

**A Draft Report to the
National Science Foundation**



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

Executive Summary

Prepared under Contract GS10F0554N/06D1403

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**Prepared for
The National Science Foundation
Directorate for Engineering**

August 2008

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

EXECUTIVE SUMMARY

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. NSF contracted with SRI International (SRI) to conduct surveys of participants in the REU program in the Directorate for Engineering (ENG).

ENG has two major award types for REUs—Site and Supplement awards. 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 EEC Sites and ERC Supplements during 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.

This executive summary describes the major results of the initial survey, which included approximately 3,900 undergraduate students and 2,000 principal investigators (PIs) and faculty mentors. The surveys were administered online, with e-mail notification and reminders. Student sample members with no e-mail address were surveyed by mail. A total of 2,619 undergraduate students and 1,319 PIs/faculty mentors responded to the initial survey. Almost all of the participants responded regarding summer programs (96% of students and 94% of faculty) rather than academic-year (fall to spring) programs. All data shown in figures and tables are derived from the REU survey conducted in 2007 by SRI International.

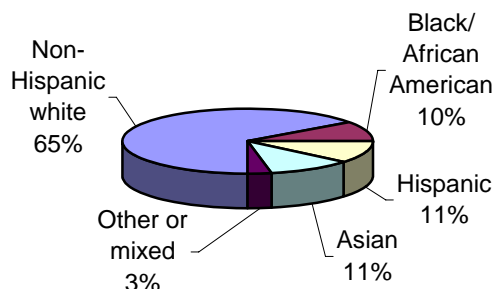
¹ Five reports on SRI’s recent studies about undergraduate research programs are available on SRI’s Web site at <http://www.sri.com/policy/csted/reports/university/>.

MAJOR SURVEY FINDINGS

Undergraduate Research Participants

Women and minorities who have been underrepresented in engineering were well represented among undergraduate researchers, but there was less diversity in terms of their grades and class level.

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



Relative to their occurrence in the population, women and traditionally underrepresented minorities were well represented among 2003-2006 ENG REU undergraduate researchers. Women comprised 42% of undergraduate researchers but only 20% of 2004-2005 engineering bachelor's degrees.² Hispanics comprised 11% and black or African Americans 10% of

undergraduate researchers but only 6% each of 2004-2005 engineering bachelor's degrees³ (Figure ES-1). Two percent of undergraduate researchers reported they have a disability or handicap that limits a major life activity. Ninety-five percent of undergraduate researchers had grade point averages of 3.0 or better, and 86% were estimated to be juniors or seniors at the time of their REU research.

Most undergraduate participants had other research experience, half had early expectations of an advanced degree, and many were currently enrolled in graduate school.

Approximately three-quarters (77%) had done some kind of undergraduate research other than the experience they reported on in the survey. Before they participated in any undergraduate research, about half were already planning to get some kind of advanced degree—25% expected to get a Master's degree, and 26% expected to get a PhD. At the time of the survey, 42% had been accepted into or were currently enrolled in graduate school, 30% were still enrolled as undergraduates, and 28% were not enrolled in school.

Selection Criteria

Faculty have diverse sets of criteria for undergraduate researchers.

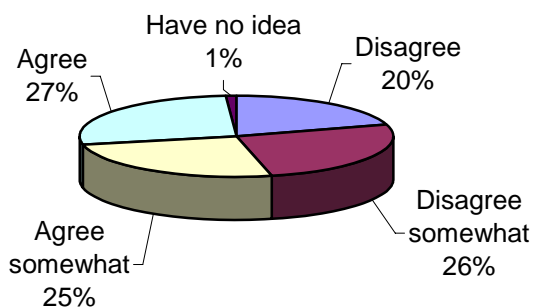
Faculty indicated diverse sets of criteria when asked about how they selected undergraduates for research participation. Asked whether they agreed or disagreed that "research experiences are more valuable for students who will pursue research or teaching careers than for those who will not," responses were almost equally divided among the four scale points (Figure ES-2). Faculty also indicated a preference for a diverse group of students. Given a choice of various types of students (e.g., by academic class, previous research experience), most responded either

² 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.

