SRI International

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EVALUATION OF NSF SUPPORT FOR UNDERGRADUATE RESEARCH OPPORTUNITIES
Survey of STEM Graduates

Draft Final Report

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The SRI Project Team

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INTRODUCTION

This report is one of several prepared by SRI International (SRI) under a contract to the National Science Foundation (NSF) to conduct a broad-based, nationwide evaluative study of NSF's support for undergraduate research. The purpose of the study is to understand better the demographic and academic characteristics of undergraduates who participate in undergraduate research opportunities (UROs) nationwide, why individuals choose to participate, the characteristics and components of UROs, and UROs' effects on students' academic and career decisions.

The major components of the study are:

- An inventory of UROs provided by public and private institutions in the United States.
- Site visits to selected research institutions that provide UROs.
- A survey of student and faculty participants in UROs funded by NSF.
- A survey of individuals ages 22 to 35 who have received a bachelor's degree in the so-called "hard" sciences, technology, engineering, or mathematics (STEM).
- A survey of individuals ages 22 to 35 who have received a bachelor's degree in the social, behavioral, or economic sciences (SBES).
- A follow-up survey in 2005 of NSF student participants.

This executive summary describes the major results of the STEM graduates survey, which included approximately 3,400 individuals. The survey's objective is to provide a longer-term and broader perspective on the academic and career effects of undergraduate research, relative to the survey that focused on UROs funded by NSF. STEM graduates were asked whether they had participated in any UROs; if so, the nature of those experiences; and the effects of those experiences on their decisions about careers and academic degrees. To facilitate comparisons, many of the questions were identical across the four surveys.

SURVEY METHODS

SRI subcontracted with NFO WorldGroup—now TNS NFO—(NFO) to provide the sample and do the data collection. NFO selected the survey sample from its Interactive Panel, which comprises 1.2 million households and 3.6 million individuals. The starting sample for this study was adults age 22 to 35 with a bachelor's degree or higher. To ensure that the sample was representative, the sample was balanced to U.S. Census profiles for adults of the specified age and education, with an added oversample of Hispanics/Latinos and blacks. Survey sample members were screened to confirm that they met the age and education requirements. STEM graduates were identified as those who indicated that they had received their bachelor's degree in a STEM field, excluding SBES. Only those who met all eligibility criteria completed the remainder of the questionnaire and are included in the final data file. The survey response rate was 40%; analyses are based on a total of 3,410 respondents.

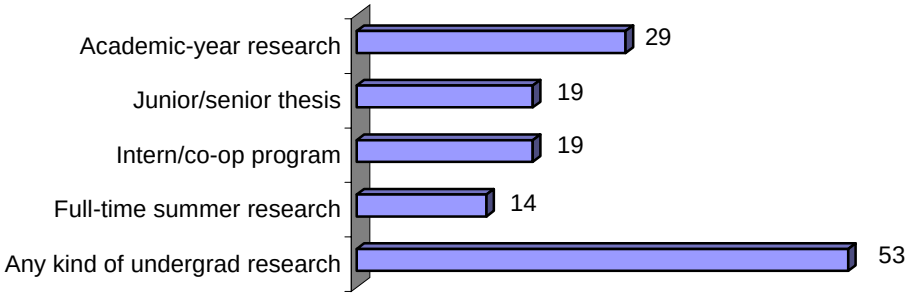
MAJOR SURVEY FINDINGS

Research Participation

About half of STEM graduates participated in research activities as undergraduates.

The most common type of undergraduate research was working with a professor or researcher during the academic year (29% of STEM graduates did so). Many students participated in more than one type of research.

Percentages of STEM Graduates Who Participated in Each Listed Type of Undergraduate Research



Source: SRI International STEM graduates survey, 2003.

Those who did not participate in research were much more likely to have <u>chosen</u> not to participate than to have been <u>unable</u> to participate.

Eight in 10 non-researchers indicated that they chose not to participate in research (e.g., there were not interested or didn't have time for research); 4 in 10 indicated that they were unable to participate, either because research opportunities were not available or because the student applied but was turned down.

It is also noteworthy that the percentage who selected "it never occurred to me [to participate in research]" decreased over time: 24% of those who graduated between 1988 and 1992, 21% of those who graduated between 1993 and 1997, and 15% of those who graduated between 1998 and 2003. Correspondingly, the participation rate increased slightly over time, from 48% of 1988 to 1992 graduates to 56% of those who graduated since 1998.

