supplement undergraduates reported that they collected/analyzed data as part of their research experience.

*This group's percentage is reliably lower than that of all other groups combined (p < .05).

**This group's percentage is reliably higher than that of all other groups combined (p < .05).

Faculty's Report of Undergraduate Research Activities

Faculty were asked which of a similar list of research activities any of the undergraduates they mentored/supervised did as part of their REU research experiences. (Faculty were not asked whether undergraduates were involved in decisions about what to do next or what research techniques/materials were used nor about whether the undergraduates had a choice of projects to work on or provided input into designing the research project).

Given that faculty were asked whether **any** of their undergraduates performed each of the listed activities, it is not surprising that higher percentages of faculty than of students reported most of the activities. The differences were largest with respect to whether students were able to complete their research project (73% of faculty vs. 54% of undergraduates) and whether undergraduates prepared/presented a poster presentation describing their research and results (62% of faculty vs. 45% of undergraduates).

TIME SPENT DOING RESEARCH

The major determinant of the amount of time spent in research-related activities was the time of year of the research. The mean time reported by summer researchers—for whom their major focus of activity was the research—was 38 hours per week; for academic-year researchers—the vast majority of whom were also attending classes while they were doing research—the mean was 17 hours (excluding the one full-time fall Site program). Summer researchers spent about the same amount of time across all award types. Most academic-year researchers were funded by ENG Supplements.

MENTOR-RELATED ISSUES

It is noteworthy that almost a quarter (22%) of undergraduate researchers reported spending less than an hour per week with their faculty mentor. Nearly half (48%) reported spending 1 to 4 hours, and the remaining quarter spent 5 hours or more. Surprisingly, given their more intensive research schedule, summer researchers spent a similar amount of time with their faculty mentor as did academic-year researchers (Table VI-2). There were no differences across award types in time spent with their faculty mentor.

Table VI-2

Hours per Week Spent by Undergraduates in Research-Related Activities with Others, by Time of Year of Research

	Faculty Mentor		Graduate Students/ Postdocs		Other Undergraduates		K-12 Grade Teachers	
	Summer	Academic Year	Summer	Academic Year	Summer	Academic Year	Summer	Academic Year
Number of respondents:	*2,479*	*136*	*2,470*	*136*	*2,475*	*136*	*2,439*	*134*
No time	3%	2%	8%	8%	19%*	30%**	91%	96%
Less than 1 hour	22	25	6	9	9	14	2	2
1 to 4 hours	48	55	19*	30**	19	18	3	1
5 to 9 hours	15	11	19	21	13	17	1	0
10 to 19 hours	6	4	19	14	12	8	< 1	0
20 hours or more	5	1	28**	16*	26**	9*	1	0

This table shows, for example, that 3% of summer undergraduate researchers reported that they spent no time each week with their faculty mentor.

Note: Percentages answering "Don't remember" (2% or less on all items) are not shown.

*This group's percentage is reliably lower than that of the other group ($p < .05$).

**This group's percentage is reliably higher than that of the other group ($p < .05$).

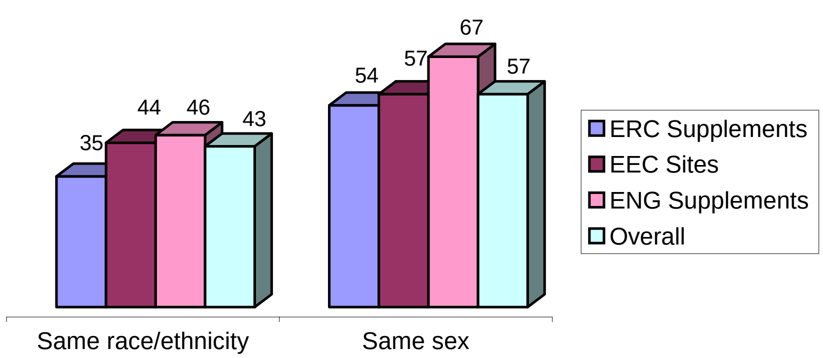
Undergraduate researchers did spend considerably more time in research-related activities with their graduate student or postdoc mentors and other undergraduates. Forty-six percent spent 10 hours or more per week with graduate students/postdocs, and 37% spent 10 hours or more per week with other undergraduates. Summer researchers spent more time with graduate student or postdoc mentors than did academic-year researchers. For example, 28% of summer researchers spent 20 hours or more per week working with graduate students/postdocs, compared with only 16% of academic-year researchers. The comparable percentages for working with other undergraduates were 26% and 9%. ENG Supplement students spent less time with graduate students/postdocs than did EEC Site or ERC Supplement students (17% spent 20 hours or more per week vs. 28% and 36%, respectively) and less time with other undergraduates (14% spent 20 hours or more per week vs. 27% and 26%, respectively). Few students (9%) spent any time with K-12 teachers, regardless of the time of year or award type.

Four in 10 undergraduates had their faculty mentor to themselves, 55% shared him/her with one or more other undergraduates, and 5% didn't know or remember. Academic-year researchers were more likely to have shared their mentor than were summer researchers (64% vs. 55%); and, likewise, ENG Supplement researchers were more likely than ERC supplement or EEC Site researchers to have shared their mentor (64% vs. 56% and 54%). Hispanic researchers were more likely to have shared their mentor (61%) and black or African American researchers were less likely (44%). There were no reliable differences between men and women.

Less than half of all undergraduate researchers (43%) reported that their faculty mentor's race/ethnicity was the same as their own; 4% were not sure. ERC Supplement researchers less often had a faculty mentor of the same race/ethnicity than did EEC Site or ENG Supplement researchers (35% vs. 44% and 46%, respectively) (Figure VI-1). Non-Hispanic white students more often had a faculty mentor of the same race/ethnicity than did minority race students (60% vs. 11% to 16%). This finding is consistent with the fact that a large majority of faculty mentors were non-Hispanic white (71%).

Overall, slightly over half of the students (57%) had mentors who were the same sex (Figure VI-1). Male students were much more likely than females to have mentors who were the same sex (85% vs. 21%), reflecting the fact that a large majority of the engineering faculty (81%) were also male. ENG Supplement students, 70% of whom were male, were thus more likely to have mentors who were the same sex (67% vs. 54% of ERC Supplement and 57% of EEC Site students).

Figure VI-1
Percentage Who Had a Faculty Mentor of the Same Race/Ethnicity and Sex, by Funding Mechanism



ACADEMIC CREDIT AND PAY FOR RESEARCH ACTIVITIES

Overall, only 16% of undergraduates received academic credit for their research, but essentially all (99%) received a stipend. The major determining factor in receiving academic credit was whether the research was done in the summer or during the academic year: 15% of summer researchers and 26% of academic-year researchers received academic credit. ERC Supplement researchers, none of whom participated during the academic year, were less likely to receive academic credit than were EEC Site or ENG Supplement researchers (6% vs. 18% and 14%, respectively) (Figure VI-2). Among the racial/ethnic groups, Hispanics were the most likely to receive academic credit (23% did so), whereas black or African Americans and other or mixed-race researchers were the least likely to do so (10% and 8%, respectively) (Figure VI-3). Hispanics were not more likely to be academic-year researchers, so it is unclear why they were more likely to receive academic credit.

There was no difference between males and females in receiving academic credit and no difference in receiving a stipend by award type, time of year, race/ethnicity or sex.

FIgure VI-2
Percentage Who Received Academic Credit for Their Research, by Funding Mechanism

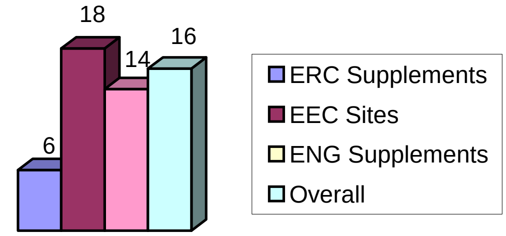
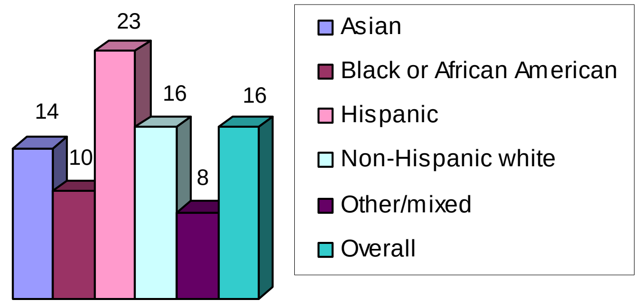


Figure VI-3
Percentage Who Received Academic Credit for Their Research, by Race/Ethnicity



VII. UNDERGRADUATES' PERCEPTIONS OF THEIR RESEARCH EXPERIENCES

The student questionnaire included a variety of topics relating to the students' thoughts about their research experiences. These included questions about the adequacy of time spent with their faculty mentor, how well prepared they felt they were for the work they were asked to do, and how satisfied they were with various aspects of the research experiences.

ADEQUACY OF CONTACT WITH FACULTY MENTOR

Almost no undergraduates (1%) thought that they had too much contact with their faculty mentor; 67% thought the amount of contact was about right, and 31% thought it was too little. A higher proportion of undergraduates (79%) felt they had the right amount of contact with graduate students or postdocs, and only 12% felt they had too little contact with them. A similar proportion of undergraduates (69%) felt they had the right amount of contact with other undergraduates who were doing research, but only 15% felt they had too little contact; 13% said this didn't apply to them because they spent no time on research with other undergraduates. Very few reported spending any time with K-12 teachers (7%), and of those who did, two-thirds felt it was about the right amount (60%) or too much (6%) contact.

Of the major dimensions of analysis (award type, race/ethnicity, sex, and time of year), the largest differences were by time of year (Table VII-1). Summer researchers more often than academic-year researchers thought they had too little contact with their faculty mentor (31% vs. 21%) and about the right amount of contact with other undergraduates (70% vs. 57%). ERC Supplement researchers were less likely than EEC Site and ENG Supplement researchers to feel they had about the right amount of contact with their faculty mentor (57% vs. 68% and 73%, respectively) and more likely to feel they had too little contact (40% vs. 30% and 23%, respectively). There were no notable differences among racial/ethnic groups or between sex.

Students' attitudes about whether they had too little, about the right amount, or too much contact with their faculty mentor were strongly related to the amount of time they actually spent with their mentor. Three-quarters of those who spent 1 to 4 hours per week with their faculty mentor felt it was about the right amount of time (Figure VII-1). Almost all (91%) of those who spent 5 hours or more per week felt it was the right amount of time spent with faculty. Summer researchers showed a similar pattern, but there were too few academic-year researchers to make a comparison. Even with substantial contact, almost no undergraduates felt they had too much contact with their mentor. It thus appears that it is very difficult for faculty to spend "too much" time with their undergraduates, but there is a wide band of time that may be considered "about the right amount." For time spent with graduate students/postdocs or other undergraduates, slightly more contact was required for undergraduates to feel it was about the right amount. Nearly all (91% or more) of those who spent 5 hours or more per week with graduate students/postdocs or other undergraduates felt it was about the right amount.

Table VII-1

Undergraduates' Attitudes about the Amount of Contact They Had with Others Doing Research, by Time of Year of Research

	Faculty Mentor		Graduate Students/ Postdocs		Other Undergraduates		K-12 Grade Teachers	
	Summer	**Academic Year**	**Summer**	**Academic Year**	**Summer**	**Academic Year**	**Summer**	**Academic Year**
Number of respondents	*2,480*	*136*	*2,471*	*136*	*2,473*	*136*	*2,457*	*132*
Too little contact	31%**	21%*	12%**	7%*	15%	13%	6%	4%
About the right amount	67*	75**	79	81	70**	57*	10	8
Too much contact	1	1	3	2	2	1	1	0
Doesn't apply	< 1	2	6	9	13*	27**	81	86

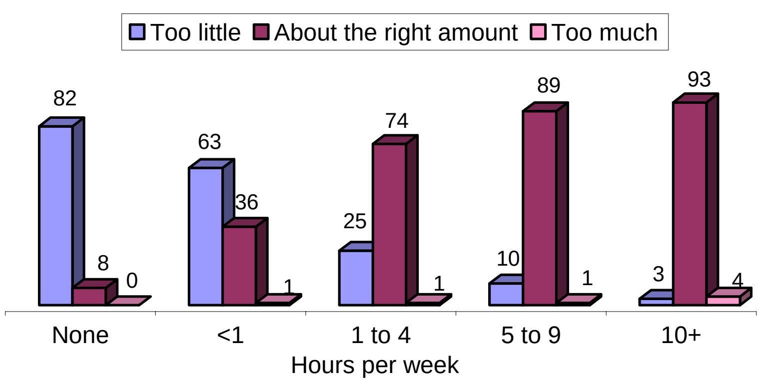
This table shows, for example, that 31% of summer undergraduate researchers reported that they had too little contact each week with their faculty mentor.

Note: Percentages who said "Don't remember" (3% or less on all items) are not shown.

*This group's percentage is reliably lower than that of the other group (p < .05).

**This group's percentage is reliably higher than that of the other group (p < .05).

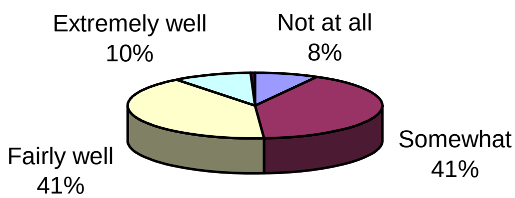
Figure VII-1
Undergraduate Perceptions of TIme Spent with Faculty Mentor, by Hours per Week Spent Together: Percentage



FEELING PREPARED

Overall, about half of the undergraduates (51%) felt fairly or extremely well prepared for the work they were asked to do (Figure VII-2).

Figure VII-2
Undergraduates' Perceptions
of How Well Prepared They Felt
for the Work They Were Asked to Do



Summer researchers were slightly less likely than academic-year researchers to feel fairly or extremely well prepared (50% vs. 60%); ERC Supplement researchers were less likely than EEC Site or ENG Supplement researchers (44% vs. 50% and 56%, respectively); females were less likely than males (46% vs. 54%); and non-Hispanic whites were more likely than others to feel fairly or extremely well prepared (54% vs. 39% of black or African Americans, 46% of Hispanics, and 44% of Asians).

SATISFACTION WITH UNDERGRADUATE RESEARCH

Undergraduates were asked about their satisfaction with various aspects of the research experience. As shown in Table VII-2, more than half were very satisfied with most aspects.

The highest levels of satisfaction were with how well organized the program was (72% very satisfied) and the overall supportiveness of one's faculty mentor (71% very satisfied). The students were least satisfied with the research project worked on (38% very satisfied) and the overall supportiveness of other undergraduate or K-12 teacher participants (46% very satisfied).

There were some differences on these items between award types (Table VII-3). ENG Supplement students were less satisfied than ERC Supplement or EEC Site students with how well organized the program was (61% vs. 71% and 73%, respectively) but more satisfied with the amount of involvement they had in selecting or designing their research project (66% vs. 55% and 58%, respectively). Summer ENG Supplement students were also less satisfied with the social/cultural activities (38% vs. 56% and 62%, respectively) and the living arrangements (34% vs. 45% and 56%, respectively). This perhaps is because ENG Supplements most often did not arrange housing or group activities. There were no differences by sex, and most racial/ethnic differences were quite small, although Hispanics were somewhat more satisfied than others with several aspects of their research experience.

Table VII-2

Undergraduates' Satisfaction with Various Aspects of the Research Experience (Listed in descending order of mean rating)

	No. Resp.	**Very Dissatisfied**	**Somewhat Dissatisfied**	**Somewhat Satisfied**	**Very Satisfied**	**Mean Rating**
How well organized the program was	*2,603*	1%	5%	23%	72%	3.7
The overall supportiveness of your faculty mentor(s)	*2,279*	3	6	20	71	3.6
The adequacy of the technical guidance you received	*2,608*	1	6	31	62	3.5
The social/cultural activities (S)	*2,434*	2	10	28	60	3.5
The independence you had in doing your work	*2,134*	2	7	24	66	3.5
The overall supportiveness of your graduate student or postdoc mentor(s)	*960*	3	5	28	56	3.5
The amount of involvement you had in selecting or designing your research project(s)	*2,591*	4	11	25	59	3.4
Your living arrangements (housing, meals) (S)	*2,187*	3	11	32	54	3.4
The extent to which you felt you were an integral part of a research team	*2,603*	3	12	35	50	3.3
The overall supportiveness of other undergraduate or K-12 teacher participants	*2,410*	7	13	36	46	3.3
The research project(s) you worked on	*2,519*	4	17	40	38	3.1

This table shows, for example, that 1% of undergraduate researchers were very dissatisfied with how well organized the program was.

Notes: Mean ratings are based on a 4-point scale: 1 = very dissatisfied, 2 = somewhat dissatisfied, 3 = somewhat satisfied, 4 = very satisfied.
Percentages are based on those to whom the item applied.
Percentages who said "Don't remember" are not shown.
(S) = asked only of summer undergraduate researchers.

Table VII-3
Undergraduates' Satisfaction with Various Aspects of the Research Experience, by NSF Award Type: Percentage Very Satisfied

	ERC Supplements	EEC Sites	ENG Supplements	All
Number of respondents:	*360*	*1,887*	*361*	*2,608*
How well organized the program was	71 %	73 %**	61 %*	72%
The overall supportiveness of your faculty mentor(s)	68	71	72	71
The adequacy of the technical guidance you received	65	61	64	62
The social/cultural activities (S)	56	62 **	38 *	60
The independence you had in doing your work	63	67	61	66
The overall supportiveness of your graduate student or postdoc mentor(s)	50	57	50	56
The amount of involvement you had in selecting or designing your research project(s)	55	58	66 **	59
Your living arrangements (housing, meals) (S)	45 *	56 **	34 *	54
The extent to which you felt you were an integral part of a research team	51	49	54	50
The overall supportiveness of other undergraduate or K-12 teacher participants	44	45	51	46
The research project(s) you worked on	36	38	41	38

This table shows, for example, that 71% of ERC Supplement students were very satisfied with how well organized the program was.

Notes: (S) = asked only of summer undergraduate researchers.

Percentages are based on those to whom the item applied.

*This group's percentage is reliably lower than that of all other groups combined ($p < .05$).

**This group's percentage is reliably higher than that of all other groups combined ($p < .05$).

Primary Correlates of an Index of Overall Satisfaction

A factor analysis of the satisfaction items that applied to both academic-year and summer undergraduate researchers showed that the items were all quite highly correlated with one another and formed a single cluster. Accordingly, we created a single overall satisfaction index by calculating the combined mean of the items. We used this index to analyze the relationships between satisfaction and other variables, using stepwise regression analysis. Across all students, variables that were the most strongly related[10] to overall satisfaction with the research experience were:

- Having done at least something that seemed like real research.
- Having been involved in project decisions about what to do next.
- Having been involved in designing their project.
- How well prepared they felt for the work they were asked to do.
- The number of research activities engaged in (those listed in Table VI-1, excluding "did little or nothing that seemed to me to be real research").
- Doing research that was at least somewhat closely related to courses they had taken in their major.
- The amount of time spent with graduate students or postdocs.
- Research enthusiasm as a reason to participate in research.
- The amount of time spent with their faculty mentor.

Respondents were grouped into four approximately equal-size categories (quartiles) on the basis of their mean rating on the index.[11] These categories were used in group comparisons and analyses of the relationships between the satisfaction index and other variables. Individuals with scores in the top 28% of the index are considered highly satisfied. Table VII-4 illustrates the relationship between each of these variables and the satisfaction index. It shows, for example, that highly satisfied students were more likely to have done at least something that seemed like real research and to have been involved in project decisions about what to do next than were those who were less satisfied with their research experience.

Hispanics were slightly more satisfied than other racial/ethnic groups. The satisfaction index scores for award types and sex were not reliably different from one another. Students who had a mentor of the same race or gender were no more or less satisfied overall than those with a mentor of a different race or gender.

---

[10] Variables retained in the regression model are reliably related at the $p < .05$ level.

[11] Because many students had equal scores, sorting into exactly equally sized quartiles was not possible. The top group of the satisfaction index, with ratings of 3.8 to 4.0, comprised 28% of respondents.