³ 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.

“some of both” or “no preference.” Few faculty stated a preference for students from schools with many research opportunities. Finally, nearly all agreed that “research is a good experience for undergraduates, regardless of their decisions about career or advanced degrees.”

Figure ES-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



Undergraduates' Motivations for Participating

The top reasons for participating in research related mostly to enthusiasm for research or need for help with a career decision.

The top five reasons 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.

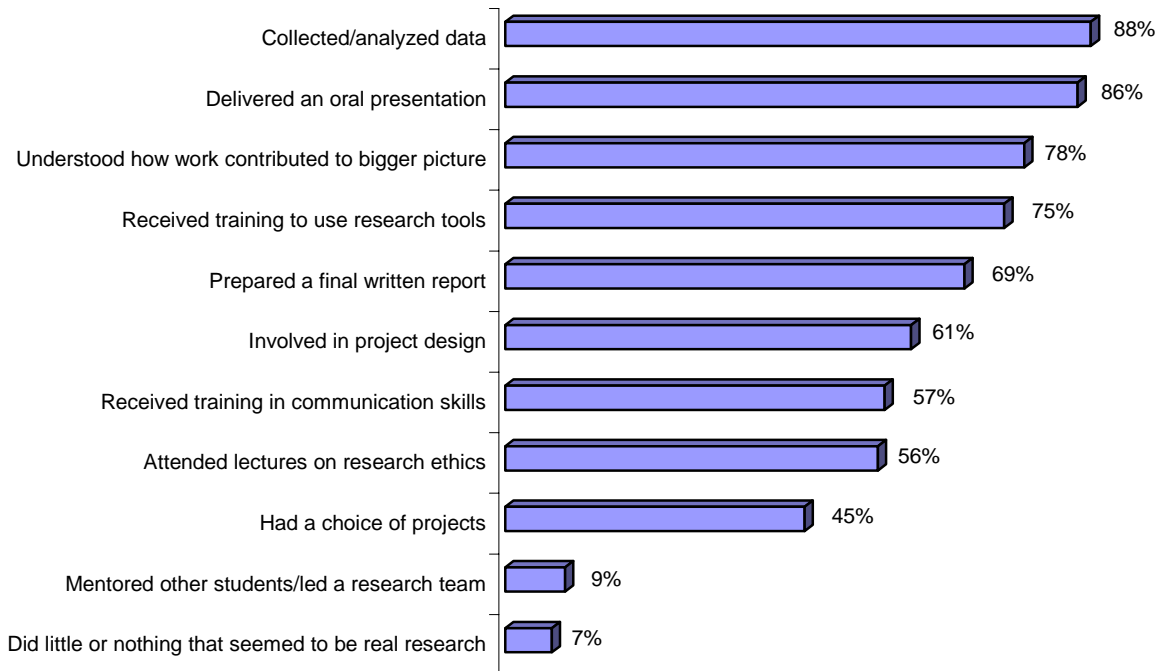
The first four were among the top-rated reasons for students in each award type. ERC Supplement students' fifth reason was “I thought it would help me get into graduate school or get a job,” and ENG Supplement students' fifth reason was “Doing research was more appealing than other kinds of jobs available.”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

Activities and Characteristics of Undergraduate Research Experiences

Most undergraduates collected and/or analyzed data, delivered an oral presentation describing their research and results, understood how their work contributed to the “bigger picture” of research in their field, and received training to use research tools.

Figure ES-3 presents a selection of the many varied research activities in which undergraduates participated. The most common research activity was collecting and/or analyzing data (88%). The least common activity was mentoring other students conducting research or leading a student research team (9%). Reassuringly, only 7% said they “did little or nothing that seemed to be real research.”

**Figure ES-3
Selected Undergraduate Research Activities and Characteristics**



Undergraduates' Perceptions of Their Research Experiences

More than two-thirds of undergraduates were very satisfied with their research experience as a whole.