There were only small differences among racial/ethnic groups and between men and women in research participation rates.

Fourteen percent of undergraduate researchers reported that they participated in research sponsored by NSF, NASA, or NIH.

Thirty-nine percent of researchers said that none of these agencies supported any of their research, and 47% said they had no idea if any of these agencies supported them. The percentages who reported sponsorship by each agency were as follows: NSF 8%, NIH 5%, and NASA 3%.

Sponsored researchers[*] tended to have longer and richer research experiences than did their non-sponsored counterparts.

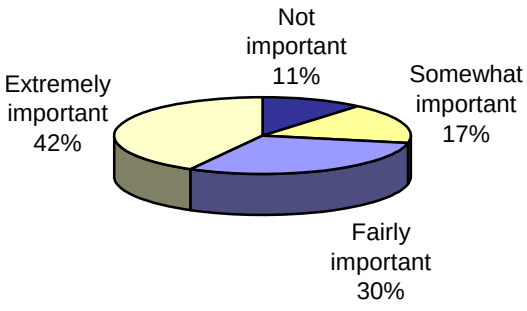
- Summer research was far more common among sponsored researchers than among their non-sponsored counterparts (60% vs. 21%, respectively).
- Sponsored researchers reported an average of 20 months of research experience (not necessarily all sponsored by NSF, NASA, or NIH), compared to 10 months for non-sponsored students.
- Reflecting the longer duration of their experiences, sponsored researchers were more likely than non-sponsored students to participate in almost all kinds of research activities/experiences.
- Compared to high-experience non-sponsored researchers (those with more than 12 months of research experience), those who participated in sponsored research were more likely to have gone on research-related field trips, attended student conferences, prepared a poster presentation, and had a choice of projects to work on.

Research Experience Effects

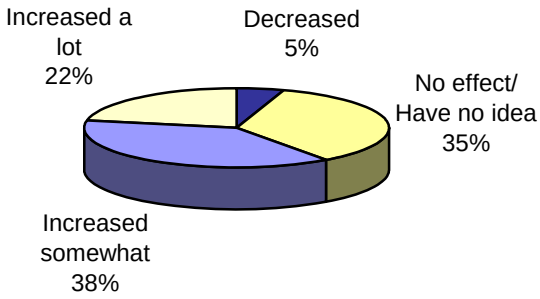
Many respondents reported that their undergraduate research experiences were important in shaping their career decisions and interests.

About 7 in 10 respondents reported that their undergraduate research was fairly or extremely important to their career decision, and about 6 in 10 said that their interest in a STEM career increased somewhat or a lot as a result of their undergraduate research experiences.

Perceived Importance of Undergraduate Research to STEM Researchers' Career Decisions



Effects of Undergraduate Research on STEM Researchers' Interest in a STEM Career

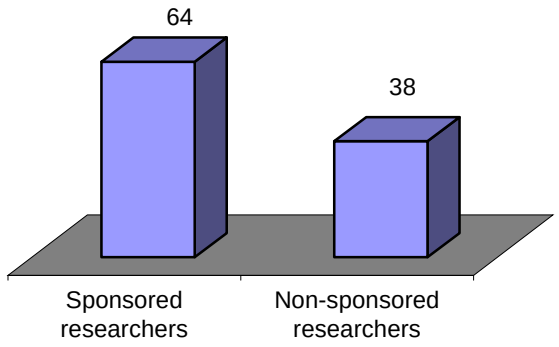


Source: SRI International STEM graduates survey, 2003.

[*] By "sponsored researchers," we mean those who knew that at least some of their undergraduate research was sponsored by NSF, NASA, or NIH. "Non-sponsored" researchers were those who did research but were not sponsored by NSF, NASA, or NIH, or were not aware that they were. Non-sponsored researchers may well have been sponsored by other organizations.

Reported research effects were considerably stronger among sponsored than non-sponsored researchers.

Percentage of STEM Sponsored and Non-Sponsored Researchers Who Rated Undergraduate Research as Extremely Important to Their Career Decision



Source: SRI International STEM graduates survey, 2003.