Table VII-4
Top Correlates of Overall Satisfaction with the Research Experience, by Level of Satisfaction: Percentage Who Did Each
(Listed in descending order of "All" column)

	Least Satisfied	Highly Satisfied	All
Number of respondents:	*704*	*735*	*2,614*
Did at least something that seemed like real research.	80%*	99%**	93%
Were involved in project decisions about what to do next.	53*	80**	70
Were involved in designing their project.	42*	75**	61
Felt fairly or extremely well prepared for the work they were asked to do.	36*	61**	51
Engaged in 10 or more research activities.	31*	47**	44
Did research that was closely related to courses taken in their major.	24*	45**	36
Spent 20 hours or more per week with graduate students or postdocs.	21*	33**	27
Rated "research enthusiasm" as a highly important reason to participate in research.	14*	36**	25
Spent 5 hours or more per week with their faculty mentor.	15*	37**	25

This table shows, for example, that 80% of the students who were the least satisfied with their REU research experience felt they did at least something that seemed like real research, vs. 99% of those who were highly satisfied.

Notes: "Highly satisfied" = those in the top 28% of the satisfaction index ratings.
"Least satisfied" = those in the bottom 27% of the satisfaction index ratings. Those in the middle 45% of the satisfaction index ratings are not shown in the table but are included in calculation of the "All" column.
"Research enthusiasm" is an index of four items; the "highly important" group comprises the top 25% of the index ratings.

*This group's percentage is reliably lower than that of all other groups combined ($p < .05$).

**This group's percentage is reliably higher than that of all other groups combined ($p < .05$).

VIII. EFFECTS OF UNDERGRADUATE RESEARCH

Effects of undergraduate research assessed in this survey were based on self-reports of the undergraduates. The kinds of effects covered included gains students had made on various dimensions as a result of their REU research experiences, increased/decreased interest in several related career areas, and changes in students' expectations regarding their highest academic degree. It is anticipated that the 2009 follow-up survey of FY 2006 students will enable us to determine whether these immediately perceived effects have persisted for those students.

INCREASED AWARENESS, CONFIDENCE, SKILLS, AND UNDERSTANDING

Undergraduates were asked to rate the extent to which their REU research experiences had increased their awareness, confidence, skills, and understanding on various dimensions. Table VIII-1 shows the individual items asked, the mean ratings, and the percentage distribution of responses.

On a 4-point scale (1 = not at all, 2 = somewhat, 3 = a fair amount, 4 = a great deal), a large majority of undergraduates felt that they had increased at least somewhat on all dimensions listed. Importantly, on the two dimensions reflecting a basic purpose of undergraduate research—understanding the nature of the job of a researcher and understanding how to conduct a research project—at least 8 in 10 rated their increase as at least "a fair amount," and 4 or 5 in 10 rated their increase as "a great deal." Students felt they had gained the least in their awareness of ethical issues in conducting research. Other dimensions that produced the least impact related to career options, which are dealt with only indirectly, if at all, in many research settings. Relatively few undergraduates thought they had learned a great deal about how to formulate a research question. This finding may reflect, in part, the fact that 37% of students had no involvement at all in designing their research project.

Factor analyses showed that all the items fell into one of four clusters:

Awareness

- Career paths of the faculty in the program (how they got to where they are now).
- How engineering knowledge is built.
- What graduate school is like.
- The variety of engineering fields you could specialize in.
- Career options in engineering.
- Ethical issues in conducting research.

Confidence

- Confidence in your research skills generally.
- Confidence in your ability to succeed in graduate school.
- Qualifications for jobs in related fields.

Table VIII-1

Undergraduate's Perceptions of Gains as a Result of REU Research Experiences (Listed in descending order of mean rating)

	How Much Each Increased:						
	No. of Resp.	**Not At All**	**Some-what**	**A Fair Amount**	**A Great Deal**	**Have No Idea**	**Mean Rating**
Your understanding of the nature of the job of a researcher (U)	*2,602*	1%	10%	34%	54%	< 1%	3.4
Your understanding of how to conduct a research project (U)	*2,610*	3	16	39	41	< 1	3.2
Your skills/abilities in working independently (S)	*2,610*	3	16	37	44	< 1	3.2
Your understanding of how to deal with setbacks, negative results, etc. (U)	*2,614*	4	18	35	43	< 1	3.2
Your confidence in your ability to succeed in graduate school (C)	*2,617*	5	17	39	38	1	3.1
Your confidence in your research skills generally (C)	*2,617*	3	21	43	33	< 1	3.1
Your skills/abilities in preparing written research reports, papers, or posters (S)	*2,605*	5	20	35	40	< 1	3.1
Your awareness of what graduate school is like (A)	*2,615*	6	20	34	39	1	3.1
Your skills/abilities in delivering oral research presentations (S)	*2,604*	7	18	37	37	< 1	3.1
Your qualifications for jobs in related fields (C)	*2,611*	6	22	41	29	1	3.0
Your understanding of how to plan a research project (U)	*2,615*	6	25	37	31	< 1	2.9
Your understanding of how engineering knowledge is built (A)	*2,606*	8	23	39	28	1	2.9
Your skills/abilities in working collaboratively with others (S)	*2,615*	7	26	38	28	< 1	2.9
Your awareness of career paths of the faculty in the program (how they got to where they are now) (A)	*2,618*	10	26	33	30	1	2.8
Your understanding of how to formulate a research question (U)	*2,618*	10	30	38	22	1	2.7
Your awareness of the variety of engineering fields you could specialize in (A)	*2,610*	13	28	34	25	1	2.7

(Continued)

Table VIII-1 (Concluded)

Undergraduate's Perceptions of Gains as a Result of REU Research Experiences (Listed in descending order of mean rating)

	How Much Each Increased:						
	No. of Resp.	**Not At All**	**Some-what**	**A Fair Amount**	**A Great Deal**	**Have No Idea**	**Mean Rating**
Your awareness of career options in engineering (A)	*2,609*	12	31	34	22	1	2.7
Your awareness of ethical issues in conducting research (A)	*2,605*	16	31	31	21	1	2.6

This table shows, for example, that 1% of undergraduate researchers indicated that their understanding of the nature of the job of a researcher was not at all increased by their research experience.

Notes: Mean rating is calculated on a 4-point scale: 1 = not at all, 2 = somewhat, 3 = a fair amount, 4 = a great deal.
(A) = part of the awareness index.
(C) = part of the confidence index.
(S) = part of the skills index.
(U) = part of the understanding index.

Skills

- Working collaboratively with others.
- Working independently.
- Preparing written research reports, papers, or posters.
- Delivering oral research presentations.

Understanding

- How to formulate a research question.
- How to plan a research project.
- How to conduct a research project.
- How to deal with setbacks, negative results, etc.
- The nature of the job of a researcher.

Primary Correlates of Increased Awareness, Confidence, Skills, and Understanding

Each cluster of items listed above was used to create an index by calculating the combined mean of the items. The four indices were used to analyze the relationships between the types of gains and other variables using stepwise regression analysis.[12] Across all students, five variables were strongly related to all four of the gains indices:

[12] Variables retained in the regression model are reliably related at the $p < .05$ level.

- The number of research activities engaged in (those listed in Table VI-1, excluding “did little or nothing that seemed to me to be real research”).
- Having done at least something that seemed like real research.
- Help with academic or career decisions as a reason for participating in research.
- Research enthusiasm as a reason to participate in research.
- Personal contact as a reason for participating in research.

Three other variables were strongly related to three of the four gains indices:

- Feeling that they spent about the right amount of time with their faculty mentor (not strongly related to the skills index).
- The amount of time spent with graduate students or postdocs (not strongly related to the skills index).
- Having gained increasing independence over the course of the research period (not strongly related to the awareness index).

For each index, respondents were grouped into four approximately equal-size categories (quartiles) on the basis of their mean rating of items combined in that index.[13] These categories were used in group comparisons and analyses of the relationships between the indices and other variables. Individuals with scores in the top approximate quartile of each index are considered high gainers. Tables VIII-2 and VIII-3 show the relationships of the top correlates to the gains indices.

In summary, participating in a great variety of research activities was the best predictor of increased awareness, confidence, skills, and understanding. The kinds of motivations the students had for participating in research also strongly affected their research outcomes. In particular, students for whom the need for help with an academic or career decision was highly important were more likely than those for whom this was unimportant to have high ratings on all four indices. Students for whom enthusiasm for research and personal contacts were highly important as reasons to participate were also more likely to have high ratings on all four indices.

[13] Because many students had equal scores, sorting into exactly equally sized quartiles was not possible. The top group of the awareness index, with ratings of 3.3 to 4.0, comprised 27% of respondents; the top group of the confidence index, with ratings of 3.6 to 4.0, comprised 31% of respondents; the top group of the skills index, with ratings of 3.6 to 4.0, comprised 22% of respondents; the top group of the understanding index, with ratings of 3.6 to 4.0, comprised 32% of respondents.

Table VIII-2
Top Correlates of Overall Gains in Awareness and Confidence, by Level of Gains: Percentage Who Did Each
(Listed in descending order of "All" column)

	Awareness		Confidence		
	Low Gainer	**High Gainer**	**Low Gainer**	**High Gainer**	**All**
Number of respondents:	*604*	*722*	*597*	*827*	*2,619*
Did at least something that seemed like real research.	*84%*	*98%*	*81%*	*99%*	93%
Gained increasing independence over the course of the research time.	*59*	*78*	*50*	*86*	72
Felt they spent about the right amount of time with their faculty mentor.	*52*	*80*	*48*	*81*	67
Engaged in 10 or more research activities.	*44*	*79*	*36*	*82*	65
Spent 20 hours or more per week with graduate students or postdocs.	*24*	*34*	*22*	*32*	27
Rated "research enthusiasm" as a highly important reason to participate in research.	*17*	*38*	*14*	*40*	25
Rated "decision help" as a highly important reason to participate in research.	*10*	*38*	*13*	*35*	24
Rated "personal contact" as a highly important reason to participate in research.	*14*	*31*	*14*	*30*	21

This table shows, for example, that 84% of those students who had gained the least in awareness during their REU research experience felt they did at least something that seemed like real research, vs. 98% of those who were high gainers in awareness.

Notes: "High gainer" = those in the top 27% of the awareness index and top 31% of the confidence index ratings.
"Low gainer" = those in the bottom 24% of the awareness index and bottom 23% of the confidence index ratings.
Those in the middle of the gains index ratings are not shown in the table but are included in calculation of the "All" column.
"Research enthusiasm," "decision help," and "personal contact" are indices comprising three or more items. The "highly important" groups are those in the top approximate quartile of ratings on each index.

All group percentages shown in the table are reliably different ($p < .05$)

Table VIII-3
Top Correlates of Overall Gains in Skills and Understanding, by Level of Gains: Percentage Who Did Each
(Listed in descending order of "All" column)

	Skills		Understanding		
	Low Gainer	**High Gainer**	**Low Gainer**	**High Gainer**	**All**
Number of respondents:	*654*	*582*	*672*	*837*	*2,619*
Did at least something that seemed like real research.	84%	99%	79%	99%	93%
Gained increasing independence over the course of the research time.	55	85	52	86	72
Felt they spent about the right amount of time with their faculty mentor.	55	79	48	79	67
Engaged in 10 or more research activities.	39	86	38	84	65
Spent 20 hours or more per week with graduate students or postdocs.	23	36	18	32	27
Rated "research enthusiasm" as a highly important reason to participate in research.	16	40	14	35	25
Rated "decision help" as a highly important reason to participate in research.	14	39	17	35	24
Rated "personal contact" as a highly important reason to participate in research.	15	34	15	29	21

This table shows, for example, that 84% of those students who had gained the least in skills during their REU research experience felt they did at least something that seemed like real research, compared with 99% of those who were high gainers in skills.

Notes: "High gainer" = those in the top 22% of the skills index and top 32% of the understanding index ratings.
"Low gainer" = those in the bottom 25% of the skills index and bottom 26% of the understanding index ratings.
Those in the middle of the gains index ratings are not shown in the table but are included in calculation of the "All" column.
"Research enthusiasm," "decision help," and "personal contact" are indices comprising three or more items. The "highly important" groups are those in the top approximate quartile of ratings on each index.

All group percentages shown in the table are reliably different ($p < .05$)

Group Differences in Increased Awareness, Confidence, Skills, and Understanding

Award types (Table VIII-4). There were only slight differences in gains indices for awareness, confidence, and understanding across the three award types, but ENG Supplement students reported lower gains in skills than did ERC Supplement and EEC Site students (15% high gainers vs. 26% and 23%, respectively).

Table VIII-4

Undergraduate Perceptions of Gains in Awareness, Confidence, Skills, and Understanding, by Award type

	ERC Supplements	EEC Sites	ENG Supplements	All
Number of respondents:	*363*	*1,893*	*363*	*2,619*
Awareness index				
Mean rating	2.73	2.81 **	2.74	2.79
Percent high gainers	23	28 **	25	27
Confidence index				
Mean rating	3.00	3.05	3.03	3.04
Percent high gainers	27 *	32	31	31
Skills index				
Mean rating	3.16 **	3.09 **	2.81 *	3.07
Percent high gainers	26	23	15 *	22
Understanding index				
Mean rating	3.00	3.10	3.10	3.08
Percent high gainers	26 *	32	34	32

This table shows, for example, that 23% of ERC Supplement participants were high gainers, and they had a mean rating of 2.73 on the "awareness" index.

Notes: Mean rating is calculated on a 4-point scale: 1 = not at all, 2 = somewhat, 3 = a fair amount, 4 = a great deal.
See text for list of items in each index.

*This group's mean/percentage is reliably lower than that of all other groups combined ($p < .05$).

**This group's mean/percentage is reliably higher than that of all other groups combined ($p < .05$).

Racial/ethnic groups (Table VIII-5). The patterns of responses among racial/ethnic groups on these indices were complex. Hispanics tended to report the highest gains in all areas, and non-Hispanic whites tended to report the lowest gains. Asians and black or African Americans were above average on awareness and skills gains but average on confidence and understanding gains. The differences were greatest on the skills index, where 34% of Hispanics and black or African Americans were high gainers, compared with 18% of non-Hispanic whites and 29% of Asians.

Students who had a mentor of a race different from themselves showed slightly higher gains on the skills index than those with a mentor of the same race (mean rating of 3.12 vs. 3.03, respectively). There were no differences on the other indices between students with a mentor of the same or a different race.

Table VIII-5

Undergraduate Perceptions of Gains in Awareness, Confidence, Skills, and Understanding, by Race/Ethnicity

	Asian	Black or African American	Hispanic	Non-Hispanic White	Mixed	All
Number of respondents:	*293*	*257*	*285*	*1,661*	*83*	*2,619*
Awareness index						
Mean rating	2.88 **	2.89 **	3.05 **	2.72 *	2.82	2.79
Percent high gainers	34 **	37 **	45 **	22 *	33	27
Confidence index						
Mean rating	3.04	3.07	3.24 **	3.01 *	3.00	3.04
Percent high gainers	33	34	42 **	29 *	32	31
Skills index						
Mean rating	3.17 **	3.23 **	3.32 **	2.98 *	3.11	3.07
Percent high gainers	29 **	34 **	34 **	18 *	22	22
Understanding index						
Mean rating	3.06	3.12	3.24 **	3.06 *	3.14	3.08
Percent high gainers	32	34	42 **	30 *	39	32

This table shows, for example, that 34% of Asians were high gainers and they had a mean rating of 2.88 on the "awareness" index.

Notes: The "All" column includes respondents with unknown race/ethnicity.
Mean rating is calculated on a 4-point scale: 1 = not at all, 2 = somewhat, 3 = a fair amount, 4 = a great deal.
See text for list of items in each index.

*This group's mean/percentage is reliably lower than that of all other groups combined (p < .05).
**This group's mean/percentage is reliably higher than that of all other groups combined (p < .05).

Sex. There were only slight differences in awareness, confidence, skills, and understanding gains between men and women overall. Looking at male-female differences within each of the racial groups, we found that the high ratings for Hispanics and black or African Americans were due mostly to females. For example, 42% of Hispanic and black or African American females were high skills gainers, compared with 28% of Hispanic males and 27% of black or African American males. Likewise, 50% of Hispanic females and 42% of black or African American females were high understanding gainers, compared with 37% of Hispanic males and 26% of black or African American males. Among other racial/ethnic groups, there tended to be smaller and less consistent differences between the sexes.

Students who had a mentor of the opposite sex showed slightly higher gains on the awareness and skills indices than those with a mentor of the same sex (mean ratings of 2.85 vs. 2.72, respectively, on awareness and 3.13 vs. 2.99, respectively, on skills) but no difference on the other two indices.

Faculty Mentors' Perceptions of Undergraduate Students' Gains

Faculty mentors were asked to what extent they thought the REU research experiences increased their undergraduate students' awareness, confidence, skills, and understanding, using an identical list of areas. Faculty tended to rate increases higher in all areas than did the students (Table VIII-6). The differences were largest on understanding of how to conduct a research project, with a mean rating of 3.6 by faculty but only 3.2 by undergraduates; skills/abilities in working collaboratively with others, rated 3.3 by faculty and 2.9 by undergraduates; and understanding of how to formulate a research question, rated 3.1 by faculty and only 2.7 by undergraduates.

Table VIII-6 also shows the relative ranking of each item among students and among faculty. Faculty perceptions of increases ranked noticeably lower than the students' on two areas: skills/abilities in working independently and qualifications for jobs in related fields. Undergraduates ranked skills/abilities in working independently as the third-highest gain, but faculty ranked it sixth. Undergraduates ranked qualifications for jobs in related fields as 10th, but faculty ranked it 14th. Faculty perceptions of increases ranked noticeably higher than the students' on only one area: skills/abilities in working collaboratively with others—undergraduates ranked it 13th, but faculty ranked it 7th.

Table VIII-6

Faculty vs. Undergraduate (UG) Rankings and Ratings of Perceptions of Gains on Various Dimensions as a Result of REU Research Experiences (Listed in descending order of undergraduates' mean rating)

	UG Ranking	Faculty Ranking	UG Mean Rating	Faculty Mean Rating
Your understanding of the nature of the job of a researcher	1	2	3.4	3.5
Your understanding of how to conduct a research project	2	1	3.2	3.5
Your skills/abilities in working independently	3	6	3.2	3.3
Your understanding of how to deal with setbacks, negative results, etc.	4	4	3.2	3.3
Your confidence in your ability to succeed in graduate school	5	3	3.1	3.4
Your confidence in your research skills generally	6	5	3.1	3.3
Your skills/abilities in preparing written research reports, papers, or posters	7	9	3.1	3.2
Your awareness of what graduate school is like	8	10	3.1	3.2
Your skills/abilities in delivering oral research presentations	9	8	3.1	3.2
Your qualifications for jobs in related fields	10	14	3.0	3.1
Your understanding of how to plan a research project	11	11	2.9	3.2
Your understanding of how engineering knowledge is built	12	12	2.9	3.1
Your skills/abilities in working collaboratively with others	13	7	2.9	3.3
Your awareness of career paths of the faculty in the program (how they got to where they are now)	14	15	2.8	2.9
Your understanding of how to formulate a research question	15	13	2.7	3.1
Your awareness of the variety of engineering fields you could specialize in	16	16	2.7	2.8
Your awareness of career options in engineering	17	17	2.7	2.8
Your awareness of ethical issues in conducting research	18	18	2.6	2.8

This table shows, for example, that undergraduate researchers ranked their understanding of the nature of the job of a researcher as the highest area of gain, with a mean rating of 3.4, whereas faculty ranked it second, with a mean rating of 3.5.

Note: Mean ratings are calculated on a 4-point scale: 1 = not at all, 2 = somewhat, 3 = a fair amount, 4 = a great deal.

CHANGES IN INTEREST IN VARIOUS CAREERS

Undergraduates were asked to what extent their interest in a career in each of the following had increased or decreased as a result of all their undergraduate research experiences: engineering, science, research, teaching, and industry. Respondents provided their ratings on a 5-point scale: 1 = decreased a lot, 2 = decreased somewhat, 3 = no effect/have no idea, 4 = increased somewhat, 5 = increased a lot. Table VIII-7 summarizes responses to these questions.