Almost all undergraduates were either very satisfied (69%) or somewhat satisfied (24%) with their research experience as a whole. Two-thirds or more also were very satisfied with how well organized the program was, the supportiveness of their faculty mentor, the adequacy of the technical guidance they received, the social/cultural activities for the summer program participants, and the independence they had in doing their work. More than half were very satisfied with the supportiveness of their graduate student or postdoc mentor, the involvement they had in selecting or designing their project, and their living arrangements.

Enthusiasm for research, spending time with their faculty mentor, engaging in a variety of research-related activities, and being involved in project design/decisions were among the factors that were important to undergraduates' overall satisfaction with their research experience.

The following study variables were the most strongly related to undergraduates' overall satisfaction with the research experience:

- Enthusiasm for research as a reason to participate.
- The amount of time spent with their faculty mentor.
- How well prepared they felt for the work they were asked to do.

- The number of research activities engaged in.
- The amount of time spent with graduate students or postdocs.
- Having done at least something that seemed like real research.
- Doing research that was at least somewhat closely related to courses they had taken in their major.
- Having been involved in project decisions about what to do next.
- Having been involved in designing their project.

Award type had very little effect on satisfaction ratings. Similarly, there were few appreciable differences by race/ethnicity or sex in overall satisfaction.

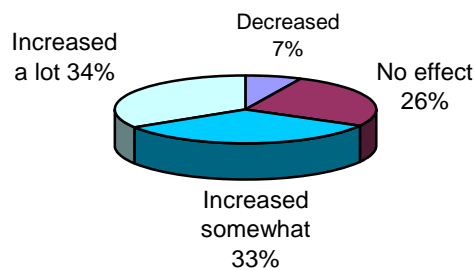
Effects of Research Experiences

Research experiences had a major impact on undergraduates’ awareness, confidence, skills, and understanding regarding research, graduate school, and related careers.

Given a wide variety of dimensions of potential research impacts (such as increased understanding of the nature of the job of a researcher, skills/abilities in working independently, confidence in ability to succeed in graduate school, and awareness of what graduate school is like), about two-thirds or more of the undergraduates rated the impact as either “a fair amount” or “a great deal.” On the two dimensions reflecting a basic purpose of undergraduate research experiences—understanding the nature of the job of a researcher and understanding how to conduct a research project—more than 8 in 10 rated the impact as “a fair amount” or “a great deal.”

Research experiences increased most students’ interest in careers in science, engineering, and research.

Figure ES-4
Effects of Research on Interest in an Engineering Career



About two-thirds of students said that their interest in careers in science, engineering, and research was increased “somewhat” or “a lot.” (Figure ES-4) Fewer students reported increased interest in careers in industry or teaching.

Degree expectations of about half of the students were raised following their research experiences.

Before they had ever participated in research, only a fourth of the students expected that their highest degree would be a PhD; at the time of the survey, 49% expected a PhD to be their highest degree (Figure ES-5). In all, at the time of the survey, more than 5 in 10 students expected to obtain a higher degree than they had anticipated receiving before their first research experience (Figure ES-6). Of the undergraduates who did not expect to receive a PhD before doing research, 30% now expect a PhD (Figure ES-7).

Figure ES-5
Highest Degree Expectations: Percentage Who Expected That Degree Would Be Highest They Received