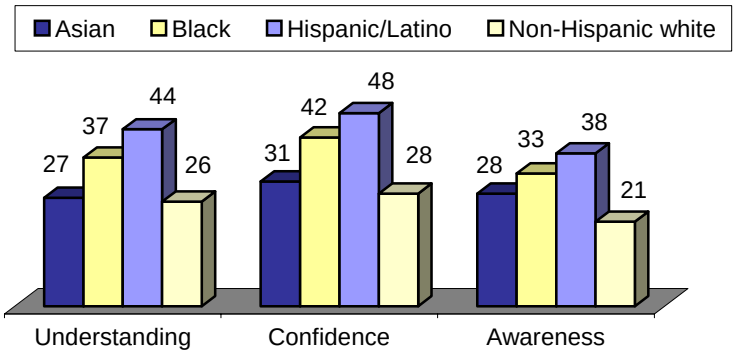
- Sponsored researchers were about twice as likely as those who were not sponsored to be "high gainers" in confidence, understanding, and awareness* as a result of their research experiences.
- Sponsored students rated research as more influential in their career decisions and interests than did non-sponsored students.

Among non-sponsored researchers, those with more than 12 months of research experience ("high-experience researchers") reported stronger research effects than those with less experience.

- High-experience researchers reported stronger gains in confidence, understanding, and awareness than did those with less research experience.
- High-experience researchers rated research as more influential in their career decisions and interests than researchers with less experience. High-experience researchers gave influence ratings that were similar to those provided by the sponsored students.

Blacks and, especially, Hispanics/Latinos were more likely than Asians or non-Hispanic whites to have shown gains in understanding, confidence, and awareness.

Percentage of STEM "High Gainers" in Understanding, Confidence, and Awareness, by Race/Ethnicity



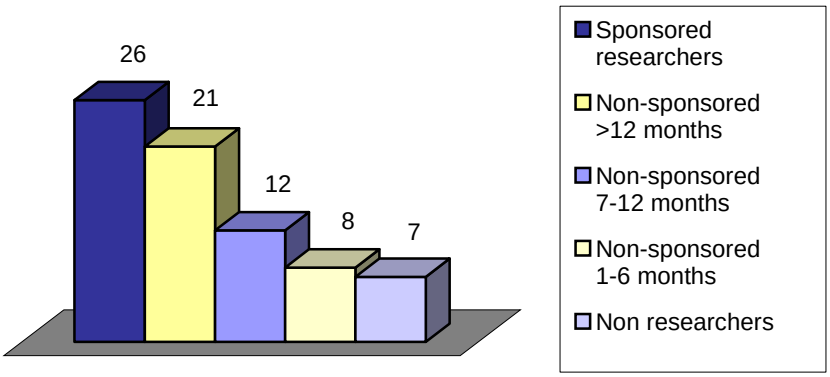
Source: SRI International STEM graduates survey, 2003.

* Confidence, understanding, and awareness were indices derived from three or more attitude items asking the extent to which the respondent's undergraduate research experiences increased their confidence, understanding, and awareness on various dimensions. "High gainers" on each index were those who scored in approximately the top quartile of that index.

There were no statistically reliable differences between men and women in their perceived gains from their research experiences.

Undergraduate research--especially sponsored research--tended to attract those who were already relatively highly academically motivated.

Percentage of Each Specified Group of STEM Graduates Who Had Pre-College Expectations of Obtaining a PhD

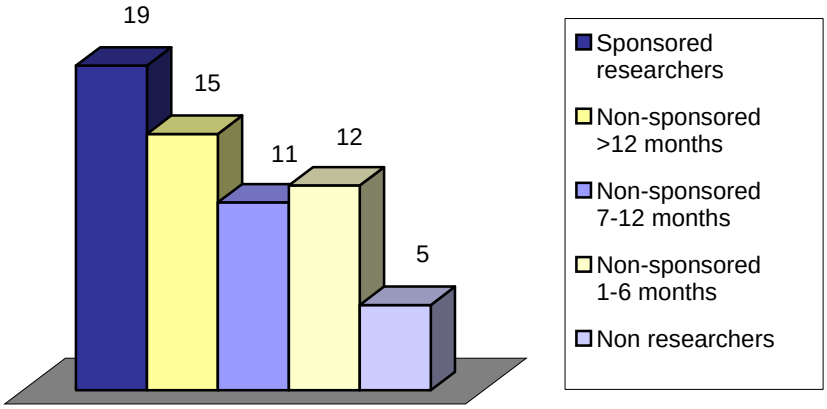


Source: SRI International STEM graduates survey, 2003.