Table VIII-7

Effect of Undergraduate Research Experiences on Undergraduates' Interest in Careers in Various Areas

(Listed in descending order of mean rating)

	No. of Resp.	**Decreased**	**No Effect/ Have No Idea**	**Increased Somewhat**	**Increased a Lot**	**Mean Rating**
Science	*2,610*	7%	26%	33%	34%	3.9
Engineering	*2,611*	11	25	36	29	3.8
Research	*2,613*	22	13	33	33	3.7
Industry	*2,610*	14	35	33	18	3.5
Teaching	*2,608*	12	46	27	16	3.4

This table shows, for example, that 7% of undergraduates thought that their interest in a career in science had decreased as a result of all their research experiences.

Notes: Mean rating is calculated on a 5-point scale: 1 = decreased a lot, 2 = decreased somewhat, 3 = no effect/have no idea, 4 = increased somewhat, 5 = increased a lot.

Students' interest in all the careers listed was much more likely to have increased than decreased. Although these results may simply reflect positive response biases, it is also possible that the "real-world" nature of the research experiences helps to increase awareness of—and thus interest in—careers in general. As we would expect, however, students' interest in careers in science, engineering, and research was the most likely to be positively affected by their research experiences—about two-thirds of students said that their interest in these careers had increased at least somewhat, and about one-third said their interest had increased a lot. It is noteworthy that another 22% of students said that their interest in a career in research had decreased as a result of their research experiences, whereas relatively few (13%) reported no effect. Clearly, undergraduate research experiences affected—either positively or negatively—most students' interest in a career in research.

Group Differences in Increased Career Interests

Racial/ethnic groups (Table VIII-8). As was the case with the gains indices, Hispanics were the most likely to report positive effects of their research experiences on their interest in various kinds of careers—especially those in science, engineering, and research. For example, 42% of Hispanics said their interest in a career in engineering had increased a lot, compared with 29% of all other racial/ethnic groups combined. Likewise, 45% of Hispanics said their interest in a career in research had increased a lot, compared with 33% of all other racial/ethnic groups combined. Other racial/ethnic groups' ratings were quite similar to one another, except for increased interest in careers in teaching and industry, in which non-Hispanic whites' ratings were appreciably lower than those of the other groups combined. Note that these ratings indicate *changes* in career interests, not absolute levels of career interests. Thus, it may be that groups with low ratings of increased interest in a given career area were relatively more interested in that career to begin with (before they did any research).

Table VIII-8

Effect of Undergraduate Research Experiences on Undergraduates' Interest in Careers in Various Areas, by Race/Ethnicity

	Asian	Black or African American	Hispanic	Non-Hispanic White	Other/ Mixed	All
Number of respondents:	*293*	*256*	*282*	*1,659*	*83*	*2,613*
Science						
Mean rating	3.96	3.78 *	4.09 **	3.94	3.98	3.94
Percent increased a lot	32	30	43 **	34	40	34
Engineering						
Mean rating	3.74	3.58 *	4.06 **	3.81 *	3.80 *	3.80
Percent increased a lot	28	23 *	42 **	28	33	29
Research						
Mean rating	3.68	3.61	4.09 **	3.69	3.81	3.72
Percent increased a lot	26 *	31	45 **	33	43	33
Industry						
Mean rating	3.67 **	3.73 **	3.65 **	3.45 *	3.30 *	3.52
Percent increased a lot	22	26 **	22	16 *	15	18
Teaching						
Mean rating	3.50	3.04	3.69 **	3.40 *	3.47	3.44
Percent increased a lot	16	19	26 **	14 *	19	16

This table shows, for example, that 32% of Asians said that their interest in a career in science had increased a lot as a result of all their undergraduate research experiences, and their mean rating was 3.96.

Notes: Mean rating is calculated on a 5-point scale: 1 = decreased a lot, 2 = decreased somewhat, 3 = no effect/have no idea, 4 = increased somewhat, 5 = increased a lot.

*This group's mean/percentage is reliably lower than that of all other groups combined ($p < .05$).

**This group's mean/percentage is reliably higher than that of all other groups combined ($p < .05$).

Mentor's racial/ethnic group (Table VIII-9). Students who had a mentor of the same race as themselves indicated a slightly greater increase in interest in a career in engineering and industry and a slightly smaller increase in interest in a career in science than those with a mentor of a different race. There was no difference in increase in interest in a career in research or teaching between students with a mentor of the same or a different race.

Table VIII-9

Effect of Undergraduate Research Experiences on Undergraduates' Interest in Careers in Various Areas, by Whether They Had a Mentor of the Same or Different Race/Ethnicity

	Same Race/ Ethnicity	Different Race/ Ethnicity	All
Number of respondents:	*1,510*	*1,096*	*2,613*
Science			
Mean rating	3.90 *	3.98 **	3.94
Percent increased a lot	33	36	34
Engineering			
Mean rating	3.86 **	3.72 *	3.80
Percent increased a lot	31 **	27 *	29
Research			
Mean rating	3.77	3.67	3.72
Percent increased a lot	33	34	33
Industry			
Mean rating	3.58 **	3.44 *	3.52
Percent increased a lot	20	17	18
Teaching			
Mean rating	3.42	3.47	3.44
Percent increased a lot	15	18	16

This table shows, for example, that 33% of students who had a mentor of the same race/ehtnicity as themselves said that their interest in a career in science had increased a lot as a result of all their undergraduate research experiences, and their mean rating was 3.90.

Notes: Mean rating is calculated on a 5-point scale: 1 = decreased a lot, 2 = decreased somewhat, 3 = no effect/have no idea, 4 = increased somewhat, 5 = increased a lot.

*This group's mean/percentage is reliably lower than that of all other groups combined ($p < .05$).
**This group's mean/percentage is reliably higher than that of all other groups combined ($p < .05$).

Research field (Table VIII-10). Those who conducted research in civil and electrical engineering reported a higher increase of interest in an engineering career than did those in other fields of research. Those who conducted research in a non-engineering field reported a higher increase of interest in careers in science or research and, not surprisingly, a lower increase of interest in a career in engineering. Bioengineering or biomedical engineering researchers also reported a higher increase of interest in a career in science and a lower increase of interest in a career in engineering. Civil engineering researchers reported the lowest increase of interest in a career in research. This likely reflects the importance to civil engineers of being licensed as a Professional Engineer (P.E.) which requires non-academic experience.

Award types and sex. There were no appreciable differences in increased interest in careers by award type or sex. Students who had a mentor of the opposite sex indicated a slightly greater increase in interest in a career in industry than did those with a mentor of the same sex (mean rating 3.59 vs. 3.44, respecitvely). There were no differences in increase in interest in a career in the other areas between students with a mentor of the same or opposite sex.

Table VIII-10

Effect of Undergraduate Research Experiences on Undergraduates' Interest in Careers in Various Areas, by Academic Field of Research

	Bio-Biomedical	Chemical	Civil	Electrical	Materials	Mechanical	Other Engineering	Non-Engineering	Interdisc. Engineering	Interdisc./Non-Engineering	All
Number of respondents:	*409*	*183*	*142*	*224*	*120*	*120*	*238*	*228*	*783*	*169*	*2,616*
Science											
Mean rating	4.09**	3.92	3.51 *	3.79 *	4.00	3.74 *	3.81 *	4.22 **	3.91	4.13 **	3.94
Percent increased a lot	40**	32	14 *	26 *	39	25 *	30	50 **	33	47 **	34
Engineering											
Mean rating	3.59*	3.72	4.11 **	4.12 **	3.75	3.94	3.92	3.24 *	3.92 **	3.63	3.80
Percent increased a lot	23*	25	41 **	41 **	26	27	32	10 *	34 **	23	29
Research											
Mean rating	3.69	3.58	3.38 *	3.76	3.93	3.75	3.49 *	3.93 **	3.76	3.96 **	3.72
Percent increased a lot	34	34	18 *	32	42	30	24 *	42 **	33	44 **	33
Industry											
Mean rating	3.48	3.51	3.54	3.80 **	3.54	3.67	3.39 *	3.26 *	3.55	3.51	3.52
Percent increased a lot	18	18	13	23	24	19	16	12 *	20	17	18
Teaching											
Mean rating	3.43	3.47	3.35	3.43	3.41	3.54	3.44	3.56	3.41	3.51	3.44
Percent increased a lot	15	19	13	16	15	19	14	18	16	15	16

This table shows, for example, that 40% of undergraduate researchers in bioengineering or biomedical engineering said that their interest in a career in science had increased a lot as a result of all their undergraduate research experiences and their mean rating was 4.09.

Notes: Mean rating is calculated on a 5-point scale: 1 = decreased a lot, 2 = decreased somewhat, 3 = no effect, 4 = increased somewhat, 5 = increased a lot.

Interdisciplinary groups did research in more than one academic field.

*This group's mean/percentage is reliably lower than that of all other groups combined ($p < .05$).

**This group's mean/percentage is reliably higher than that of all other groups combined ($p < .05$).

Primary Correlates of Increased Career Interests

To analyze the relationships between increased interest in various careers and the many research motivations, activities, and gains, we again used stepwise regression analysis.[14] Increased confidence and enthusiasm for research as a reason to participate tended to be the strongest correlates of increased interest in the several career areas. For example:

- 47% of those whose interest in an engineering career increased a lot were high gainers in confidence, as opposed to only 16% of those whose interest in an engineering career decreased.
- 36% of those whose interest in a research career increased a lot rated research enthusiasm as an important reason to participate, as opposed to only 11% of those whose interest in a research career decreased.

Table VIII-11 shows the variables that were most strongly related to increased interest in careers in engineering and research.

[14] Variables retained in each regression model are reliably related at the $p < .05$ level.

Table VIII-11
Top Correlates of Interest in a Career in Engineering or Research, by Rated Change in Interest: Percentage Who Did Each
(Listed in descending order of "All" column)

	Interest in a Career in Engineering:				
	Decreased	**No Effect / Have No Idea**	**Increased Somewhat**	**Increased a Lot**	**All**
Number of respondents:	*286*	*650*	*927*	*748*	*2,619*
Rated as high gainer on "confidence" index	16%*	22%*	29%	47%**	31%
Rated highly satisfied overall with research experience	15*	22*	27	40**	28
Rated as high gainer on "awareness" index	17*	15*	26	43**	27

	Interest in a Career in Research:				
	Decreased	**No Effect / Have No Idea**	**Increased Somewhat**	**Increased a Lot**	**All**
Number of respondents:	*568*	*325*	*844*	*876*	*2,619*
Rated as high gainer on "confidence" index	14%*	29%	27%*	47%**	31%
Rated highly satisfied overall with research experience	16*	24	27	39**	28
Rated as high gainer on "awareness" index	16*	22*	26	38**	27
Rated "research enthusiasm" as a highly important reason to participate in research.	11*	19*	24	36**	25
24 months or more of research	18*	16*	22	31**	24

This table shows, for example, that 16% of those students who had decreased interest in a career in engineering as a result of their REU research experience were rated as high gainers on the "confidence" index.

Notes: "Confidence," "satisfaction," "awareness," and "research enthusiasm" are indices comprising three or more items. The "high gainer" or "highly important" groups are those in the top approximate quartile of ratings on each index.

*This group's percentage is reliably lower than that of all other groups combined ($p < .05$).

**This group's percentage is reliably higher than that of all other groups combined ($p < .05$).

CHANGES IN HIGHEST DEGREE EXPECTATIONS

Undergraduates were asked, "Before your first undergraduate research experience, what was the highest degree you expected to receive?" and "What is the highest degree you expect to have 10 years from now?" As shown in Figure VIII-1, the percentage who expected that a bachelor's degree (BA/BS) would be their highest degree fell, whereas the percentage who expected a master's (MA/MS) or PhD increased. Comparing the difference for each student between pre-research and current expectation, we found that 53% raised their expectations (for example, from a Bachelor's degree to a Master's or PhD degree) and only 8% lowered their expectations (for example, from a PhD degree to a Master's degree) (Figure VIII-2). Of the undergraduates who did not expect to receive a PhD before doing research, 30% now expect a PhD. Figure VIII-3 shows the change in PhD expectations from before doing research to current.

Figure VIII-1
Highest Degree Expectations Before Research and Current: Percentage Who Expected That Degree Would Be Highest They Received

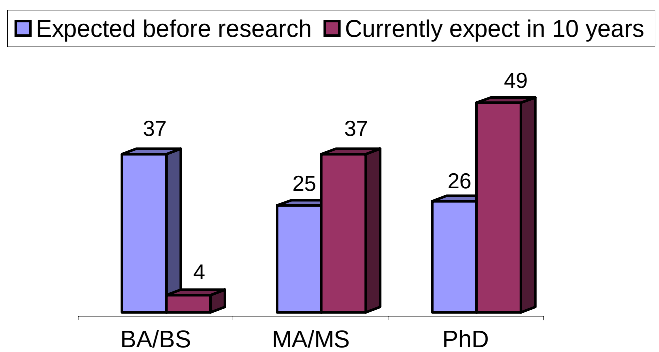


Figure VIII-2
Changes in Degree Expectations: Before Research to Current

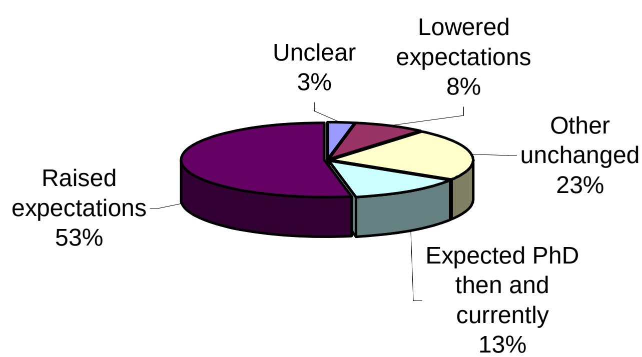
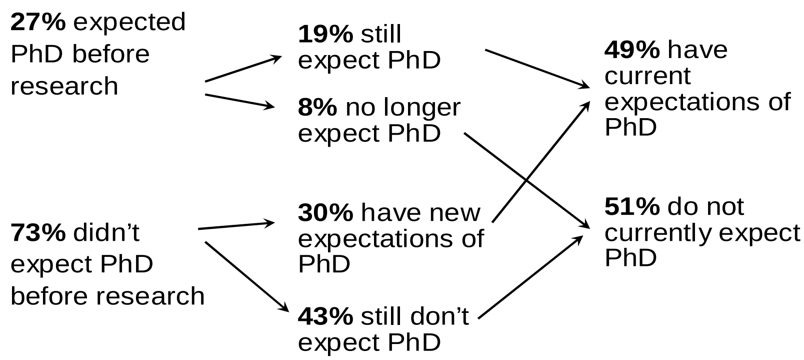


Figure VIII-3
PhD Expectations Flow Chart for REU Researchers



Group Differences in Changes in Degree Expectations

Tables VIII-12 through VIII-14 show students' pre-research degree expectations, current degree expectations (at the time of the survey), and changes in degree expectations—by research field, race/ethnicity, and award type. Among research fields, undergraduate researchers in a non-engineering field were the most likely group to have both pre-research and current expectations of a PhD. Consequently, undergraduate researchers in this group were the least likely to have raised their degree expectations since their pre-research days. At the other end of the distribution, civil engineering researchers were the least likely to have expectations of earning a PhD, either pre-research or currently. There were no notable differences among engineering fields for having raised degree expectations. Among racial/ethnic groups, black or African Americans were slightly more likely than others to have an expectation of receiving a PhD both before they participated in research and currently, but the differences were considerably smaller than those among research fields. Hispanics were the most likely to have raised their expectations. There were no reliable differences in degree expectations among participants on the basis of their award type. Students who had a mentor of the same race or sex as themselves were slightly more likely to have new expectations of receiving a PhD than were students with a mentor of a different race or sex (32% vs. 28%, respectively, for both race and sex comparisons).

Table VIII-12

Pre-Research, Current, and Change in Expectations of Highest Degree, by Academic Field of Research: Percentage Who Expected Each Degree

	Bio-Biomedical	Chemical	Civil	Electrical	Materials	Mechanical	Other Engineering	Non-Engineering	Interdisc. Engineering	Interdisc./Non-Engineering	All
Number of respondents:	*410*	*183*	*142*	*224*	*121*	*120*	*238*	*228*	*783*	*169*	*2,618*
Pre-research expectations											
Bachelor's	27*	45**	41	41	44	44	41	24 *	39	31	37
Master's	21*	14*	45 **	30	25	24	31 **	17 *	27	21	25
PhD	31**	31	7 *	21 *	25	22	18 *	44 **	24	33 **	26
Current expectations											
Bachelor's	4	5	3	4	5	4	5	1 *	4	4	4
Master's	20*	28*	61 **	48 **	35	43	50 **	22 *	41 **	32	37
PhD	53	57**	30 *	45	57	48	37 *	64 **	47	52	49
Change in expectations											
Lowered expectations	10	8	4 *	7	5	4	5 *	10	9	12	8
PhD unchanged	12	18	4 *	12	15	14	12	28 **	10 *	15	13
Raised expectations	49	55	54	60	60	56	51	43 *	55	45 *	53

This table shows, for example, that before they did any undergraduate research, 27% of undergraduate researchers in bioengineering or biomedical engineering expected to receive a bachelor's degree.

Note: Change in expectations examples: lowered expectations from a Master's degree to a Bachelor's degree or raised expectations from a Bachelor's degree to a Master's or PhD degree.

Other degrees and other unchanged or unclear changes in expectations are not shown in this table.

The interdisciplinary engineering group did research in more than one engineering field.

The interdisciplinary/non-engineering group did research in both engineering and non-engineering fields.

*This group's percentage is reliably lower than that of all other groups combined (p < .05).

**This group's percentage is reliably higher than that of all other groups combined (p < .05).

Table VIII-13

Pre-Research, Current, and Change in Expectations of Highest Degree, by Race/Ethnicity: Percentage Who Expected Each Degree

	Asian	Black or African American	Hispanic	Non-Hispanic White	Other	All
Number of respondents:	*293*	*257*	*285*	*1,661*	*83*	*2,619*
Pre-research expectations						
Bachelor's	27%	35%	45%*	38%	39%	37%
Master's	24	24	22	26	22	*25*
PhD	30	34**	25	24*	24	*26*
Current expectations						
Bachelor's	4	4	1*	4	5	*4*
Master's	42**	32	39	37	30	*37*
PhD	39*	55**	52	48	53	*49*
Change in expectations						
Lowered expectations	14**	9	6	7	5	*8*
PhD unchanged	10	17	13	13	12	*13*
Raised expectations	48	50	59**	53	55	*53*

This table shows, for example, that before they did any undergraduate research, 27% of Asians expected to receive a bachelor's degree.

Note: Change in expectations examples: lowered expectations from a Master's degree to a Bachelor's degree or raised expectations from a Bachelor's degree to a Master's or PhD degree.

Other degrees and other unchanged or unclear changes in expectations are not shown in this table.

*This group's percentage is reliably lower than that of all other groups combined (p < .05).

**This group's percentage is reliably higher than that of all other groups combined (p < .05).

Table VIII-14

Pre-Research, Current, and Change in Expectations of Highest Degree, by Award Type: Percentage Who Expected Each Degree

	ERC Supplements	EEC Sites	ENG Supplements	All
Number of respondents:	*363*	*1,893*	*363*	*2,619*
Pre-research expectations				
Bachelor's	33%	37%	40%	37%
Master's	27	24	29	25
PhD	27	27	21*	26
Current expectations				
Bachelor's	2*	4	5	4
Master's	37	36	42**	37
PhD	45	50	45	49
Change in expectations				
Lowered expectations	11	8	6	8
PhD unchanged	10	14	13	13
Raised expectations	51	53	52	53

This table shows, for example, that before they did any undergraduate research, 33% of ERC Supplement undergraduate researchers expected to receive a bachelor's degree.

Note: Change in expectations examples: lowered expectations from a Master's degree to a Bachelor's degree or raised expectations from a Bachelor's degree to a Master's or PhD degree.

Other degrees and other unchanged or unclear changes in expectations are not shown in this table.

*This group's percentage is reliably lower than that of all other groups combined ($p < .05$).

**This group's percentage is reliably higher than that of all other groups combined ($p < .05$).

Primary Correlates of Changes in Degree Expectations

Study variables were not nearly as strongly related to changes in degree expectations as they were to changes in career interests. Variables that showed the strongest relationships with positive changes in degree expectations (that is, either raised expectations or shifted from law or medicine to a PhD) were:

- Increased confidence as a consequence of the research experience.
- Increased awareness as a consequence of the research experience.
- Involvement in designing their research project.
- Having gained increasing independence over the course of the research.