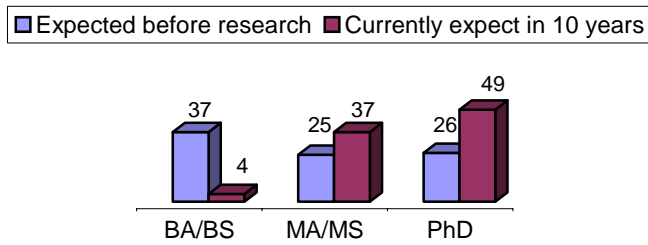


Figure ES-6
Changes in Degree Expectations: Before Research to Current

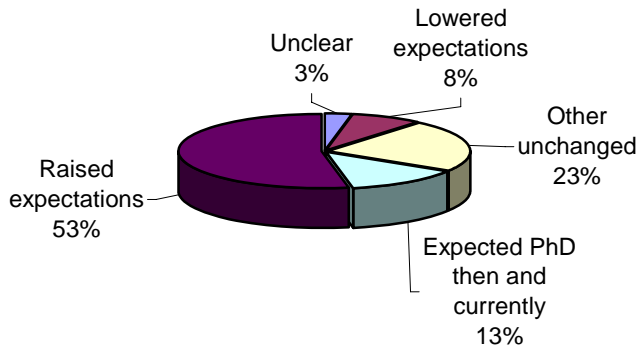
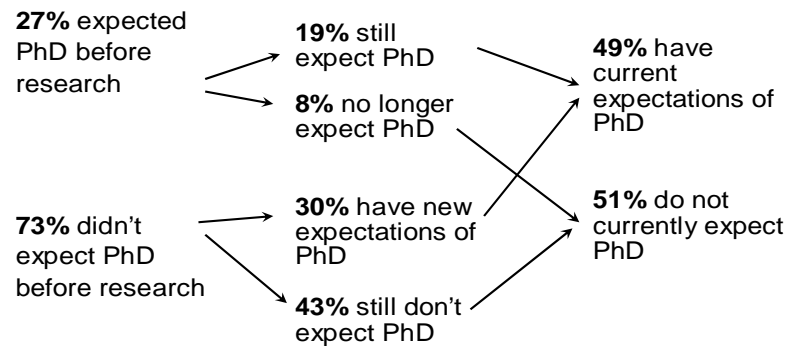


Figure ES-7
PhD Expectations Flow Chart for REU Researchers



Group Differences in Research Experience Effects

Differences in perceived gains were more pronounced among race/ethnicity groups than among award types or between men and women.

There were only slight differences in perceived gains in awareness, confidence, and understanding regarding research, graduate school, and related careers across the three award types, but ENG Supplement students reported lower gains in research related skills than did ERC Supplement and EEC Site students. Hispanics tended to report the highest gains in all areas and non-Hispanic whites tended to report the lowest gains. The differences were greatest for research skills, where 34% of Hispanics and black or African Americans were high gainers, compared with 18% of non-Hispanic whites. There were only slight differences in perceived gains between men and women overall, but 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.

Changes in career interests were more pronounced among research fields and race/ethnicity groups than among award types or between men and women.

As was the case with the perceived gains, Hispanics were the most likely to report positive effects of their research experiences on their interest in careers in engineering, science, and research. Among research fields, 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. Civil engineering researchers reported the lowest increase of interest in a career in research. There were no appreciable differences in increased interest in careers by award type or sex.

Differences in degree expectations were also more pronounced among research fields and race/ethnicity groups than among award types or between men and women.

Undergraduate researchers in a non-engineering field were the most likely group to have both pre-research and current expectations of a PhD. Consequently, 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 at the time of the survey. Hispanics were the most likely to have raised their expectations. There were no appreciable differences in degree expectations among participants on the basis of their award type or sex.

Correlations Among Effects of Research Experiences

Increased awareness and confidence were related to increased interest in related careers and to raised degree expectations.

Of the various kinds of research effects (increased awareness, confidence, skills, and understanding), increased awareness and confidence were the most strongly related to increased interest in related careers and to raised degree expectations. For example, 43% of students who said their interest in a career in engineering increased a lot showed high gains in awareness, compared with 17% of those whose interest in a career in engineering decreased. Thirty-four percent of those with raised degree expectations showed high gains in confidence, compared with 28% of those who did not raise their degree expectations.

A variety of elements of the research experience were related to increased awareness and confidence.

Elements of the research experience that were related to increased awareness and confidence included participating in a variety of research-related activities, gaining independence, and having sufficient contact with a research mentor. For example, 81% of those showing a high gain in confidence felt they spent about the right amount of time with their faculty mentor, compared with 48% of those showing a low gain in confidence; and 79% of those showing a high gain in awareness engaged in 10 or more research activities, compared with 44% of those showing a low gain in awareness.

Three types of motivations for participating in research were related to positive research outcomes.