STEM graduates who participated in research tended to have higher pre-college degree expectations than did graduates who did not participate in research. Among those who participated in research, sponsored students had considerably higher pre-college expectations than other researchers in general, and they also had higher expectations than the high-experience non-sponsored group.

Undergraduate research—again, especially sponsored research--seemed to motivate/ encourage undergraduates to pursue a PhD.

Percentage of Each Specified Group of STEM Graduates With "New" PhD Expectations

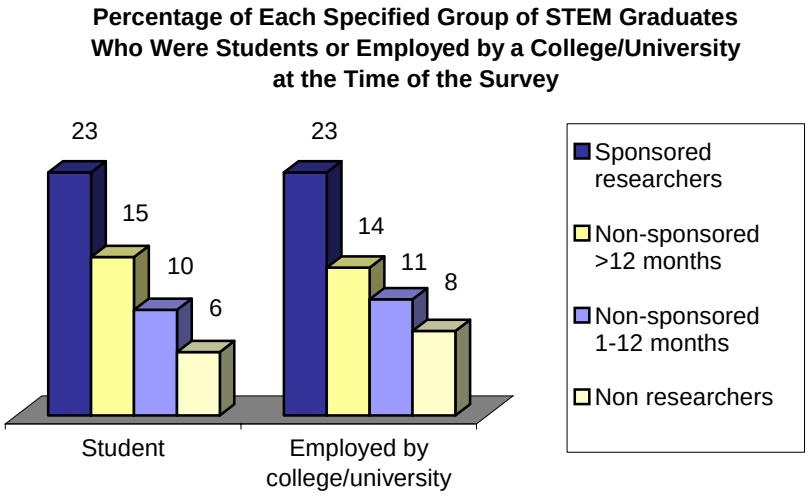


Source: SRI International STEM graduates survey, 2003.

At the time of the survey, more than twice as many researchers as non-researchers had obtained a PhD or expected to obtain one in the next 10 years (20% vs. 8%, respectively). By a similar margin, researchers were more likely than non-researchers to have "new" expectations of obtaining a PhD[1] (13% vs. 5%). The corresponding percentages of sponsored researchers were 33% and 19%.

[1] By "new PhD expectations," we mean that the respondents did not have pre-college expectations of obtaining a PhD, but at the time of the survey they either had a PhD or expected to obtain one in the next 10 years.

Sponsored researchers were considerably more likely than others to still be students or to be employed in academia.



SUMMARY

Half of STEM graduates over the past 15 years reported that they had at least some hands-on research experiences as undergraduates. A large majority of those who did not participate in research chose not to do so; the absence of opportunities for research was a much less commonly reported reason for not participating. Although blacks and Hispanics/Latinos were underrepresented in STEM majors, those who were in those majors were as likely as Asians or non-Hispanic whites to participate in research; similarly, women were as likely as men to participate in research. Most striking were the findings that those who participated in research sponsored by NSF, NASA, or NIH ("sponsored researchers") were quite different from their non-sponsored counterparts in terms of the richness and duration of their research experiences and the strength of the research experience effects they reported. Undergraduate research in general, but especially sponsored research, tended to attract students who already expected to obtain an advanced degree, but it also helped encourage them to pursue a doctorate. Sponsored researchers also were more likely than others to still be students or to be employed in academia.

I. INTRODUCTION

This report is one of several prepared by SRI International (SRI) under a contract to the National Science Foundation (NSF) to conduct a broad-based, nationwide evaluative study of NSF's support for undergraduate research. The purpose of the study is to understand better the demographic and academic characteristics of undergraduates who participate in undergraduate research opportunities (UROs) nationwide, why individuals choose to participate, the characteristics and components of UROs, and UROs' effects on students' academic and career decisions.