Table VIII-15 shows how each of these variables related to changes in degree expectations.

Table VIII-15
Top Correlates of Positive Changes in Degree Expectations: Percentage Who Did Each

	Did Not Raise Expectations	Raised Expectations	All
Number of respondents:	*1,175*	*1,444*	*2,619*
High gainer in "awareness" as a consequence of the research experience	24 %*	30 %**	27%
High gainer in "confidence" as a consequence of the research experience	28 *	34 **	31
Had input into design of research project	58 *	65 **	61
Gained increasing independence over the course of the research	68 *	75 **	72

This table shows, for example, that 24% of students who did not raise their degree expectations were high gainers in "awareness," compared with 30% of students who did raise their degree expectations.

Notes: "Confidence" and "awareness" are indices comprising three or more items. The "high gainer" groups are those in the top approximate quartile of ratings on each index.

*This group's percentage is reliably lower than that of all other groups combined (p <. 05).
**This group's percentage is reliably higher than that of all other groups combined (p < 05).

IX. FACULTY MENTORS' VIEWS ON UNDERGRADUATE RESEARCH

In this section, we discuss faculty mentors' views about several aspects of undergraduate research, including what they see as benefits and drawbacks to themselves personally of including undergraduates in their research, their opinions about the importance of various factors to providing a high-quality undergraduate research experience, and their perceptions of some potential barriers to increasing the number of undergraduate researchers.

MENTOR PERCEPTIONS OF BENEFITS AND DRAWBACKS OF UNDERGRADUATE RESEARCH

Based on preliminary interviews conducted during our URO study, we developed a number of agree-disagree items about mentors' reasons for involving undergraduates in their research and what the benefits and drawbacks were. The responses to these items are summarized in Table IX-1.

Overall, responses to these items suggest that it was the positive nature of the experience and personal satisfaction, much more than career, political, or research factors, that were the strongest motivators for most faculty. For instance:

- Almost all faculty agreed at least somewhat that research is a good experience for undergraduates (98%) and that mentoring undergraduates is a good experience for graduate students (94%).
- Almost all faculty also agreed that they get a lot of personal satisfaction out of working with undergraduates (95%).
- Many faculty also saw mentoring undergraduates as a good way to recruit them to be graduate students in their lab or department (82%) and said that their work lends itself well to undergraduate participation (78%).
- Their own positive experiences doing undergraduate research motivated 62% of faculty to be a mentor.

Faculty most often disagreed with the potentially negative aspects of mentoring. For instance:

- Very few faculty (9%) agreed they probably would not involve undergraduates in their research if there were no external pressures to do so.
- Slightly more faculty (19%) agreed that involving undergraduates in their research was more of a burden than an asset to their research.
- One-third of faculty agreed that they probably would not involve undergraduates in their research if they did not receive funding specifically for including them.

Table IX-1

Faculty Mentors' Attitudes about Mentoring Undergraduate Research

(Listed in descending order of mean rating)

	No. of Resp.	Disagree	Disagree Somewhat	Agree Somewhat	Agree	Have No Idea/ Doesn't Apply	Mean Rating
Research is a good experience for undergraduates, regardless of their decisions about career or advanced degrees.	*1,276*	1%	1%	18%	80%	1%	3.8
All in all, mentoring undergraduates is a good experience for graduate students.	*1,279*	< 1	2	26	68	4	3.7
I get a lot of personal satisfaction out of working with undergraduates doing research.	*1,280*	1	4	31	64	< 1	3.6
Mentoring undergraduates is a good way to recruit them to be graduate students in my lab/department.	*1,273*	3	10	34	48	4	3.3
My own positive experiences doing undergraduate research help motivate me to be a mentor.	*1,259*	6	5	24	38	26	3.3
My work lends itself well to undergraduate participation.	*1,273*	4	17	40	38	1	3.1
Involving undergraduates in my research enables me to expand the avenues of investigation that I can pursue.	*1,269*	12	17	38	30	3	2.9
Mentoring undergraduates is viewed favorably in my department's tenure/promotion review process.	*1,276*	10	17	35	23	15	2.8
Undergraduates have opened my eyes to things in my research I probably would have overlooked.	*1,270*	15	24	40	17	3	2.6
Research experiences are more valuable for students who will pursue research or teaching careers than for those who will not.	*1,275*	20	26	25	27	1	2.6
Involving undergraduates in my research gives me the opportunity to do something risky.	*1,271*	21	26	29	19	4	2.5
If I did not receive funding specifically for including undergraduates, I probably would not involve them in my research.	*1,279*	38	28	21	11	2	2.0

(Continued)

Table IX-1 (Concluded)

Faculty Mentors' Attitudes about Mentoring Undergraduate Research

(Listed in descending order of mean rating)

	No. of Resp.	**Disagree**	**Disagree Somewhat**	**Agree Somewhat**	**Agree**	**Have No Idea/ Doesn't Apply**	**Mean Rating**
All in all, involving undergraduates in my research has been more of a burden than an asset to my research.	*1,278*	49	31	15	4	1	1.7
If there were no external pressures to do so, I probably would not involve undergraduates in my research.	*1,276*	67	23	6	3	1	1.4

This table shows, for example, that 1% of faculty disagreed that research is a good experience for undergraduates, regardless of their decisions about career or advanced degrees.

Note: Mean rating is calculated on a 4-point scale: 1 = disagree, 2 = disagree somewhat, 3 = agree somewhat, 4 = agree.

Differences among the award types were small, with only two notable exceptions: ENG Supplement faculty more often agreed than did ERC Supplement and EEC Site faculty that they probably would not involve undergraduates in their research if they did not receive funding specifically for including them (44% vs. 34% and 27%, respectively, agreed at least somewhat), and ERC Supplement faculty less often agreed than did EEC Site and ENG Supplement faculty that involving undergraduates in their research enables them to expand the avenues of investigation that they can pursue (59% vs. 68% and 76%, respectively).

MENTOR OPINIONS ABOUT FACTORS IN HIGH-QUALITY MENTORING

All mentors were asked to rate the importance of each of six factors (Table IX-2) in providing a high-quality research experience for undergraduates. Response categories were "not important," "somewhat important," "fairly important," "extremely important," "too much variation among students to generalize," and "have no idea."

Large majorities of mentors felt that open and regular communication, sound technical guidance, and making the student feel that he/she is an integral part of the project team were all extremely important. Far fewer felt that student independence or involvement in project design/selection was extremely important, and almost no one felt that a close relationship between research and course work was extremely important. There were only slight differences on these items among the various award types.

Table IX-2

Faculty Mentors' Opinions about the Importance of Various Factors in Providing a High-Quality Undergraduate Research Experience

(Listed in descending order of mean rating)

	No. of Resp.	**Not Important**	**Somewhat Important**	**Fairly Important**	**Extremely Important**	**Too Much Variation to Generalize**	**Mean Rating**
Open and regular communication between the student and a mentor/ supervisor	*1,295*	0%	2%	16%	81%	1%	3.80
Providing sound technical guidance	*1,289*	<1	1	19	79	<1	3.78
Making the student feel as though he/she is an integral part of the project team	*1,295*	<1	3	26	70	<1	3.67
Giving the student independence in conducting his/her research	*1,287*	2	17	47	31	3	3.11
Involving the student in designing or selecting his/her project	*1,293*	8	32	39	18	2	2.70
A research project that is closely related to the student's regular academic course work	*1,296*	20	39	30	8	2	2.28

This table shows, for example, that no faculty mentors indicated that open and regular communication between the student and a mentor/supervisor was not important.

Note: Mean rating is calculated on a 4-point scale: 1 = not important, 2 = somewhat important, 3 = fairly important, 4 = extremely important.

Percentages for "Have no idea" (1% or less on all items) are not shown.

Although it is not possible to directly compare the students' opinions on these issues with those of the faculty mentors, we did ask the students about their satisfaction on various issues related to their mentors. A large majority of faculty mentors (70%) said that "making the student feel as though he/she is an integral part of the project team" was extremely important but only half the students were very satisfied with the extent to which they felt they were an integral part of the research team. This suggests that mentors did not always integrate students very well into the research team

On other issues of high importance to faculty mentors, students appeared to be fairly satisfied. For example, 81% of faculty said that open and regular communication between the student and a mentor was extremely important and 62% of students were very satisfied with the overall supportiveness of their faculty mentor and 67% felt they had about the right amount of contact. (However, a mere 2 in 10 were very satisfied with the supportiveness of their graduate student or postdoc mentors.) Seventy-nine percent of faculty said that providing sound technical guidance was extremely important and 61% of students were very satisfied with the adequacy of the technical guidance they received.

Only 8% of faculty said a research project that is closely related to the student's regular academic course work was extremely important but students whose research was somewhat closely related to their course work were more likely to be satisfied with their research experience (Table VII-4). This suggests that mentors underestimated the importance of relating research to course work.

On other issues of less importance to faculty, slightly more than half of the students were very satisfied with their independence in conducting research (55%) and with their involvement in selecting or designing their research project (58%).

MENTOR PERCEPTIONS OF BARRIERS TO INCREASED UNDERGRADUATE RESEARCH

Faculty were asked their perceptions of a variety of potential barriers to increasing the number of undergraduates who conduct research, including additional financial support, additional mentors, more space, and increased interest among students (Table IX-3). All items were perceived as barriers by more than half of the faculty respondents. The most commonly perceived barriers were related to financial support. Eighty-nine percent agreed, at least somewhat, that they would include more undergraduates if they had financial support for more undergraduates, and 76% agreed that more financial support for program administration was needed. The next most commonly perceived barriers were related to having enough mentors. Seventy-six percent agreed that they would include more undergraduates if they had more faculty or researchers available or willing to be mentors, and 68% agreed they would include more if they had more graduate students or postdocs available or willing to be mentors. Insufficient lab space, facilities, or equipment and not enough interested or qualified undergraduates were perceived to be barriers by 54% to 58% of faculty.

Faculty in the three award type groups differed only with regard to having financial support for more undergraduates and having more undergraduates who were interested. EEC Site faculty were more likely than their ERC Supplement counterparts to agree that they would include more undergraduates if they had financial support for more (73% vs. 58%), and ENG Supplement faculty were more likely than ERC Supplement faculty to agree that they would include more undergraduates if there were more who were interested (65% vs. 53%).

Table IX-3

Faculty Mentors' Perceptions of Barriers to Increased Undergraduate Research

(Listed in descending order of mean rating)

	No. of Resp.	**Disagree**	**Disagree Somewhat**	**Agree Somewhat**	**Agree**	**Have No Idea/ Doesn't Apply**	**Mean Rating**
We probably would include more undergraduates in our research if...							
...we had financial support for more undergraduates	*1,311*	3%	7%	19%	70%	2%	3.59
...we had more financial support for program administration	*1,296*	7	12	32	44	5	3.20
...we had more faculty or researchers available/willing to be mentors/supervisors	*1,298*	9	11	30	46	4	3.18
...we had more grad students or postdocs available/willing to be mentors/supervisors	*1,291*	11	16	30	38	5	3.00
...we had more lab space, facilities, or equipment	*1,294*	17	21	29	29	4	2.73
...there were more undergraduates who were interested	*1,305*	17	22	30	27	4	2.70
...there were more undergraduates who were qualified	*1,304*	17	25	27	27	4	2.66

This table shows, for example, that 3% of faculty mentors disagreed that they would include more undergraduates in their research if they had financial support for more undergraduates.

Note: Mean rating is calculated on a 4-point scale: 1 = disagree, 2 = disagree somewhat, 3 = agree somewhat, 4 = agree.

X. UNDERGRADUATE SUGGESTIONS

This section provides a summary of the undergraduate students' responses to two open-ended questions asked at the end of the questionnaire: "What was the most important thing you learned about yourself as a result of your undergraduate research experiences?" and "If you were designing undergraduate research programs, how would you make them better than the programs you participated in?" Only suggestions addressed by 100 or more respondents are described.

WHAT WAS THE MOST IMPORTANT THING YOU LEARNED ABOUT YOURSELF?

More than 2,300 undergraduates told us the most important thing they learned about themselves. More than a quarter of the respondents said they gained career or academic direction; another quarter said they learned more of the nature of research; and nearly a quarter said they gained a better awareness of their own strengths, weakness, or preferences. Less frequent comments related to having gained independence or confidence or learned new skills (each mentioned by about 10% of the respondents). Direct quotes follow.

Gained Career or Academic Direction

I gained a better understanding of what I would expect from graduate school.

Obtaining a graduate degree isn't as hard as it seems.

I am certain I want to attend graduate school and obtain a Ph.D.

I MAY be qualified for an advanced degree. I had never really thought about getting any more than an undergraduate degree.

I will not fit in at graduate school. I do not have the drive or personality. I'd be happier with just a bachelor's degree.

That I don't have the energy for graduate school, and that I don't want to devote years of my life to it. That I really don't enjoy research, and that that's okay.

I learned that I do not want to pursue research full-time after I graduate, nor do I want to attend graduate school. I like interacting with people more than what a research position would give me.

I learned that I wanted a career in research and that I wanted to pursue a doctorate degree in engineering.

Confirmed that I would really enjoy doing research as a career.

I am capable of doing research but would rather work in industry.

I could actually do engineering work and enjoyed it.

I do not want to pursue a career in academia as a professor and/or researcher.

My undergraduate research experience ranks among the most important activities which I participated in during my college career. The experiences that I had refined my focus on my future career path as well as enhanced my classroom education.

Learned More of the Nature of Research

Engineering is all about continuous learning and research, together with teamwork. Once you acquire these skills, it is possible to master any engineering field.

Research is challenging and rewarding. I learned how to work without specific set goals because research involves some "feeling around in the dark." I learned how to deal with setbacks and approaching a problem from many angles.

I learned that research - the day to day running of experiments, data analysis, discussion and paper writing - is incredibly fun, challenging and satisfying. I especially loved writing up papers and operating cutting edge technology.

I learned that research is not all instant success, that it takes hard work - but that this hard work yields important results, and that one does not have to be brilliant beyond measure to see success as a scientist. Basically, I learned that I am capable of being a scientist.

Research is a collaborative effort that involves patience as well as respect for others. It is of critical importance to maintain strong relations with those in your lab and to keep up to date with not only your work, but work conducted in labs interested in similar things.

I learned how to conduct a research project, from the initial planning phase to the data analysis and presentation stage.

How to conduct research in an efficient and productive way. Also, I learned a lot about how to write effectively and communicate my ideas to others in a way they could easily understand.

Research is something that requires patience. I learned how to fail and start something new.

It allowed me to realize the need for research in order to attain a more complete education. It really prepares you for the "real world" because we actually solved real issues that were affecting real companies.

Gained Self-Awareness

I learned that research was something that fit well with my personality.

I am a type of person who enjoys more hands on rather than theoretical stuff.

I am much more resilient when facing setbacks than I anticipated.

I love science, but I do not want to be a researcher.

I learned that I am not very independent and that I need to be independent. I also learned that I can't be afraid to try new things and that I should have confidence in what I know.

With a little guidance and some creative thinking, I can do anything I want.

What my strengths were and how best to apply them in a field where I could excel.

There are highs and lows involved in the research process, and I've learned that I can psychologically endure through the difficulties.

The most important thing I learned about myself through my research experience is that I like to work on new, innovative technology using unique procedures. I like to be the person who creates the experiments for the specialized product using known & unknown knowledge.

I have an internal drive to learn more about the subjects that interest me, and that I want to make contributions to science through research.

I have the potential to provide solutions that our planet faces.

I am a strong team leader who is capable of taking the ideas, decided upon by the team as a whole and placing them into effect.

I realized how much I love learning and how amazing it feels to discover new facts everyday while doing research.

I learned that staying focused on the task at hand is something I need to improve.

I learned that I don't know as much as I thought I did. It turns out that while I am generally pretty good at understanding concepts, I have a difficult time balancing perfection and progress when implementing my ideas.

I learned a lot from my mistakes and that I should not be afraid to try something in fear of failure.

I discovered that I was a very determined individual. All of my research experiences involved overcoming some type of obstacle; whether it was personal or research related. I never allowed anything to prevent me from obtaining results in the lab.

Gained Independence, Confidence, or Learned New Skills

I am mostly self-sufficient and am a good self-learner and self-starter.

I learned how to conduct research independently, how to ask questions when I needed help, and how to figure things out on my own. Learning to push myself when no one else was watching me was one of the best things I learned.

I learned how to try and solve problems independently. My mentor was there whenever I needed her, but I was allowed the freedom to research my own topic and apply what I knew to gather more information to solving a problem.

I am intelligent and I have more capabilities than I thought. It gave me the confidence to apply to graduate schools and seek out research experiences.

I learned that I was capable of doing meaningful work, and could contribute to the scientific/engineering community.

I have the ability to conduct research and present to my peers and professors in a professional manner. This provided me with skills to have confidence in my academic pursuits.

I have the ability to use my ideas to contribute to society and make a difference. I learned that there were other people like me with similar goals and attitudes and this increased my overall self confidence in both academic and non-academic environments.

I learned how to work in a group setting and how to manage deadlines.

Ability to conduct long term research and re-evaluate plans based on negative results, ability to work with others and present findings orally.

How to interpret data, solve problems.

How to live on my own and how to problem solve.

I learned how to manage my time and set small goals to achieve a long term plan.

How to write technical papers, how to present research findings, and how to search through journal articles.

One of the most important things I learned was how to think critically and formulate how to tackle questions.

HOW WOULD YOU MAKE UNDERGRADUATE RESEARCH PROGRAMS BETTER?

More than 2,000 undergraduates gave suggestions for improving undergraduate research programs. The most frequent suggestions related to increased mentor involvement and overall satisfaction with the program (each addressed by more than 300 students). Other frequent suggestions related to social activities, choosing a research project, understanding the goal of the research, involvement in designing and planning the research, and time constraints (each addressed by more than 100 students). Direct quotes follow.

Increase Mentor Involvement

Have the faculty or assistants spend more individual time with undergraduate researchers to point them in the right direction. We had entirely too much freedom as first and second year students.

Encourage weekly meetings with advisors and words of support at appropriate times.

I would require a set number of hours per week that a mentor must meet with the student, because I found that time to be when I learned the most.

I know professors are really busy, but one-on-one contact with my faculty mentor would have greatly improved my experience.

I would make sure to get faculty mentors who had enough time to devote to mentoring the student researchers. I would make sure to include weekly group meetings for students to voice their opinions on how their research and other aspects of the program were going.

I would also provide a checks-and-balances-type system of advisor and researcher evaluations to ensure the success of every undergraduate. I know many students who had horrible experiences because their advisors did not have time for their project.

I think it's really important to have engaged faculty and graduate students who really care about the students. My faculty member and his graduate student were really great and inspired me to continue into graduate school.

Screen the faculty involved for their willingness to actually interact with the students they take. I was completely ignored by mine.

The professor and grad mentors are very important for a good research experience. If they don't really want to be involved, they shouldn't sign up.

I would include training for the faculty and graduate student mentors, who often do not know the best way to guide students who are new to research.

I would be sure to have the mentor present on site for the entire summer.

No Change Needed

They were perfectly designed and the people who worked on it worked hard on every aspect.

The program I participated in was amazing. It is hard to think of something I would change.

At the age of 22 I co-published 3 papers and spoke as an author at international conferences throughout the United States. Where else can anyone gain these types of experiences?

It is a great program. It gives undergrads an opportunity to experience a possible path of their career with only short term commitment. It helped me a great deal.

I don't think it's possible to have a better REU than the one I participated in. It went above and beyond my wildest expectations. Awesome!

I wouldn't change anything. The research program was very rigorous, well organized, and everyone involved was extremely supportive.

This program was so good that I don't think it can be improved. The intellectual environment was great. The students were great. The location had great weather. We had every possible accommodation.

Mine was fairly unique, but perfect. There was an incredible amount of freedom and great resources.

I thought the REU program was very good in that it had components that addressed ethics in research and career opportunities in addition to providing feedback on written and oral presentation of research. I thought that the program gave a small taste of all the aspects of research and gave me a really good sense of what it would be like to go into research in grad school and a career.

I would be hard pressed to envision a better program. It struck a great balance between interesting, challenging work and fun activities and friendship. I think that's a key component missing in other programs I'm aware of--having the housing, etc., all nailed down, having everybody in one place, and encouraging activities outside the given ones all go a long way to getting people excited and working.