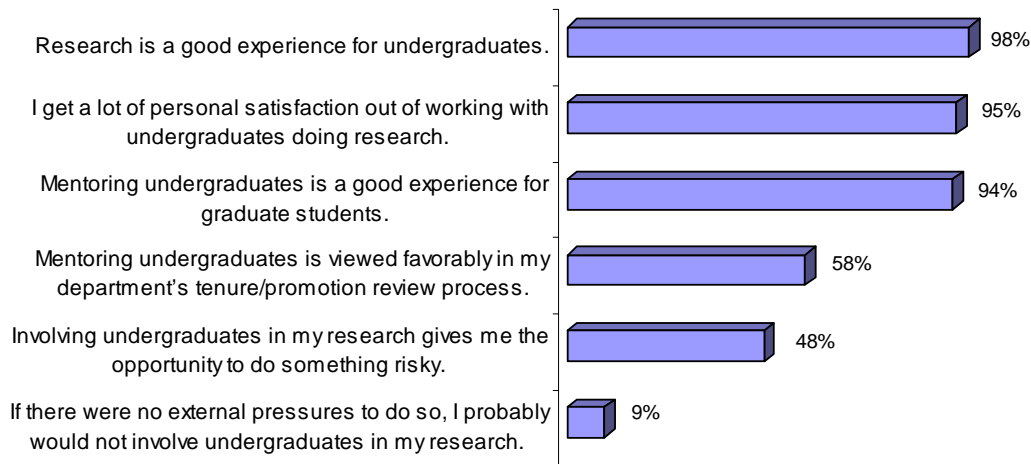
Undergraduates who gained a lot in awareness and confidence were highly motivated by research enthusiasm (an index comprising four items), need for help with a career decision (four items), or personal contacts (three items). Research enthusiasm also was positively related to raised degree expectations.

Faculty Mentor Views on Undergraduate Research

Positive experience and personal satisfaction—much more than career, political, or research factors—appeared to be the driving force behind most faculty participation in undergraduate research.

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%). Faculty most often disagreed with the potentially negative aspects of mentoring (Figure ES-8).

Figure ES-8
Faculty Mentor Attitudes about Undergraduate Research:
Percentage who Agreed at Least Somewhat



Mentors felt that faculty-student communication, sound technical advice, and making the student an integral part of the project team were very important elements of high-quality mentoring.

On scales rating the importance of several factors for a high-quality research experience, large majorities of mentors rated open and regular communication between mentor and student, providing sound technical advice, and making the student feel that he/she is an integral part of the project team as 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.

Mentors underestimate the importance of relating research to course work and often fail to integrate students into the research team.

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. Few faculty (8%) 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. These findings suggest that mentors underestimated the importance of relating research to course work and 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, 8 in 10 faculty said that open and regular communication between the student and a mentor was extremely important and about two-thirds of the students were very satisfied with the overall supportiveness of their faculty mentor or felt they had about the right amount of contact with their faculty mentor.

Need for greater financial support is the greatest barrier to increasing the number of undergraduate researchers.

Eighty-nine percent of faculty mentors 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. In response to the open-ended question “How do you think NSF can involve more undergraduate students in the REU program?”, more than half of those responding to the question said more funding is needed.

SUMMARY

Research experiences for undergraduates had a variety of significantly positive effects on the undergraduates who participated in them, including gains in awareness, confidence, skills, and understanding; increased interest in related careers; and raised academic expectations. There were only slight differences in gains in awareness, confidence, skills, and understanding and no differences in increased interest in related careers or raised degree expectations across the three award types. Among the several racial/ethnic groups, Hispanics were the most likely to report these various positive effects. There were no reliable differences in effects between men and women.

Undergraduates who were motivated to participate in research because they wanted help with career decisions, had enthusiasm for research, or had prior personal contact with researchers showed the highest gains in awareness, confidence, skills, and understanding. Those involved in a variety of research-related activities, who had adequate time with a research mentor, and who gained increasing independence over the course of the research also showed higher gains in these areas. Undergraduates who indicated a higher increase in confidence and awareness as a result of their research experiences also showed increased interest in a career in engineering or research and were more likely to currently expect to obtain a PhD.