MAJOR STUDY COMPONENTS

The major components of this study are:

- An inventory of UROs provided by public and private institutions in the United States.
- Site visits to selected research institutions that provide UROs.
- A survey of student and faculty participants in UROs funded by NSF.
- A survey of individuals ages 22 to 35 who have received a bachelor's degree in ("hard") science, technology, engineering, or mathematics (STEM).
- A survey of individuals ages 22 to 35 who have received a bachelor's degree in a social, behavioral, or economic science (SBES).
- A follow-up survey in 2005 of NSF student participants.

The focus of this report is on the STEM graduates survey. Reports on the inventory, the site visits, and the NSF-program participant survey have been prepared and submitted to NSF previously. Reports on the SBES graduates survey and the follow-up student survey will be prepared in 2005. Each of the study components is described briefly below.

Inventory of UROs

The first major task of the study was the compilation of an inventory of the kinds of UROs that are supported by NSF and other government and non-government entities in the United States.[2] The primary focus of the inventory was on undergraduate research in STEM, particularly the disciplines that are supported by NSF. The focus was also on programs and organizations that themselves fund UROs, as opposed to programs and organizations that provide such experiences for undergraduates with funding from other sources. The inventory is organized first by type of sponsoring organization: NSF, other federal agencies, foundations, and industry. Each organization's list is ordered by the amount of funding it provides for undergraduate research, insofar as it is possible to determine, and according to how specifically and/or determinably the programs provide an actual research experience. Finally, there is a cross-cutting element that distinguishes those programs that are generic (open to all groups) from

[2] C.A. Ailes *et al*., "Evaluation of NSF Support for Undergraduate Research Opportunities: Inventory of Undergraduate Research Opportunities," report to the National Science Foundation. December 2003. Arlington, VA: SRI International.

those that are targeted, sometimes geographically, but generally to racial/ethnic groups that are underrepresented in science and engineering careers.

Site Visits

Primarily to help guide development of the survey questionnaires, SRI conducted site visits to 20 institutions that provide research opportunities for undergraduates.[3] Institutions were selected to provide diversity in terms of types of students served, academic field of research, geographic location, and types of NSF awards supporting undergraduate research. To include both summer and academic-year (fall to spring) participants, some visits were conducted during the summer and others were conducted during the regular academic terms. Interviews and focus groups were conducted with principal investigators (PIs), other faculty mentors, graduate student mentors, and undergraduates currently participating in research. For the most part, individual interviews were conducted with faculty, and group interviews were conducted with undergraduates and graduate students.

NSF-Program Participant Survey

Conducted mostly through Web-based questionnaires, the NSF-program participant survey included more than 4,500 undergraduates, 800 graduate student/postdoc mentors, and 2,200 principal investigator (PI) and other faculty mentors who participated in over 1,000 active NSF awards between June 2002 and May 2003.[4] The overall response rate was 79%, ranging from 76% of the undergraduates to 95% of the PIs. Respondents were asked about the undergraduate research experiences they had during either the 2002 summer or the 2002-2003 academic year (fall through spring). Undergraduates were asked about their reasons for participating, the kinds of activities they engaged in, areas of satisfaction and dissatisfaction with the research experience, and perceived effects of the experiences. Graduate students, PIs, and faculty mentors were asked questions that paralleled many of those asked the undergraduates as well as questions about their attitudes about involving undergraduates in research and undergraduate mentoring needs.

STEM Graduates Survey

The STEM graduates survey is the focus of this report. The survey involved a nationwide sample of approximately 3,400 individuals ages 22 to 35 who had received a STEM bachelor's degree. Respondents were asked whether they had participated in any UROs; if so, the nature of those experiences; and the effects of those experiences on their decisions about careers and academic degrees.

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[3] C.A. Ailes *et al*., "Evaluation of NSF Support for Undergraduate Research Opportunities: Site Visit Report," report to the National Science Foundation. October 2003. Arlington, VA: SRI International. The institutions visited were Arizona State University, Georgetown University, George Washington University, Georgia Institute of Technology, Hampton University, Haverford College, Hope College, Howard University, IBM Almaden Research Center, Jackson State University, Johns Hopkins University, National Institute of Standards & Technology, Southern University, Southwest Indian Polytechnic Institute, Stanford University, University of California at Irvine (California AMP Symposium), University of Colorado, University of Maryland, University of South Carolina, and University of Wisconsin.