Provide More Social Activities

I would make sure that all the students could be housed on campus and that there were activities outside of the lab such as trips to industry locations or national laboratories as well as social events.

I also think that fun activities for the students to do is important so they have stuff to do on the weekends and don't get too home sick.

I would have enjoyed more interaction with the other students involved and my grad student. It would have been enjoyable to have more planned social time with the other students in the program.

I really liked the group activities offered through the REU program I did. These include presentations from a variety of professors about their research, the introductions to research tools/equipment used in the field, and cultural/social activities. I wish the other two summer research programs I participated in included group activities like these.

Be sure to have social events to get students acquainted with each other and help students become familiar with location.

I'd have more group activities. The best things I remember weren't related to the work. It was the memories made with the group of kids that you were going through the program with.

Add more fun to it.

There can never be enough social events.

Have less cultural and social activities.

I would try to focus the program on research. This means leaving out all the luncheons and social events that try to get you to interact with the other students.

Allow Choice of Research Project

I would allow students to have some input with regards to what research project they would be working on. I would also conduct feedback surveys throughout the REU to ensure that students are satisfied with the work they are doing.

Allow the students to interact directly with the faculty and propose their own projects. Faculty input could guide the students toward the selection of a topic. They can suggest what research capabilities/facilities the institution offers, as well as what projects are already underway in the research group.

It all depends on how interested the student is in the project and how interested the mentor is in the student. If those two things fit, then the experience will be great. I would recommend that steps are taken to allow the students to choose or perhaps talk, even online, with the research mentors before even going to the site for the summer.

More detailed descriptions of the potential research projects in the application would be beneficial. I could have made a more informed decision about what projects to pick, had the descriptions been more detailed.

Give more opportunity to see the laboratories and research projects before assigning/choosing which one to participate in.

Try to match the project more with the individual or give them more of a choice in projects.

Create a rotational system, similar to those at most graduate schools, so that undergraduates can experience research in several laboratories before deciding which to stick with for the remainder of their undergrad years.

Help Undergraduates Understand the Goal of the Research

I would also make sure that each student and their professor completed some type of research plan so that the student would know what their objectives were and what was expected of them.

The direction I received during my projects has been pretty good, but often other students were left with no idea what to do or how to proceed with their projects. Faculty members should make sure these students are aware of their project goals and summer responsibilities.

I would have benefited greatly if my advisor had spent a little more time explaining the project to me - why we were doing it, what we expected, and what our purpose was.

Define clear goals and set definite deadlines.

Better prepare students for the work that they are doing and give them a general outline of the research project they are going to be working on. It is sometimes difficult to get the "big picture" when the focus is only on small aspects of the research project.

I felt like I never knew what the overall goal of the research was...why were we doing this? Maybe there wasn't a goal. It would have been nice to have more of a "big picture" view than I did have.

I would make sure the participating undergraduates understood how the research was contributing to the advancement of that field.

Do a better job of connecting the research to work being done outside of the school. Make the researcher feel like he or she is actually working towards a worthwhile goal.

Involve Undergraduates in Designing and Planning the Research

I would make the undergraduates more involved in the decision making.

I would allow them more input into the research project they are supposed to work on, perhaps by connecting them to the project mentor ahead of time and starting the information exchange earlier.

Give the students as much power as they want in designing their research project. I was able to define exactly what I wanted to do and I loved it.

Allow researchers the opportunity to contribute more toward the ideas and direction of the research so that they truly "own" a part of the project.

I know that one of the whole points of research is posing questions that haven't been solved and attempting to derive solutions. However, I think that more organized ideas from faculty mentors and grad students in guiding my research would have been beneficial. At times I felt lost, with nothing to do.

I would make sure the projects for the students are very well defined and attainable in the summer months. Having too big or too small of a project will really badly affect the student's experience.

Expand the Time Frame

The research programs need to be longer than 8-10 weeks, because this is a relatively short span for anyone to conduct a research project. Having a 10-15 week program seems like a more reasonable length.

Instead of ten weeks I would make it 14-16 weeks so there is more opportunities. I would also incorporate a time for rotations to where you help with other projects so you can get an idea of other areas of the field. Have one primary project but provide assistance to 2 others.

Maybe make them a little bit longer or give the students the option of continuing with the research the next summer.

Design research projects with objectives that are achievable and practical for the time frame the students enrolled for, whether it is 6 weeks or 6 months.

I would make more effort to ensure that research projects were able to get started immediately, and could actually be finished within the summer semester. I was waiting on supplies for several weeks before I got started, and I didn't have much for conclusive results at the end since we didn't get to finish the intended research.

Have clearer expectations on the number of hours required as some students worked much harder than others and earned the same stipend.

I would allow for researchers to make their own hours of work. I prefer working at night, when it's quiet.

I would tell the participants and mentors to keep the last two weeks of the program open for preparing presentations and writing the written reports.

Not have them start before schools on the quarter schedule get out for summer.

XI. FACULTY MENTOR SUGGESTIONS

This section provides a summary of the faculty mentors' responses to four open-ended questions asked at the end of the questionnaire: "What is your single most important objective in mentoring undergraduate research?;" "How do you think NSF can improve the REU experience for faculty mentors?;" "How do you think NSF can improve the REU experience for undergraduate students?;" and "How do you think NSF can involve more undergraduate students in the REU program?" Only suggestions addressed by 100 or more respondents are described.

WHAT IS YOUR SINGLE MOST IMPORTANT OBJECTIVE IN MENTORING UNDERGRADUATE RESEARCH?

More than 1,100 faculty mentors told us their most important objective in mentoring undergraduate research. The majority of faculty (more than 750) said their objective was to provide a good quality research experience for undergraduates. More than 250 faculty said their objective was to recruit potential graduate students to their field of research and more than 100 said their objective was to obtain additional labor to further their research. Direct quotes follow.

Provide a Good Quality Research Experience

Developing a project that the student will be able to complete and one that relates to the interests of the student.

Get them exposed to independent research where compromises and tradeoffs must be deliberated.

Get them excited about research.

Have the students gain an objective understanding of what research is like - failures and successes - and how they can overcome obstacles to make progress.

Helping the student to have a good experience while gaining an improved understanding of what research is about.

I wanted the students to apply what they have learned in their course work and actually build something practical.

Provide a good research experience for a student that builds their confidence as a researcher and makes them feel that their contribution was important to the field.

To provide a meaningful experience that introduces the student to the open ended nature of research which is far different from solving problems to which there are known answers.

To provide the student with an appropriate mix of challenging yet satisfying research activities that foster a sense of accomplishment while pushing the student beyond what they already know.

Expose students to cutting edge research which will encourage them to pursue graduate studies and engineering fields as a career.

Exposing undergraduates to research to let them know whether they want to pursue graduate study and what life in a research environment is like.

Recruit Potential Graduate Students

Giving undergraduates a feel for the experiences they can expect if they undertake a career in engineering research.

Make sure that they have a positive experience such that at the end they understand what is research so that they can make an informed decision on whether they would like to pursue graduate school.

Provide talented students the opportunity to do research which will encourage more students to pursue graduate study.

Bring the most talented young people to my research area.

Develop the student's interest in research in order to simulate interest in being a graduate research assistant in my lab.

Getting students (especially female) excited about pursuing careers in science and engineering.

Getting the top 5% of the students to pursue Ms/PhD degrees.

To encourage undergraduates to pursue advanced degrees and research related careers, either in academia or industry.

My highest priority is to ignite a passion for research in the students that will motivate them to pursue advanced studies and design-oriented engineering work.

Further My Research

As a for-profit company, we are looking for a win-win. The experience should help with the education/skills of the undergraduate and should help our organization advance its goals.

Getting a win-win situation in which both the student and my research program benefit from the experience.

To help generate more data for myself.

Get certain tasks done that would be a burden to a grad student but that an undergrad is glad to do, such as CAD drawings or machining of certain components. It gets them involved. If they are motivated and/or talented, they will ask for more.

Getting the work done and helping them to acquire hands on experience.

Providing a training opportunity for the undergraduate students and increasing the research capacity of my lab.

To have a mutually beneficial exchange of training for the students and research assistance for the mentor.

It allows me to initiate new projects for which I do not have enough money to support a graduate student.

Work on projects that can lead to new research or answer existing research questions that are not necessarily appropriate for graduate students.

HOW DO YOU THINK NSF CAN IMPROVE THE REU EXPERIENCE FOR FACULTY MENTORS?

Almost 900 faculty mentors gave suggestions for how to improve the REU experience for faculty mentors. About 200 said more money is needed generally to increase the number or size of the awards. About 300 said more money is needed specifically to better compensate mentors, to cover program administration, supplies or equipment, or for students. Slightly more than 100 said no improvement is needed. Direct quotes follow.

Provide More Money

More Money for More or Larger Awards

I have served on four REU review panels. My experience is that out of 30 proposals, I can pick 10 in a few hours that ought to be funded. Then, I spend about a day and half with 6 or 7 other people to reduce this list to the 2 or 3 that will actually get funded. NSF needs to find a way to increase the budget for the REU program by a factor of 2 or 3!!!

Increase the average grant size. The NSF basically funds 1 1/3 graduate students per grant -- its funding has been flat for over twenty years.... At present I spend more than 1/2 my time fundraising. I can't spend over 50% of my time writing grants ... and then also teach..... Something has to give. It's supervising undergraduates that takes the most energy, so that's the first thing I cut back on….

Provide adequate funds. $6000 per summer is a joke! and then, [NSF] only gives 1 per contract, not two. Another joke!

REU supplements in some divisions of NSF have become so small they are "not worth the effort" to apply for. Require supplements to pay a reasonable summer stipend (minimum $4K) or don't offer them.

We have more faculty who want REU students than we can support with current funding. Increasing the number of REUs would help

Increase the budget and make grants 5 years, so we don't have to spend so much time raising money.

More Money for Mentors

The budgets are too low to support much faculty salaries. Even though faculty should do the REU program because they like it, they should be compensated because it is a lot of work. One summer month for each faculty PI's should be sufficient.

Additional resources such as a decent research budget and some offset for 10% of a graduate student's time would really help--so time for graduate students to supervise them in the labs.

Provide partial support for postdocs and staff to provide day-to-day hands-on mentorship in the lab.

Allowing faculty to take salary for undergraduate research advising might help bridge the time gap between supervising a graduate student and an undergraduate student.

Since we are a research institute not an academic department, research staff are required to bill their time to specific projects. More NSF support for research mentors' time would encourage mentor participation in the REU.

A small amount of summer salary for faculty mentors would be an incentive for more faculty to participate.

More Money for Program Administration, Supplies or Equipment

Establish equipment grants for undergraduate labs.

Provide funds for a program administrator salary so that paperwork, assessment, scheduling and implementation of student activities and other program administration do not burden the PI and participating faculty mentors.

Provide more funds in the REU grants for administrative costs - recruiting, tracking students, maintaining data.

Require less administrative work in connection with joining an REU program as a mentor, or better compensate the university for its management.

Funds to offset expenses for materials - undergraduates can be particularly hard on instruments.

Provide additional funds for publications resulting from undergraduate research.

Provide more funds for program management and technical assistance, i.e. not just funds for undergrad student participants. Experimental research with untrained students requires constant supervision and assistance from trained personnel. To expect this amount of time from faculty who are also engaged in competitive research is unrealistic.

More Money for Students

It is really important to help provide appropriate funding to support the student's salary/stipend and a minimal funding for limited supplies. If faculty can financially support the students' efforts, it provides the students with a reward for their dedication. It is a really good motivation factor.

Making the stipends competitive with industrial internship for engineering undergraduates.

Provide more funds for more students - NOT higher stipends for individual students.

No Improvement Needed

Mere existence of the program is helpful. We appreciate this program of NSF and ask for more resources to fund more students.

Continue to provide funds for REU programs as well as funds to support undergraduate thesis research.

Current system is excellent.

I don't think NSF can or should do anything. Appropriate research opportunities do not come around that easily and not every research accommodates easily to undergraduate experience.

I think our faculty mentors would all agree that the experience as it is now is excellent. We do this stuff because we like to work with the students.

It has been very nice to have support from NSF for REU. A little money has gone a long way. Keep up your support of REU.

NSF has done all it probably can by providing support for students and the administration of the program. The success of the program is really tied to the interaction between the REU fellows and their faculty or post-doc mentors, and the perceived importance of the research topic by the REU Fellow.

REU supplements for single PIs are outstanding. I think they should remain a component of the program.

The NSF REU supplement is a good mechanism to provide faculty mentors some funding to involve undergraduates in their existing research.

HOW DO YOU THINK NSF CAN IMPROVE THE REU EXPERIENCE FOR UNDERGRADUATE STUDENTS?

More than 750 faculty mentors gave suggestions for how to improve the REU experience for undergraduate students. As for the previous question, the most frequent suggestions were about funding. More than 200 of the faculty said more money is needed to involve more students, to fund travel and research supplies or equipment, and to increase the student stipend. More than 100 faculty suggested expanding the research time; about 100 suggested providing more opportunities for undergraduates to present their research; and another 100 said no improvement is needed. Direct quotes follow.

Provide More Money

More Money for More Students

Increase the REU program by a factor of 2 or 3 to let more REU students in. Increasing the experience for the 'chosen few' doesn't make much sense to me.

Offer more experiences - there are many more students who want to do an REU than there are program slots.

More Money for Travel, Supplies, etc.

Travel money for students to attend a professional conference to present their results. This conference would be within 1 year of their summer experience.

Funding for tuition remission for one class per student

Provide housing allowances so that students from poorer areas in the country can come to the best schools located in expensive cities.

Our funding has not provided housing or food allowances for students. We could be more competitive with other programs if we could provide this funding.

Allow funds to be used for the cohort social activities. There should be less constraints to providing the social aspect of the REU site. This is paramount to the experience and too often these 'events' are not paid for by NSF.

By providing travel opportunities to conferences, labs, leading research programs, and to field experiences. Undergraduate students appreciate being exposed beyond the laboratory.

More Money to Increase Student Stipends

The more you can make research stipends competitive with summer jobs, the more you'll get students to consider doing research over the summer.

Make REUs more financially competitive against other summer sources of employment.

To provide more financial support to students to ensure that they can survive during the summer research program since they cannot work outside the program. We would like to provide ample stipends while paying for their housing and tuition. Such support attracts more quality candidates.

Expand the Research Time

Be sure to facilitate (via funding and other means) ways to employ undergrads during the academic year as well as in summer programs.

Allow them to automatically renew their REU fellowship for the following summer.

6 weeks is too short. Fund a year-long program as an add-on to any federally funded grant to bring UGs into the research group. Then they can be really productive.

Encourage 10-week programs (as opposed to 8-week programs).

Encourage 6 month experiences.

Fund them for longer periods of time so that they have more meaningful and productive involvement in projects.

I think a key thing NSF can do is offer to extend the REU experience into the fall and spring. This will allow them to extend their research areas and encourage faculty mentors to devote more time to undergraduate students because they may be able to keep them around longer to get more research done. As it is, by the time a student has really figured out what he/she is doing, it seems like the summer is almost over.

I think giving the REU's more than 10 weeks to get something accomplished would help a lot. For example, the NSF could provide travel money to get them started and trained on equipment and teleconferencing early in the spring in preparation for summer work.

I wish that the research carried out by the REU students could go on a little longer for the sake of getting some decent publications for these undergraduate student; e.g., by sponsoring these students for a short trip returning to the host institution during the following winter break or even the spring break to wrap up any issues for the purpose of publications and/or help recruit new REU participants.

Provide Opportunity for Undergraduates to Present their Research

Create a poster forum and an award competition.

It would be great to have the top 10% meet at NSF over the winter break or some other time to give presentations or be part of a NSF undergrad research symposium. That way each REU site could have some additional value for the top performing students.

Sponsor a nationwide REU conference for students to present their results.

Create a website where the students and their background/project and supervising professor can be showcased.

An annual proceedings of the REU would allow students to publish their findings in a non-peer reviewed format.

Conduct a paper competition and reward the winning students with a scholarship for grad school.

Hold national or regional conference where REU students from various institutions can meet and present their project work.

Organizing highly visible national forum for them to present their research, meet other REU students and share experiences. Develop connections!

Create an infrastructure where REU students from different universities can interact, maybe an internet forum.

Creating a showcase for all research might be a help - maybe a web site where power points of students' presentations might be good. Maybe have a national NSF-sponsored undergrad research symposium (maybe co-sponsored with Sigma Xi).

No requirement for publication of the REU work. It is nonrealistic and should not be a goal.

No Improvement Needed

NSF's REU program is excellent. Student feedback indicated that my REU students had a great experience.

I am certain NSF is doing its best in securing funds for REU program from the government. Keep up the good work, we need lots more.

Based on my discussions with students mentored in 2006 and 2007, I think they are very pleased with the program and expressed no dissatisfaction of which I am aware.

Based on our current program, the undergraduates report that they have an amazing, life-changing experience.

Cannot think of any at the moment. The REU program I am involved in seems to be well organized for the students. There is diversity, students participate in several professional workshops and meetings and also interact with other REU students.

I think our programs are extremely good with a mix of research, education, and social activities.

No improvements needed. The REU experience is very beneficial. It probably benefits the student more than the mentor, which is okay.

Our College has a great environment for undergrad researchers, so NSF doesn't need to do anything more for us than provide us with funding for REU Sites.

The program here is outstanding please continue it as the students we receive from it have been excellent, hard working and really team players in the lab.

HOW DO YOU THINK NSF CAN INVOLVE MORE UNDERGRADUATE STUDENTS IN THE REU PROGRAM?

Nine-hundred faculty mentors gave suggestions for how to involve more undergraduate students in the REU program. Again, the majority of faculty (more than 500) said more money is needed. More than 200 faculty suggested more advertising is needed and about 100 faculty suggested expanding the program to other types of institutions, students, and disciplines. Direct quotes follow.

Provide More Money

Additional funding.....More money.....$$$

Fund more graduate students.

Fund more sites.

Double the size of each site program.

Fund more REU programs! All REU programs I know of have more students applying than there are openings, usually by a factor of 4 to 6.

Stipend size is a serious issue for engineering students. Industry offers internships which pay 5x more than our stipends.

Provide more funding and make the funding possible for the whole summer and at a level that is competitive with industrial employment for the summer. Our best students often HAVE to work for higher levels than we can pay REU students.

Provide funding for more than one student per supplement.

Encourage universities to provide some matching.

For each NSF grant that a faculty member has, NSF could automatically give them funds to provide research experiences for 1-2 undergraduates each year of the grant, instead of the faculty member using money from the grant to support the students.

There has to be a financial incentive for the mentors and the researchers who get the REU sites. Undergraduates take so much time that I can't afford to mentor more.

It may help to provide support or fellowships for graduate students who are interested in serving as mentors to undergraduate students. I have had two graduate students who were really excellent mentors for undergrads, and I would like to see these students rewarded some how.

For some faculty the extra help does not compensate for the effort required to train and oversee the students. With graduate-student related research projects, it is expected the budget will include support for materials, supplies, and faculty time. It's possible that allowing some help in these areas as part of the REU award (which is typically mostly for student salary) could influence more faculty to be involved which would allow more students to be involved.

NSF needs to increase the size of the NSF grant. Critical mass for a project is TWO people, a student and a postdoc.

Provide More Advertising

Educate undergraduates about the value of being involved in research.

A website that has testimonies of students who have participated in REU programs and the benefits of getting involved should be established.

Keep the previous undergraduates involved in advertising activities so that they share their experiences and inspire more people.

Advertise the various programs, especially to non-research institutions and to institutions serving under-represented groups.

Increase the visibility of the program with National competitions, awards, etc.

A single web-site application for all REU programs with openings. Students could select programs they want to apply to and may have to answer questions for specific sites. Admission should still be done locally but this would facilitate the application process, let the students know where the programs are, and help ensure students interested could find a match across the country.

Create a central system (web site) that is HEAVILY advertised around the country. How is it possible that 95% of a class of juniors in chemical engineering have never heard of the NSF REU program for summer research? The web site probably already exists, but where is the publicity?

The NSF needs a "cool" web site for the REU program where students can learn about the opportunity... not the existing web site with lists of REU sites, but something more exciting. Perhaps include "video logs" of past REU participants (students and faculty mentors) describing their experiences and virtual tours of some of the campuses with REU programs. The web site should be advertised using posters at campuses across the country because, frankly, most undergraduate students don't seem to know about the REU program.

Advertise through existing science and engineering departments. Create (if it does not already exist) a clearing house on the web to advertise opportunities. Perhaps create a common application, if possible.

Advertise better. I would love to see a document sent to all accredited engineering programs in the U.S.

Go to school job fairs as any other agency does.

Industry comes to our campus to recruit for summer internships and co-ops in the September/October. By January, they are already making offers. On our campus, REU is not even MENTIONED until January. Therefore, our candidate pool consists only of those students which were not taken up by industry. At best, we get the second tier students. Therefore, the REU needs to be advertised in the Fall semester.

Perhaps require that all departments that receive REU money advertise to their undergraduates paid REU opportunities available at other schools. Since we try to recruit primarily non-[campus] students into our REU program, many of our own undergraduates are not aware that such experiences exist at other schools. This may be the case at other schools.

Expand the Program

Expand to Other Institutions

Allow students from the host school to participate.

Ensure that REU programs are distributed evenly across schools with different regional locations, different research levels, and different research interests.

Add international options.

Maybe provide specific funds to Sigma Xi so that they could handle undergrad research applications and funnel funds to faculty/students that apply.

I have been asked if I could help mentor students at nearby, smaller, non-PhD granting universities with the help of faculty there. There is no way that I could use our REU money for this, so I am wondering how these students might be funded. It might be interesting to consider a program like NASA's Space Grant that funded undergrad research at a consortium of universities and colleges.

Maybe also develop programs that bring research to UG students (e.g., mentor-in-residence) at places that do not have research opps at their schools.

Another possibility is to have cross-institutional programs that allow students from one institution to study for one year at a different institution. The coordination of coursework would take some work, but this kind of exchange program could be a great experience for students.

Expand to Other Students

Start to offer some of these opportunities sooner (e.g., high school) and make them available to all, not just underrepresented groups.

Extend the funding to include REU programs for high school students in their junior and senior years. We use this quite effectively for the recruitment of high school girls into engineering.

Strongly support the inclusion of freshmen and sophomores in REU Sites to stimulate a culture of research among undergraduates at an early stage in their careers.

I know it is not popular, but place less emphasis on under-represented groups. In many fields, attracting any U.S. student into graduate level research would be a plus.

Allow REU students between their senior year and first year of graduate school.

Expand to Other Disciplines

Why not supplement with some funds to support students to work with us on NASA/DOD/etc. projects?

Reach out to students from other fields and invite them to work on teams wherein the work of the team might have a core of engineering but would require other skills.

More real-world projects in addition to pure engineering research projects, which might require some degree of coordination across Centers. This would be like a mini internship during the summer, set in academia instead of industry. For that matter, REU's with intentional connections to industry might fill this bill.

Expand to the Academic Year

I think there is an option to extend the research assignment beyond the summer, but because all of our REUs are visiting from other schools, this has no point. I think the program might be better if open to local students.

It could be helpful to increase the opportunities for students to complete research projects at the university where they are obtaining their undergraduate degree. This would involve reduced travel requirements and logistics, and could make it easier to set up opportunities.

Funding should pay for work over the entire year and not just summer.

Encourage more research experiences during fall and spring semesters; it is my experience that more undergrads are interested in getting involved if it does not require a full-time commitment during the summer.

Provide academic year REU funding for students at their own institution. I think it is important for the students to experience the environment at other institutions during the summer, but the amount of research that can be accomplished in a 10 week time span is limited. Faculty would be more interested in undergraduate research if they knew that the student would work with them for a full year.

APPENDIX A
STUDY DESIGN AND METHODS

This appendix describes the study design and methods, including questionnaire development, participant information collection, questionnaire data collections, and weighting and analysis procedures.

STUDY DESIGN

The overall study design called for surveying participants in the NSF Directorate for Engineering (ENG) REU awards that were active during FY 2003 through FY 2006. Initially, the survey was designed to include all REU Sites funded by the Division of Engineering Education and Centers ("EEC Sites") and REU Supplements funded by Engineering Research Centers ("ERC Supplements"). At NSF's request, the study was later expanded to include REU Supplements funded by other divisions within ENG ("ENG Supplements") during FY 2006. A follow-up survey of undergraduate participants in the FY 2006 awards will be conducted in 2009 to assess the longer-term effects of all their undergraduate research experiences.

The survey population comprised the 652 awards that NSF databases indicated were made during FY 2003 through FY 2006. Within each award, all undergraduates who participated in research during that time were eligible for the survey. Also eligible were all faculty—including the principal investigators (PIs)—who mentored undergraduate researchers under these awards.

COLLECTION OF PARTICIPANT CONTACT INFORMATION

The PI of each award was contacted by e-mail or telephone and asked to provide names and contact information for eligible undergraduate students and their faculty mentors. Follow-up was conducted as necessary to remind and encourage PIs to provide the needed information. Once obtained, the contact information was reviewed for obvious problems (in which case the PI was recontacted for resolution of the problem) and entered onto an Excel worksheet. After the contact information collection was completed, the individual award files were merged into a single file, and a search to identify and remove duplicates was conducted.

The 652 awards in the survey sample were led by 417 PIs. Four PIs indicated they did not participate in REU during FY 2003 through FY 2006. Participant names and contact information were obtained from 363 of the 413 eligible ENG REU PIs—all 21 ERC Supplement PIs, 111 EEC Site PIs, and 231 ENG Supplement PIs—for an overall PI response rate of 88% (Table A-1).

Table A-1

Numbers of ENG REU PIs and Those Who Provided Participant Contact Information, by Award Type

	ERC Supplements (FY 2003-2006)	EEC Sites (FY 2003-2006)	ENG Supplements (FY 2006)	All
PIs identified by NSF	21	147	249	417
Did not participate in REU during FY 2003-2006	0	3	1	4
Eligible PIs	21	144	248	413
Provided contact information	21	111	231	363
Response rate	100%	77%	93%	88%

This table shows, for example, that NSF identified 21 PIs for ERC Supplement awards during FY 2003 through FY 2006.

Sources: NSF databases, 2006; SRI International REU survey, 2007

Table A-2 shows the numbers of undergraduate students and PIs or faculty mentors included in the survey: 3,936 undergraduates and 2,037 faculty. Some students (n = 74) participated in more than one fiscal year; they were surveyed regarding the first year they participated in an REU. Many PIs and faculty (n = 771) mentored undergraduates during more than one year; they were surveyed regarding the most recent year they participated.

QUESTIONNAIRE DEVELOPMENT

For this survey, questionnaires were developed for each of the following groups:

- Summer undergraduate researchers
- Academic-year undergraduate researchers
- Summer faculty mentors
- Academic-year faculty mentors

The questionnaires for each summer/academic-year pair (e.g., summer and academic-year undergraduate researchers) are very similar. Separate questionnaires were developed for the two times of year mostly because slight differences in question-wording were necessary; creating a single questionnaire incorporating both summer and academic-year experiences would have made the questions more complex and potentially confusing for respondents. The questionnaires comprise Appendix B to this report.

Table A-2

Numbers of ENG REU Awards, Undergraduate Student Participants, and Faculty Mentors, by Fiscal Year, ENG Division, and Award Type

Fiscal Year ENG Division and Award Type	REU Awards	Awards That Provided Participant Information	Undergraduate Students	PIs and Faculty Mentors
FY 2003				
EEC Sites	84	58	639	408
ERC Supplements	14	14	101	73
FY 2004				
EEC Sites	82	62	673	445
ERC Supplements	16	16	174	110
FY 2005				
EEC Sites	77	60	674	450
ERC Supplements	20	20	171	109
FY 2006				
EEC Sites	94	83	942	689
ERC Supplements	17	17	141	115
ENG Supplements				
Bioengineering and Environmental Systems (BES, now part of CBET)	20	20	34	26
Civil and Mechanical Systems (CMS, now part of CMMI)	40	38	65	59
Chemical and Transport Systems (CTS, now part of CBET)	37	32	62	48
Design and Manufacturing Innovation (DMI, now part of CMMI)	51	44	96	66
Office of Industrial Innovation (OII, now IIP)	40	38	75	74
Electrical and Communciations Systems (ECS, now ECCS)	46	44	90	75
Engineering Education and Centers (EEC, still EEC)	14	13	71	61
Total participants	652	559	4,010	2,808
Total participants, excluding duplicates[a]	**652**	**559**	**3,936**	**2,037**

This table shows, for example, that 84 EEC Site awards during FY 2003 were included in the survey.

[a] 74 students and 771 faculty participated in more than one year.

Note: BES, CMS, CTS, DMI, ECS, and EEC Supplements are combined for purposes of analysis and are referred to as “ENG Supplements.”

To help guide development of the questionnaires, we drew heavily on the questionnaires developed for the URO studies conducted by SRI,[15] the objectives of which corresponded closely to those of this study. In collaboration with our NSF program officers, questions were adapted to engineering programs, and other questions of particular interest to REU program officers were added.

Each questionnaire was pretested with eight members of the respondent group to be sure that the questions were clear and easily understandable and that most respondents would be willing and able to provide the information requested. Pretests were conducted by e-mailing the questionnaire to individuals who had agreed to help and then having each individual answer the questionnaire in a telephone interview with an SRI researcher. During each pretest session, the SRI researcher probed for areas of potential difficulty or ambiguity. Modifications made as a result of pretests were then pretested with other individuals to confirm that the changes were indeed improvements.

After the questionnaires were final, they were formatted in HTML for a Web-based data collection effort. The Web versions were tested extensively to ensure that skip logic was correct and that responses were retrieved and reported correctly by the survey software.

QUESTIONNAIRE DATA COLLECTION

The preferred data collection strategy was e-mail notification, with a hyperlink to the online questionnaire containing an embedded identification number and year of participation. The identification number was automatically stored with the questionnaire answers to enable us to link responses back to year and award type and to send incentives to respondents. The year of participation was dynamically loaded into each appropriate question.

If an e-mail address was not available or if the available one “bounced” and we had a postal address for the student, a paper copy of the questionnaire was mailed. (A total of 986 undergraduates were mailed a questionnaire.) If we had only a telephone number, we attempted to contact the individual to obtain an e-mail or postal address. For any faculty mentor for whom we were not provided an e-mail address, an online search and/or phone calls were conducted to obtain an e-mail address. Participants for whom no contact information was available were not included in the survey.

Undergraduate students were offered a $20 Amazon.com gift certificate as an incentive to participate in the survey. All respondents were offered a copy of the final report summary. Online sample members received approximately weekly e-mail reminders over an 11-week data collection period between September and December 2007. Postal address sample members were sent a postcard reminder about a week after the initial questionnaire mailing. They were sent a second copy of the questionnaire if we had not received a response within about 4 weeks of the initial mailing. Students who had not responded by early November were phoned to encourage their participation and to confirm their e-mail or postal address. (A total of 1,473 undergraduate students were phoned.)

---

[15] Reports on SRI’s studies about undergraduate research programs are available on SRI’s Web site at http://www.sri.com/policy/csted/reports/university/.

Overall response rates were 67% for undergraduates and 69% for PIs and faculty mentors (Table A-3). We anticipated difficulty in contacting the earlier-year students, who were likely to have left their undergraduate institution and lost contact with the REU PIs by the time of the survey. Accordingly, we requested home phone and postal mailing addresses in case e-mails bounced or were unavailable. As expected, the response rates were lower for earlier-year students than for more recent students, ranging from 50% in FY 2003 to 79% in FY 2006. Not only were addresses more often unavailable or invalid for the earlier years (19% in 2003 vs. 3% in 2006), but failure to respond was also higher for the earlier years (31% in 2003 vs. 17% in 2006). Although the e-mail addresses for these nonresponders did not bounce back to us as invalid, we suspect that many of these earlier year e-mail addresses were no longer being used by the students and that the survey invitation never reached them.

Table A-3
Survey Response Rate, by Survey Group and Year of REU Participation

	FY 2003	FY 2004	FY 2005	FY 2006	All Years
Undergraduate students					
Number eligible:	*728*	*816*	*819*	*1,573*	*3,936*
No address or phone	19%	15%	6%	3%	9%
No response	31%	32%	24%	17%	24%
Response rate	**50%**	**53%**	**70%**	**79%**	**67%**
PIs/Faculty mentors					
Number eligible:	*149*	*245*	*297*	*1,213*	*1,904*
No address or phone	16%	8%	3%	2%	4%
No response	36%	33%	30%	24%	27%
Response rate	**48%**	**59%**	**67%**	**74%**	**69%**

This table shows, for example, that we had no valid address or phone number for 19% of the 728 eligible FY 2003 ENG REU undergraduate students.

Note: Students who participated in more than one year are counted only in the earliest year of their participation. PIs and faculty who participated in more than one year are counted only in the most recent year of their participation.

A similar pattern of nonresponse is evident for the faculty mentors—16% of FY 2003 participants had invalid addresses, compared with 2% of FY 2006 participants, and 36% of FY 2003 participants did not respond, compared with 24% of FY 2006 participants.

Table A-4 shows the number of individuals on the mailing list for each award type and survey group and the disposition of the sample for each group. ENG Supplement students and faculty had the highest response rates (74% of students and 72% of faculty), and ERC Supplements had the lowest rates (64% of students and 63% of faculty). Response rates for EEC Sites were 66% of students and 70% of faculty. The relatively high ENG Supplement response rates are due at least partly to the fact that the survey sample for this group was restricted to FY 2006 participants.

Table A-4

Survey Sample Numbers and Response Rates, by Survey Group and Award Type

	ERC Supplements (FY 2003-2006)	EEC Sites (FY 2003-2006)	ENG Supplements (FY 2006)	All Awards
Undergraduate students				
Mailing list	573	2,949	517	4,036
Ineligible	3	73	24	100
Total eligible	**570**	**2,876**	**490**	**3,936**
No address or phone	53	277	29	359
No response	154	706	98	958
Completed	363	1,893	363	2,619
Response rate	**64%**	**66%**	**74%**	**67%**
PIs/Faculty mentors				
Mailing list	301	1,297	439	2,067
Ineligible	50	55	28	133
Total eligible	**251**	**1,242**	**411**	**1,904**
No address or phone	15	54	5	75
No response	77	323	111	511
Completed	159	865	295	1,319
Response rate	**63%**	**70%**	**72%**	**69%**

This table shows, for example, that the survey mailing list included 573 undergraduates who participated in research funded by an ERC Supplement REU award during FY 2003 through FY 2006.

Notes: The most common reason for ineligibility was that the individual did not participate in research during FY 2003 through FY 2006. Other ineligibles were graduate students, deceased, or duplicates.
Total eligible is calculated as the number on the mailing list minus the number of ineligibles.
The response rate is calculated as the number completed divided by the total eligible.

After review of the initial draft report, NSF requested that another question be asked of undergraduate students. Students were recontacted via e-mail and asked to respond to the question "Do you have a disability or handicap that limits a major life activity?" Three e-mail reminders were sent to all non-responding students over a two-week period. Of the 2,416 students with an e-mail address, 1,812 (75%) responded to the additional question. Two percent of the respondents indicated they have a disability or handicap.

WEIGHTING PROCEDURES

For undergraduate students, responses were weighted by NSF award type and year, as outlined below.

1. We calculated the estimated population size as follows: for each cell (for example, FY 2003 EEC Sites), the number of awards in that cell was multiplied by the mean number of students in that group who were identified during the list collection activity.
2. We entered the estimated population size and number of respondents in each cell.
3. We calculated each respondent's weight as the estimated number in the population for that cell divided by the number of the respondents for that cell. For example, if a cell had 911 estimated in the population and 310 respondents, all respondents in that cell had a weight of 2.94.

Responses were not weighted for PIs and faculty mentors. Many PIs and faculty participated in more than one year, and some participated in more than one NSF award type. Their responses are considered representative of the population of PIs and faculty.

DATA ANALYSES

Analyses of the survey data consisted of tabulating frequency distributions showing the percentage of the entire respondent group who gave each potential response, calculating mean ratings on scaled variables, and comparing the responses of various subgroups of respondents with one another, using a proprietary SRI software program to assess the reliability of the observed differences. In addition, factor analyses were conducted of various groups of survey items to facilitate discussions of group differences on study variables, and a number of stepwise regressions were conducted to gain insight on relationships between outcome measures and other study variables.

REPORTING

For students, all survey results that are reported are based on weighted data. Group comparisons noted in this report are reliable at least at the $p < .05$ level. In essence, a difference that is found to be significant at the $p < .05$ level has a 95 percent probability that it would not have occurred simply by chance.

APPENDIX B
SURVEY QUESTIONNAIRES AND OVERALL RESULTS

This appendix presents the undergraduate student participant and faculty mentor survey questionnaires and overall results for each.

NATIONAL SCIENCE FOUNDATION DIRECTORATE FOR ENGINEERING

RESEARCH EXPERIENCES FOR UNDERGRADUATES (REU) PROGRAM

FY 2003-2006 Student Participant Survey and Overall Results

Number of Respondents = 2,619 (2,500 Summer, 119 Academic Year)

Year of participation		Time of year		Award Type		ENG Division	
FY 2003	21%	Summer	96%	ERC Supplement	12%	BES.....................	1%
FY 2004	21	Academic Year	4	EEC Site	77	CMS....................	1
FY 2005	21			ENG Supplement......	11	CTS.....................	2
FY 2006	36					DMI	2
						ECS.....................	2
						EEC	91
						OII	1

Factors in Your Decision to Do Research

1. How important was each of the following in your decision to first do research? (If an item does not apply to you, please select the "not important" category.) **(PLEASE SELECT ONE IN EACH ROW)**
LISTED IN DESCENDING ORDER OF MEAN RATING*

	Not Important	Somewhat Important	Fairly Important	Extremely Important	Don't Remember	Mean Rating*
I wanted to learn more about what it's like to be a researcher.	2%	5%	24%	70%	0%	3.6
I wanted hands-on research experiences to reinforce what I learned in class.	3	11	28	57	0	3.4
I thought it would be fun.	2	10	41	48	0	3.3
I thought it would help me get into graduate school or get a job.	6	14	31	49	0	3.2
I wanted to know if going to graduate school in engineering was for me.	11	10	24	55	< 1	3.2
Doing research was more appealing than other kinds of jobs available to me.	10	18	30	42	0	3.0
I wanted to know if engineering was for me.	27	21	28	24	< 1	2.5
I needed/wanted the academic credit I could get from doing research.	77	11	7	5	< 1	1.4
I needed to fulfill my school's or scholarship's requirements for research.	85	7	4	4	< 1	1.3

*Mean rating based on a scale of 1 to 4 where 1=Not Important and 4=Extremely Important.

2. How important was each of the following in your decision to apply to participate in the specific research project that you were in during [REU time period]?
(If an item does not apply to you, please select the "not important" category.)
(PLEASE SELECT ONE IN EACH ROW)
LISTED IN DESCENDING ORDER OF MEAN RATING*

	Not Important	Somewhat Important	Fairly Important	Extremely Important	Don't Remember	Mean Rating*
The research project(s) sounded interesting.	3%	11%	37%	48%	1%	3.3
I wanted to do something different than what I've done before.	8	12	33	46	< 1	3.2
I wanted to know if this field of research was for me.	7	15	37	40	< 1	3.1
I like this field of research and wanted to work in it.	9	22	36	33	1	2.9
Personal interaction with the program coordinator, director, or other faculty member or researcher.	18	16	29	36	1	2.8
The living arrangements for this program. (SUMMER ONLY)	13	22	37	27	< 1	2.8
The amount of the stipend and support package (housing, meals, etc.). (SUMMER ONLY)	20	23	34	22	< 1	2.6
The reputation of the host institution. (SUMMER ONLY)	24	22	30	24	1	2.5
The social/cultural activities for this program. (SUMMER ONLY)	29	23	29	20	< 1	2.4
I wanted to be close to home. (SUMMER ONLY)	32	26	26	15	1	2.2
This was the first program/project that accepted me for [REU time period].	39	19	25	17	< 1	2.2
Someone I knew recommended it.	47	15	18	18	3	2.1
This was the only research program/project that accepted me for [REU time period].	51	13	16	16	4	2.0
Personal interaction with other undergraduates, grad students, or K-12 teachers	58	9	12	17	4	1.9
I wanted to be far from home. (SUMMER ONLY)	68	11	12	9	< 1	1.6
Geographic location of the project (not the distance from home *per se*) was appealing. (SUMMER ONLY)	72	13	9	6	< 1	1.5

*Mean rating based on a scale of 1 to 4 where 1=Not Important and 4=Extremely Important.

3. Did you apply to any **other** research or intern programs/projects for [REU time period]?
(PLEASE SELECT ONE)

Yes	46%	→ *PLEASE CONTINUE*
No	45	→ *QUESTION 4 = 1 PROGRAM*
Don't remember	9	→ *QUESTION 4 = DON'T REMEMBER*

4. To how many research or intern programs/projects did you apply, including the program you participated in during [REU time period]? **(PLEASE ENTER YOUR BEST ESTIMATE)**

Mean number of programs	2.4
1	47%
2 or 3	20
4 or more	18
Don't remember	15

Your Research Activities

5. Did your research activities during [REU time period] take place entirely in the United States, or did they take place at least in part in another country? **(PLEASE SELECT ONE)**

Entirely in the United States	96%
At least part was in another country	4

6. Where did the research that you participated in during [REU time period] take place?
(PLEASE SELECT ONE OR MORE)

At the college I was already attending	31%
At another college	67
At a non-academic institution	7

7. Did you receive academic credit for your research activities during [REU time period]?
(PLEASE SELECT ONE)

Yes	16%
No	82
Don't remember	2

8. Did you receive pay (for example, a stipend) for your research activities during [REU time period]?
(PLEASE SELECT ONE)

Yes	99%
No	1
Don't remember	< 1

9. When you started the [REU time period] research program/project, how well prepared did you feel you were for the work you were asked to do? **(PLEASE SELECT ONE)**

Mean rating*	2.5
Not at all prepared................	8%
Somewhat prepared..............	41
Fairly well prepared.............	41
Extremely well prepared.......	10
Don't remember....................	< 1

*Mean rating based on a scale of 1 to 4 where 1=Not at all prepared and 4=Extremely well prepared.

10. What was the average number of hours per week that you spent engaged in **research-related activities** during [REU time period]? **(PLEASE ENTER YOUR BEST ESTIMATE)**

Mean number of hours...	36.9
30 hours or less	23%
31 to 40 hours.................	53
More than 40 hours........	16
Don't remember.............	8

11. During your research experiences during [REU time period], what was the average number of hours per week that you spent engaged in **research-related activities with each of the following types of individuals**? **(PLEASE SELECT YOUR BEST ESTIMATE IN EACH ROW)**
Note: If your research was done at a non-academic institution, please consider the senior researcher(s) or engineer(s) you worked with to be "faculty."
LISTED IN DESCENDING ORDER OF MEAN RATING*

	Average number of hours per week:							
	No Time With This Person	**Less Than 1 Hour**	**1 Hour Up to 5 Hours**	**5 Hours Up to 10 Hours**	**10 Hours Up to 20 Hours**	**20 Hours or More**	**Don't Remember**	**Mean Rating***
Graduate students/ postdocs	8%	6%	19%	19%	19%	27%	1%	4.2
Other undergraduates	20	9	18	13	12	25	2	3.6
Your faculty mentor(s)	3	22	48	15	6	4	1	3.1
K-12 grade teachers	91	2	3	1	0	1	2	1.1

*Mean rating based on a scale of 1 to 6 where 1=No Time and 6=20 Hours or More.

12. Overall, how did you feel about the amount of contact you had with each of the following during [REU time period]? **(PLEASE SELECT ONE IN EACH ROW)**
LISTED IN DESCENDING ORDER OF "ABOUT THE RIGHT AMOUNT"

	Too Little Contact	About the Right Amount	Too Much Contact	Doesn't Apply	Don't Remember
Graduate students/postdocs	12%	79%	3%	6%	1%
Other undergraduates who were doing research	15	69	2	13	1
Your faculty mentor(s)	31	67	1	< 1	1
K-12 grade teachers	6	10	1	81	3

13. Did any **other** undergraduates do research during [REU time period] with the **same faculty mentor as you**? **(PLEASE SELECT ONE)**

Yes 55%
No... 40
Don't know or don't remember 5

14. Was your faculty mentor male or female? **(PLEASE SELECT ONE)**

Male............. 82%
Female 18

15. Was your faculty mentor's race/ethnicity the same as yours? **(PLEASE SELECT ONE)**

Yes................ 43%
No................. 53
Not sure 4

16. When your research activities began during [REU time period], did you have a choice of projects to work on? **(PLEASE SELECT ONE)**

Yes 45%
No......................... 48
Don't remember ... 7

17. Which one of the following best describes your involvement in designing your research project during [REU time period]? (If you had more than one research project, please answer for the one you worked on the most.) **(PLEASE SELECT ONE)**

Someone else had primary responsibility for designing my research project but I provided input	45%
The research project was designed by someone else, without input from me	31
I had primary responsibility for designing the research project that I worked on	15
I shared responsibility for designing the research project with others	1
Other *(please specify:)*	< 1
Don't remember	2
Doesn't apply: Did not have my own research project	6

18. **Generally speaking,** who made each of the following kinds of decisions during [REU time period]? **(PLEASE SELECT ONE IN EACH ROW)**

	I Did	**Faculty/Grad Student Mentor and I Together**	**Faculty/Grad Student Mentor**	**Don't Remember**
What research techniques/materials were used	8%	50%	40%	2%
What to do next (for example, following interim results)	10	60	27	3

19. Which of the following did you do as part of your research experiences during [REU time period]? **(PLEASE SELECT ONE OR MORE)**
LISTED IN DESCENDING ORDER OF PERCENTAGE

Collected and/or analyzed data or information to try to answer a research question	88%
Delivered an oral/PowerPoint presentation describing my research and results	86
Understood how my work contributed to the "bigger picture" of research in this field	78
Received training to use research tools (computer program/language, lab or field equipment, etc.)	75
Gained increasing independence over the course of the summer	72
Prepared a final written research report describing my research and results	69
Received training in written or oral communication skills	57
Attended lectures/seminars on research ethics	56
Went on research-related field trip(s) (to other labs, universities, industry, etc.)	54
Was able to complete my research project (either then or later)	54
Prepared/presented a poster presentation describing my research and results	45
Wrote a proposal describing the research I planned to do	31
Attended student conference(s) that included students from multiple colleges	26
Authored or co-authored a paper that has been or will be submitted for publication in a professional journal	21
Attended professional conference(s) (conferences not specifically for students)	20
Mentored other students conducting research or led a student research team	9
Did little or nothing that seemed to me to be real research	7
Don't remember	< 1

Number of research activities (includes questions 16, 17, 18, and 19)

Mean number of activities	10.8
1 to 6	11%
7 to 11	46
12 to 20	43

20. To what extent, if at all, do you think your research experiences during [REU time period] **increased** each of the following? **(PLEASE SELECT ONE IN EACH ROW)**

LISTED IN DESCENDING ORDER OF MEAN RATING*

	Not At All	Some-what	A Fair Amount	A Great Deal	Have No Idea	Mean Rating*
Your understanding of the nature of the job of a researcher	1%	10%	34%	54%	< 1%	3.4
Your understanding of how to conduct a research project	3	16	39	41	< 1	3.2
Your skills/abilities in working independently	3	16	37	44	< 1	3.2
Your understanding of how to deal with setbacks, negative results, etc.	4	18	35	43	< 1	3.2
Your confidence in your ability to succeed in graduate school	5	17	39	38	1	3.1
Your confidence in your research skills generally	3	21	43	33	< 1	3.1
Your skills/abilities in preparing written research reports, papers, or posters	5	20	35	40	< 1	3.1
Your awareness of what graduate school is like	6	20	34	39	< 1	3.1
Your skills/abilities in delivering oral research presentations	7	18	37	37	< 1	3.1
Your qualifications for jobs in related fields	6	22	41	29	1	3.0
Your understanding of how to plan a research project	6	25	37	31	< 1	2.9
Your understanding of how engineering knowledge is built	8	23	39	28	1	2.9
Your skills/abilities in working collaboratively with others	7	26	38	28	< 1	2.9
Your awareness of career paths of the faculty in the program (how they got to where they are now)	10	26	33	30	1	2.8
Your understanding of how to formulate a research question	10	30	38	22	1	2.7
Your awareness of the variety of engineering fields you could specialize in	13	28	34	25	1	2.7
Your awareness of career options in engineering	12	31	34	22	1	2.7
Your awareness of ethical issues in conducting research	16	31	31	21	1	2.6

*Mean rating based on a scale of 1 to 4 where 1=Not At All and 4=A Great Deal.

21. How dissatisfied or satisfied were you with each of the following aspects of your research experiences during [REU time period]? **(PLEASE SELECT ONE IN EACH ROW)**
LISTED IN DESCENDING ORDER OF MEAN RATING*

	Very Dissatisfied	Somewhat Dissatisfied	Somewhat Satisfied	Very Satisfied	Doesn't Apply	Don't Remember	Mean Rating*
How well organized the program was	1%	5%	23%	71%	< 1%	< 1%	3.7
The overall supportiveness of your faculty mentor(s)	3	5	17	62	12	1	3.6
The experience as a whole	1	6	24	69	0	1	3.6
The adequacy of the technical guidance you received	1	6	31	61	< 1	< 1	3.5
The social/cultural activities (ACADEMIC YEAR=Doesn't Apply)	2	9	26	56	6	< 1	3.5
The independence you had in doing your work	2	6	20	55	17	< 1	3.5
The overall supportiveness of your graduate student or postdoc mentor(s)	1	2	11	21	62	3	3.5
The amount of involvement you had in selecting or designing your research project(s)	4	11	25	58	1	< 1	3.4
Your living arrangements (housing, meals) (ACADEMIC YEAR=Doesn't Apply)	2	9	27	46	15	1	3.4
The extent to which you felt you were an integral part of a research team	3	12	35	50	< 1	< 1	3.3
The overall supportiveness of other undergraduate or K-12 teacher participants	3	12	33	42	9	1	3.3
The research project(s) you worked on	3	17	39	37	4	1	3.1

*Mean rating based on a scale of 1 to 4 where 1=Very Dissatisfied and 4=Very Satisfied.

22. Which of the following best describe the academic field(s) of your research during [REU time period]? **(PLEASE SELECT ONE OR MORE)**

Aerospace engineering	3%
Agricultural engineering	1
Architectural engineering	< 1
Bioengineering or biomedical engineering	28
Chemical engineering	18
Civil engineering	10
Computer engineering	7
Electrical engineering	18
Environmental engineering	8
Industrial or manufacturing engineering	3%
Materials or metallurgy engineering	14
Mechanical engineering	14
Mining or mineral engineering	< 1
Nuclear engineering	< 1
Ocean, marine, or naval engineering	1
Systems engineering	2
Transportation engineering	1
Other engineering ***(please specify below)***	2
A non-engineering field ***(please specify below)***	15

Please specify a "non-engineering field":

Biology	2%
Chemistry	2
Mathematics	1
Physics	4
Other non-engineering	6

23. How related was your research during [REU time period] to courses in your major that you have taken, either before that time or since then? **(PLEASE SELECT ONE)**

It was **closely** related to courses I have taken in my major	36%
It was **somewhat** related to courses I have taken in my major	52
It was **unrelated** to courses I have taken in my major	12
I do not have a major	< 1

24. Were you enrolled in classes during [REU time period]? **(PLEASE SELECT ONE)**

Yes	15%
No	84
Don't remember	< 1

25. Did you continue your research after [REU time period], either with the same faculty mentor or with a different mentor? **(PLEASE SELECT ONE)**

Yes, with the same mentor	23%
Yes, but with a different mentor	10
No	67
Don't remember	< 1

Other Research-Related Issues

26. When did you first become interested in engineering? **(PLEASE SELECT ONE)**

I've been interested ever since I was a child	20%
During high school	49
During college	19
Doesn't apply to me: I'm really **not** very interested in engineering	9
Don't remember	3

27. While you were in high school or the summer after you graduated from high school, did you participate in any science or math fairs? **(PLEASE SELECT ONE)**

Yes	35%
No	65

28. Were the [REU time period] research activities at the college/university you were already attending? **(PLEASE SELECT ONE)**

Yes	32%	→ ***QUESTION 29 = YES***
No	68	→ ***PLEASE CONTINUE***

29. Were there any opportunities for undergraduates in your major to do research at the undergraduate college/university you attended? **(PLEASE SELECT ONE)**

Yes	93%	→ ***PLEASE CONTINUE***
No	5	→ ***QUESTION 30 = NO***
Not sure	2	→ ***QUESTION 30 = NOT SURE***

30. At your undergraduate college/university, are undergraduates in your major **required** to do hands-on research (other than library research)? **(PLEASE SELECT ONE)**

Yes, all in my major are	19%
Only for honors or scholarship	11
No	62
Do not have a major	< 1
Not sure	8

31. Please read all the way through the list of activities below and then indicate:
   A. **Including the research you did during [REU time period]**, which kinds of hands-on research activities you have participated in, either at your high school, your college, or at some other location.
   (PLEASE SELECT ONE IN EACH ROW)
   B. If "yes" on A, for how many months in total you have you done this.
   (PLEASE ENTER YOUR BEST ESTIMATE FOR EACH APPLICABLE ITEM)

A. Have you done this, either in high school or college? Please do not include an activity in more than one category.)		**B. Mean total number of months you have done this:**
	Yes	
Summer research, other than intern or co-op program, <u>with some group activities</u>. Undergraduates work one-on-one with professors or other researchers. The focus is full-time individual research, supplemented by regular group meetings and other group activities. Usually some kind of final report or presentation is required at the end.	86%	4.6
Summer research, other than intern or co-op program, <u>with few or no group activities</u>. A full-time research project with a professor or researcher. Differs from item (1) in that there are few or no group activities with other undergraduates.	31	4.6
Hands-on research with a professor during one or more academic terms, while enrolled in classes.	63	11.3
Intern or co-op program that involved hands-on research as its <u>main</u> component. Usually, a company or other organization pays you for working on a research project at its site. Sometimes you receive academic credit at your school for this research. May happen any time of year.	26	6.2
A junior or senior thesis that involves hands-on research (other than library research) as its <u>main</u> component	32	7.2
Mean total number of months you have done any type of research		15.9

32. At which of the following kinds of organizations have you participated in any hands-on research with a teacher, professor, or research engineer or scientist? **(PLEASE SELECT ONE OR MORE)**

My college/university	83%
Other college or university..................................	55
For-profit company	13
My high school	12
Government lab/facility	11
Hospital or medical clinic	7
Non-profit research organization	4
Other organization *(please specify below)*	< 1

Effects of Your Undergraduate Research Experiences

33. To what extent has your interest in each of the following increased or decreased as a result of **all** the undergraduate research experiences you have had? **(PLEASE SELECT ONE IN EACH ROW)**
LISTED IN DESCENDING ORDER OF MEAN RATING*

Your interest in:	Decreased a Lot	Decreased Somewhat	No Effect	Increased Somewhat	Increased a Lot	Have No Idea	Mean Rating*
A career in science	1%	6%	25%	33%	34%	1%	3.9
A career in engineering	4	7	23	36	29	2	3.8
A career in research	6	16	12	33	33	1	3.7
A career in industry	4	10	33	33	18	2	3.5
A career in teaching	4	8	44	27	16	2	3.4

*Mean rating based on a scale of 1 to 5 where 1=Decreased a Lot and 5=Increased a Lot.

34. A. Before your **first** undergraduate research experience, what was the highest degree you expected to receive?
B. What is the highest degree that **you expect to have 10 years from now**?
(PLEASE SELECT ONE IN EACH COLUMN)

	A. Expectations Before <u>First</u> Undergraduate Research Experience	**B. Expectations 10 Years from Now**
Undecided	6%	3%
High School	< 1	0
Associate of Arts (AA)	1	0
Bachelor's (BA or BS)	37	4
Master's (MA, MS, or MBA)	25	37
LLB or JD	< 1	2
PhD	19	42
MD	4	5
MD **or** PhD (not sure which)	6	3
MD **and** PhD (both degrees)	1	4
Other doctorate	< 1	1
Expected any PhD	27	49

Change in degree expectation

Unclear change	3%
Lowered expectations or away from PhD	8
Horizontal shift to PhD	3
PhD unchanged	13
Other unchanged or no PhD effect	20
Raised expectations	53
New PhD expectation	30

Your General Academic Experience

35. Did you start your undergraduate education at a 2-year college? (Do **not** include summer school at a 2-year school before you started at a 4-year school in the fall.) **(PLEASE SELECT ONE)**

Yes......... 10%
No.......... 90

36. What is the highest level of formal education that you have **now completed**? **(PLEASE SELECT ONE)**

Some college or Associate of Arts (AA) degree	28%
Bachelor's (BA or BS) degree	38
Some graduate work, but no graduate degree	20
Master's (MA, MS, MBA, etc.) degree	12
LLB or JD degree	< 1
Post-Masters work but no doctorate	1
PhD degree	< 1
MD degree	< 1
MD and PhD (both) degrees	0
Now completed any PhD	< 1

37. What is the full name and location of the school from which you received or will receive your bachelor's degree? (If you do not expect to obtain a bachelor's degree, please enter the name of the school you attended most recently.)

38. What was/is your total cumulative Grade Point Average (GPA) as an undergraduate? (Out of a possible 4.0)

Mean GPA	3.6
Less than 3.4	24%
3.4 to 3.6	27
3.7 to 3.8	24
3.9 or higher	21
Have no idea	4

39. Which of the following best describe your undergraduate major? (Include only those fields in which you completed or expect to complete the requirements for a major.) **(PLEASE SELECT ONE OR MORE)**

Aerospace engineering	2%
Agricultural engineering	< 1
Architectural engineering	< 1
Bioengineering or biomedical engineering	15
Chemical engineering	16
Civil engineering	9
Computer engineering	5
Electrical engineering	16
Environmental engineering	4
Do not have a major	< 1
Industrial or manufacturing engineering	2%
Materials or metallurgy engineering	3
Mechanical engineering	12
Mining or mineral engineering	0
Nuclear engineering	< 1
Ocean, marine, or naval engineering	< 1
Systems engineering	< 1
Transportation engineering	< 1
Other engineering ***(please specify below)***	2
A non-engineering field ***(please specify below)***	25

Please specify "non-engineering field":

Biology	4%
Chemistry	5
Mathematics	3
Physics	6
Computer Science	1
Other non-engineering	6

40. Which of the following describe your current academic status? **(PLEASE SELECT ONE)**

I am currently enrolled as an undergraduate:	
Freshman	1%
Sophomore	1
Junior	5
Senior (including fifth or sixth year senior)	22
I am currently enrolled working on a 2nd Bachelor's degree	1
I have been accepted into a graduate program, but have not yet begun	1
I am currently enrolled as a graduate student (including medical, law, business school, etc.)	41
I am not currently enrolled in college	28

41. Have you ever attended or been accepted to graduate school? **(PLEASE SELECT ONE)**

Yes	52%	→ ***PLEASE CONTINUE***
No	48	→ ***PLEASE SKIP TO QUESTION 46***

Number of respondents attended or accepted to graduate school = 1,234

42. For how many years have you attended **graduate** school?

Mean number of years	1.4
Less than 1 year	20%
1 year	37
More than 1 year	43

43. What is the full name and location of the school where you are, will be, or were a **graduate** student?

44. Which of the following best describe your field of study in **graduate** school?
(PLEASE SELECT ONE OR MORE)

Aerospace engineering	1%
Agricultural engineering	1
Architectural engineering	< 1
Bioengineering or biomedical engineering	17
Chemical engineering	11
Civil engineering	9
Computer engineering	3
Electrical engineering	15
Environmental engineering	5
Industrial or manufacturing engineering	1%
Materials or metallurgy engineering	5
Mechanical engineering	9
Mining or mineral engineering	0
Nuclear engineering	1
Ocean, marine, or naval engineering	< 1
Systems engineering	1
Transportation engineering	< 1
Other engineering ***(please specify below)***	2
A non-engineering field ***(please specify below)***	30

Please specify a “non-engineering field”:

Biology	2%
Chemistry	3
Mathematics	1
Physics	5
Computer Science	2
Medicine/Dentistry	7
Other non-engineering	10

45. Overall, how important were your undergraduate research experiences to each of the following?
(PLEASE SELECT ONE IN EACH ROW)

LISTED IN DESCENDING ORDER OF MEAN RATING*

	Not Important	Somewhat Important	Fairly Important	Extremely Important	Have No Idea	Mean Rating*
Your decision about whether to go to graduate school	10%	14%	27%	49%	< 1%	3.1
Your decision about what field to study in graduate school	13	16	29	43	< 1	3.0
Your acceptance into the graduate school where you are now	17	13	25	39	5	2.9
Your decision about where to apply for graduate school	28	17	23	32	< 1	2.6

*Mean rating based on a scale of 1 to 4 where 1=Not Important and 4=Extremely Important.

Employment Information

46. Are you currently employed? **(PLEASE SELECT ONE)**

Yes, I am employed full-time (35 or more hours per week)	26%	→ ***PLEASE CONTINUE***
Yes, I am employed part-time (fewer than 35 hours per week)	1	→ ***PLEASE CONTINUE***
Yes, but I am currently a student.	32	→ ***Please skip to question 51***
No	41	→ ***Please skip to question 51***

Number of respondents employed but not a student = 635

47. By what kind(s) of organization(s) are you currently employed? **(PLEASE SELECT ONE OR MORE)**
LISTED IN DESCENDING ORDER OF PERCENTAGE

For-profit company (other than medical or research)	70%
Government (other than military)	10
Research organization	7
College or university	6
Hospital, medical center, etc.	3
Non-profit organization (other than medical or research)	4
Elementary or secondary school	3
Military	2
Self-employed	2
Other *(please specify:)*	< 1

48. How related is your current job to your undergraduate major? **(PLEASE SELECT ONE)**

Not related	15%
Somewhat related	32
Closely related	53

49. How much, if at all, do you use **any** of the skills you learned doing undergraduate research in your current job? **(PLEASE SELECT ONE)**

Not at all	26%
Somewhat	55
A lot	19

50. Does your current job involve engineering? **(PLEASE SELECT ONE)**

Yes	76%
No	24

Background Information

51. What is your age?

Mean age	23.5
18 to 21	16%
22	20
23	20
24 or older	43

52. What is your sex? **(PLEASE SELECT ONE)**

Male	58%
Female	42

53. What is your ethnicity? **(PLEASE SELECT ONE)**

Hispanic or Latino	11%
Not Hispanic or Latino	89

54. What is your race? **(PLEASE SELECT ONE OR MORE)**

White	76%
Asian	13
Black or African American	12
American Indian or Alaskan Native	2
Native Hawaiian or Pacific Islander	1
Other	0

Overview

55. What was the most important thing you learned about yourself as a result of your undergraduate research experiences?

56. If you were designing undergraduate research programs, how would you make them better than the programs you participated in?

57. Other comments.

58. Do you have a disability or handicap that limits a major life activity? **(PLEASE SELECT ONE)**
Number of respondents: 1,812

Yes	2%
No	98

NATIONAL SCIENCE FOUNDATION DIRECTORATE FOR ENGINEERING

RESEARCH EXPERIENCES FOR UNDERGRADUATES (REU) PROGRAM

FY 2003-2006 Faculty Mentor Survey and Overall Results

Number of Respondents = 1,319 (1,241 Summer; 78 Academic Year)

Most Recent Year of Mentoring		Time of year		Award Type		ENG Division	
FY 2003	5%	Summer	94%	ERC Supplement.....	12%	BES	2%
FY 2004	11	Academic Year....	6	EEC Site	66	CMS	3
FY 2005	15			ENG Supplement.....	22	CTS	2
FY 2006	69					DMI.............	4
						ECS	4
						EEC.............	81
						OII	4

Selection Criteria

1. Were you involved in selecting undergraduates to participate in the summer program for an Engineering Research Center (ERC) or REU Site? **(SUMMER ONLY)** **(PLEASE SELECT ONE)**

   Yes .... 53% → **PLEASE CONTINUE**

   No.............. 47 → **PLEASE SKIP TO QUESTION 7**

1a. How selective are you in accepting undergraduates for participation in your research? **(ACADEMIC YEAR ONLY)** **(PLEASE SELECT ONE)**

   I am selective .... 78% → **PLEASE CONTINUE**

   I take pretty much anyone who wants to participate........ 15 → **PLEASE SKIP TO QUESTION 7**

   Someone else selects undergraduates for me................... 6 → **PLEASE SKIP TO QUESTION 7**

   Doesn't apply: Students are required to do research....... 0 → **PLEASE SKIP TO QUESTION 7**

Number of respondents involved in selecting undergraduates = 720

2. How important was each of the following in selecting undergraduates to participate in the research activities of your REU program? **(PLEASE SELECT ONE IN EACH ROW)**
LISTED IN DESCENDING ORDER OF MEAN RATING*

	Not Important	Somewhat Important	Fairly Important	Extremely Important	Don't Remember	Mean Rating*
Motivation, enthusiasm	1%	4%	23%	70%	1%	3.6
Student's interests match faculty interests	2	9	37	51	1	3.4
Major	2	10	46	42	1	3.3
Letter(s) of recommendation **(SUMMER ONLY)**	6	12	31	49	3	3.3
Grade point average in major or selected courses	3	9	50	38	1	3.2
Dependability **(ACADEMIC YEAR ONLY)**	2	14	36	49	0	3.2
Have sufficient time available **(ACADEMIC YEAR ONLY)**	2	17	40	42	0	3.2
Overall grade point average	2	15	56	26	1	3.1
Courses taken	4	18	49	28	1	3.0
Obtaining a racially/ethnically diverse group	10	20	38	31	1	2.9
Student's essay **(SUMMER ONLY)**	11	20	34	32	3	2.9
Including a good mix of male and female students	13	19	37	29	2	2.8
Interview or other personal contact with student	24	20	25	27	4	2.6
Interest in research as a career **(ACADEMIC YEAR ONLY)**	12	37	38	13	0	2.5
Including students with disabilities	24	26	27	15	8	2.4

*Mean rating based on a scale of 1 to 4 where 1=Not Important and 4=Extremely Important.

3. In selecting undergraduates for participation in your REU program, which of the following did you tend to prefer?
NOTE: These preferences may be determined by the target audience specified in your grant.

A. Those who were undecided about graduate school OR those who were already committed to going to graduate school? **(PLEASE SELECT ONE)**

Those who were undecided..........	7%
Those who were committed	16
Some of both	39
Other *(please specify:)*	0
No preference	35
Don't remember	3

B. Those with research experience OR those with no research experience? **(PLEASE SELECT ONE)**

Research experience.....................	23%
No research experience	8
Some of both	42
Other *(please specify:)*	0
No preference	26
Don't remember	1

C. Those from schools with few undergraduate research opportunities OR those from schools with many undergraduate research opportunities? **(PLEASE SELECT ONE) (SUMMER ONLY)**

Those from schools with few undergraduate research opportunities ...	19%
Those from schools with many undergraduate research opportunities ...	5
Some of both	36
Other *(please specify:)*	0
No preference	38
Don't remember	2

D. Rising sophomores OR juniors OR seniors? **(PLEASE SELECT ONE OR MORE)**

Freshmen	7%	→ **(ACADEMIC YEAR ONLY)**
Rising sophomores.......................	14	
Rising juniors	47	
Rising seniors...............................	35	
Some from all classes...................	22	
No preference	14	
Don't remember	1	

Other important selection criteria: ____

4. How many undergraduates **applied** to participate in research in your summer ERC or REU Site program? Please include all applicants, regardless of the potential source of their support. **(SUMMER ONLY)** **(PLEASE ENTER YOUR BEST ESTIMATE. ENTER "99" IF YOU HAVE NO IDEA)**

Mean number of applicants	58.5
Less than 10	11%
10 to 30	12
31 to 79	12
80 or more	12
Don't remember/Have no idea	53

5. How many undergraduates **participated** in your summer ERC or REU Site program? **Please include all participants, regardless of the source of their support. (SUMMER ONLY)** **(PLEASE ENTER YOUR BEST ESTIMATE)**

Mean number of participants	10.5
1 or 2	16%
3 to 9	12
10 to 14	24
15 or more	15
Don't remember	33

6. Did any K-12 teachers or community college faculty participate in research in your summer ERC or REU Site program? **(PLEASE SELECT ONE)** **(SUMMER ONLY)**

Yes	15%
No	67
Don't remember	17

Barriers to Increased Undergraduate Research

7. How much do you agree or disagree with each of the following statements about the number of undergraduates who conduct research? **(PLEASE SELECT ONE IN EACH ROW)**
LISTED IN DESCENDING ORDER OF MEAN RATING*

In my department, we probably would include more undergraduates in our research…	Disagree	Disagree Somewhat	Agree Somewhat	Agree	Have No Idea/ Doesn't Apply	Mean Rating*
…if we had financial support for more undergraduates	3%	7%	19%	70%	2%	3.6
…if we had more faculty or researchers available/willing to be mentors/ supervisors	9	11	30	46	4	3.2
…if we had more financial support for program administration	7	12	32	44	5	3.2
…if we had more graduate students or postdocs available/willing to be mentors/supervisors	11	16	30	38	5	3.0
. …if we had more lab space, facilities, or equipment	17	21	29	29	4	2.7
…if there were more undergraduates who were interested	17	22	30	27	4	2.7
…if there were more undergraduates who were qualified	17	25	27	27	4	2.7

*Mean rating based on a scale of 1 to 4 where 1=Disagree and 4=Agree.

Other barriers to increased undergraduate participation in research: ___________________________________

Your Undergraduate Research Mentoring/Supervising

8. For how many undergraduates, if any, were you **personally** a research mentor/supervisor during [REU time period] (regardless of the source of their support)?

Mean number of undergraduates..	2.5
None	1%
One	36
Two	28
Three or more	31
Don't remember	4

IF NONE, PLEASE SKIP TO QUESTION 19

Number of respondents who mentored undergraduates = 1,302

9. What was the average number of hours **per week** that you spent engaged in **research-related mentoring activities** with **all** of the undergraduates you mentored/supervised during [REU time period]? **(PLEASE SELECT YOUR BEST ESTIMATE)**

Less than 1 hour per week	4%
1 hour up to 5 hours per week	54
5 hours up to 10 hours per week	29
10 hours up to 20 hours per week	9
20 hours or more per week	3
Have no idea	< 1

10. Which of the following did **any** of the undergraduates you mentored/supervised do as part of their research experiences during [REU time period]? **(PLEASE SELECT ONE OR MORE)**
LISTED IN DESCENDING ORDER OF PERCENTAGE

Collected and/or analyzed data or information to try to answer a research question	92%
Understood how their work contributed to the "bigger picture" of research in this field	86
Gained increasing independence over the course of the summer	85
Received training to use research tools (computer program/language, lab or field equipment, etc.)	85
Delivered an oral/PowerPoint presentation describing their research and results	76
Prepared a final written research report describing their research and results	75
Were able to complete their research project (either during the summer or later)	73
Prepared/presented a poster presentation describing their research and results	62
Received training in written or oral communication skills	61
Attended lectures/seminars on research ethics	47
Went on research-related field trip(s) (to other labs, universities, industry, etc.)	46
Authored or co-authored a paper that has been or will be submitted for publication in a professional journal	34
Wrote a proposal describing the research they planned to do	33
Attended student conference(s) that included students from multiple colleges	33
Attended professional conference(s) (conferences not specifically for students)	21
Mentored other students conducting research or led a student research team	14
Worked on research with K-12 grade teachers **(SUMMER ONLY)**	6
Don't remember	< 1

11. To what extent, if at all, do you think your undergraduates' experiences during [REU time period] **increased** each of the following? **(PLEASE SELECT ONE IN EACH ROW)**
LISTED IN DESCENDING ORDER OF MEAN RATING*

	Not At All	Some-what	A Fair Amount	A Great Deal	Have No Idea	Mean Rating*
Their understanding of how to conduct a research project	1%	9%	33%	58%	< 1%	3.6
Their understanding of the nature of the job of a researcher	< 1	9	33	57	< 1	3.6
Their confidence in their ability to succeed in graduate school	1	10	40	45	3	3.4
Their understanding of how to deal with setbacks, negative results, etc.	1	16	38	44	1	3.4
Their confidence in their research skills generally	0	10	46	43	1	3.3
Their skills/abilities in working independently	1	12	41	46	< 1	3.3
Their skills/abilities in working collaboratively with others	1	14	38	46	1	3.3
Their skills/abilities in delivering oral research presentations	5	17	34	43	1	3.3
Their skills/abilities in preparing written research reports, papers, or posters	2	16	38	44	1	3.2
Their awareness of what graduate school is like	3	15	38	43	2	3.2
Their understanding of how to plan a research project	2	19	40	38	1	3.2
Their understanding of how engineering knowledge is built	3	19	42	32	3	3.2
Their understanding of how to formulate a research question	2	19	42	36	2	3.1
Their qualifications for jobs in related fields	1	17	46	31	4	3.1
Their awareness of career paths of the faculty in the program (how you got to where you are now)	5	28	38	27	2	3.0
Their awareness of the variety of engineering fields they could specialize in	6	27	40	22	4	2.8
Their awareness of career options in engineering	6	29	38	23	4	2.8
Their awareness of ethical issues in conducting research	6	33	38	20	4	2.8

*Mean rating based on a scale of 1 to 4 where 1=Not At All and 4=A Great Deal.

Academic Field

12. Which of the following best describe the academic field(s) of your REU research? **(PLEASE SELECT ONE OR MORE)**

Aerospace engineering	4%
Agricultural engineering	1
Architectural engineering	1
Bioengineering or biomedical engineering	27
Chemical engineering	17
Civil engineering	12
Computer engineering	8
Electrical engineering	20
Environmental engineering	9
Industrial or manufacturing engineering	5%
Materials or metallurgy engineering	17
Mechanical engineering	19
Mining or mineral engineering	< 1
Nuclear engineering	< 1
Ocean, marine, or naval engineering	1
Systems engineering	5
Transportation engineering	2
Other engineering ***(please specify below)***	3
A non-engineering field ***(please specify below)***	15

If you selected a "non-engineering field," please specify the field:

Biology	3%
Chemistry	3
Mathematics	< 1
Physics	4
Other	5

Your Experience with Undergraduates and Undergraduate Research Generally

13. For how many years have you mentored/supervised undergraduates doing research, including mentoring/supervising you might have done as a graduate student or postdoc? **(PLEASE ENTER YOUR BEST ESTIMATE)**

Mean number of years	11.8
1 to 5 years	28%
6 to 10 years	29
11 to 15 years	17
16 years or more	26

14. Did you yourself do research as an undergraduate? **(PLEASE SELECT ONE)**

Yes	62%	→ **PLEASE CONTINUE**
No	38	→ **QUESTION 15 = NOT IMPORTANT**

15. How important were your undergraduate research experiences to your decision to pursue teaching/research as a career? **(PLEASE SELECT ONE)**

Mean Rating*	2.4
Not important	42%
Somewhat important	9
Fairly important	16
Extremely important	34
Have no idea	1

*Mean rating based on a scale of 1 to 4 where 1=Not important and 4=Extremely important.

16. How much do you disagree or agree with each of the following statements about undergraduates and undergraduate research? **(PLEASE SELECT ONE IN EACH ROW)**
LISTED IN DESCENDING ORDER OF MEAN RATING*

	Disagree	Disagree Somewhat	Agree Somewhat	Agree	Have No Idea/ Doesn't Apply	Mean Rating*
Research is a good experience for undergraduates, regardless of their decisions about career or advanced degrees.	1%	1%	18%	80%	1%	3.8
All in all, mentoring undergraduates is a good experience for graduate students.	< 1	2	26	68	4	3.7
I get a lot of personal satisfaction out of working with undergraduates doing research.	1	4	31	64	0	3.6
Mentoring undergraduates is a good way to recruit them to be graduate students in my lab/department.	3	10	34	48	4	3.3
My own positive experiences doing undergraduate research help motivate me to be a mentor.	6	5	24	38	26	3.3
My work lends itself well to undergraduate participation.	4	17	40	38	1	3.1
Involving undergraduates in my research enables me to expand the avenues of investigation that I can pursue.	12	17	38	30	3	2.9
Mentoring undergraduates is viewed favorably in my department's tenure/promotion review process.	10	17	35	23	15	2.8
Undergraduates have opened my eyes to things in my research I probably would have overlooked.	15	24	40	17	3	2.6
Research experiences are more valuable for students who will pursue research or teaching careers than for those who will not.	20	26	25	27	1	2.6
Involving undergraduates in my research gives me the opportunity to do something risky.	21	26	29	19	4	2.5
If I did not receive funding specifically for including undergraduates, I probably would not involve them in my research.	38	28	21	11	2	2.1
All in all, involving undergraduates in my research has been more of a burden than an asset to my research.	49	31	15	4	1	1.7
If there were no external pressures to do so, I probably would not involve undergraduates in my research.	67	23	6	3	1	1.4

*Mean rating based on a scale of 1 to 4 where 1=Disagree and 4=Agree.

17. Which of the following best describes **your department's** position on undergraduate research mentoring/supervising? **(PLEASE SELECT ONE)**

Faculty are not required to mentor/supervise undergraduate research, but are encouraged to do so......	62%
The department takes no position on mentoring/supervising undergraduate research	30
Faculty are required to serve as mentors/supervisors on undergraduate research	6
Doesn't apply: No academic department	2
Other *(please specify below)*	0

18. In **your experience**, how important are the following to providing a high quality research experience for undergraduates? **(PLEASE SELECT ONE IN EACH ROW)**
LISTED IN DESCENDING ORDER OF MEAN RATING*

	Not Important	Somewhat Important	Fairly Important	Extremely Important	Too Much Variation Among Students to Generalize	Have No Idea	Mean Rating*
Providing sound technical guidance	< 1%	1%	19%	79%	< 1%	< 1%	3.8
Open and regular communication between the student and a mentor/ supervisor (either faculty or graduate student)	0	2	16	81	1	< 1	3.8
Making the student feel as though he/she is an integral part of the project team	< 1	3	26	70	< 1	< 1	3.7
Giving the student independence in conducting his/her research	2	17	47	31	3	< 1	3.1
Involving the student in designing or selecting his/her project	8	32	39	18	2	1	2.7
A research project that is closely related to the student's regular academic course work	20	39	30	8	2	< 1	2.3

*Mean rating based on a scale of 1 to 4 where 1=Not Important and 4=Extremely Important.

Background Information

19. By which of the following kinds of organizations are you currently employed? **(PLEASE SELECT ONE OR MORE)**

College/university	92%
For-profit organization	5
Government lab	4
Non-profit organization	3
Retired	< 1
Other *(please specify below)*	0

IF YOU ARE NOT CURRENTLY EMPLOYED IN ACADEMIA, PLEASE SKIP TO QUESTION 22

Number of respondents employed in academia = 1,209

‘

20. (If currently employed in academia) What is your current academic rank? **(PLEASE SELECT ONE)**

Professor	44%
Associate professor	30
Assistant professor	20
Research associate	4
Instructor or lecturer	1
Administrator	1
Other *(please specify below)*	1
Adjunct professor	< 1

21. (If currently employed in academia) What is your current tenure status? **(PLEASE SELECT ONE)**

Tenured	67%
On tenure track but not tenured	19
Not on tenure track	10
Doesn't apply: No tenure system here	3

22. What is your age? **(PLEASE SELECT ONE)**

Under 30	3%
30 to 39	27
40 to 49	36
50 to 59	23
60 to 69	10
70 or older	2

23. What is your sex? **(PLEASE SELECT ONE)**

Male..............	81%
Female	19

24. What is your ethnicity? **(PLEASE SELECT ONE)**

Hispanic or Latino............	4%
Not Hispanic or Latino.....	96

25. What is your race? **(PLEASE SELECT ONE OR MORE)**

White	75%
Asian...	22
Black or African American	3
American Indian or Alaskan Native..........	< 1
Native Hawaiian or Pacific Islander..........	0
Other...	0

26. Do you have a disability or handicap that limits a major life activity? **(PLEASE SELECT ONE)**

Yes................	1%
No.................	99

Overview

27. What is your single most important objective in mentoring/supervising undergraduate research?

28. How do you think NSF can improve the REU experience for faculty mentors?

29. How do you think NSF can improve the REU experience for undergraduate students?

30. How do you think NSF can involve more undergraduate students in the REU program?

31. Other comments:

APPENDIX C
SURVEY RESULTS

Tabulations of survey results for undergraduate students and faculty mentors can be found in an accompanying Excel spreadsheet and are bound separately.