[4] S.H. Russell, "Evaluation of NSF Support for Undergraduate Research Opportunities: 2003 NSF-Program Participant Survey," report to the National Science Foundation. February 2004. Arlington, VA: SRI International.

The overall purpose of this survey was to provide a longer-term and broader perspective on the academic and career effects of undergraduate research than could be provided from a survey limited to current URO participants and to UROs sponsored by NSF. A sample derived from award- or institution-based lists of past participants in UROs was considered and rejected because of the difficulty/high cost of locating individuals and, especially, because those who are located in such efforts tend to be disproportionately in academia. In a study of the effects of UROs on career and academic decisions, such a bias would have seriously damaged the validity of the results.

SBES Graduates Survey

A survey of SBES graduates that is analogous in scope and size to the STEM graduates survey was conducted in 2004. As of March 2005, analysis of this survey is underway.

NSF Student Follow-up Survey

A follow-up survey of all undergraduate respondents to the 2003 NSF program survey is planned for 2005. This survey will focus on tracking near-term outcomes of the students' 2002-2003 research experiences and will compare these outcomes with expectations that they reported in the 2003 survey. To facilitate comparisons, many of the survey questions are identical across the four surveys.

STEM GRADUATES SURVEY: STUDY METHODS

Sample Design and Data Collection

From a sampling perspective, the objective of this survey was to obtain a nationally representative sample of individuals who had received a bachelor's degree in a STEM field within the last 15 years. Because it would have been prohibitively expensive to obtain such a sample "from scratch" (for example, using random digit dialing techniques to contact households and then screening for the desired subset of individuals), SRI subcontracted with NFO WorldGroup—now TNS NFO—(NFO) to provide the sample and do the data collection.

The NFO Interactive Panel comprises 3.6 million individuals in 1.2 million U.S. households. Panel members are recruited through random gathering of e-mail addresses. When individuals join the panel, they provide complete demographic information about themselves and their households, thereby providing the basis for selecting population subsets for subsequent surveys. (For more information about NFO, go to http://www.tns-global.com.)

The starting sample for this survey was adults ages 22 to 35 with a bachelor's degree or higher. Both age and educational attainment are pre-identified demographics in NFO's Interactive Panel. To ensure that the sample was representative, the sample was balanced to U.S. Census profiles for adults of the specified age and education on the following demographics: geographic location, market size, age, household income, household size and race. Hispanics/Latinos and blacks were oversampled to obtain sufficient numbers of respondents for analyses.[5] NFO sent survey participation requests to a total of 23,950 individuals; of these,

[5] NSF also considers persons with disabilities to be an underrepresented group, the inclusion of which is encouraged in all NSF-supported activities. Disability status was not included in this survey because previous SRI surveys have found that self-reports of disabilities are unreliable.

9,622 (40%) logged into the survey. These individuals were then screened to confirm that they met the age and education requirements. STEM graduates were identified as those who indicated that they had received their bachelor's degree in a STEM field,[6] excluding social sciences.[7] Only those who met all eligibility criteria completed the remainder of the questionnaire and are included in the final data file.

Data Cleaning and Weighting

NFO sent a total of 3,669 completed questionnaires to SRI. Of these 3,669 respondents, 259 indicated that they had completed their bachelor's at a non-U.S. institution and were deleted from the file, leaving a total of 3,410 respondents.

The demographic profiles of survey respondents were compared with NFO population estimates with regard to sex, race/ethnicity, household income, household size and composition, and geographic region. The comparisons showed that the only variable on which there were differences of at least five percentage points between groups was household income. (Households with incomes of $60,000 to $89,999 represented 35% of respondents and 27% of the population.) Also, Hispanics/Latinos represented 7.6% of respondents vs. 5.5% of the population, a small difference in terms of percentage points but quite large proportionally. To adjust for these differences, the responses were weighted by household income and ethnicity (Hispanic vs. non-Hispanic) to parallel Census data.

Survey responses also were weighted by academic major, separately for men and women, to correspond with Department of Education (ED) statistics for the 2000-2001 academic year.[8] Two groups of majors were dealt with as special cases: One of these was interdisciplinary majors, a category not included in the ED tables. This category was treated as self-weighting. The other special case was STEM education majors. ED data indicated that fewer than 1% of STEM graduates had this major, but it was reported by almost 5% of respondents (n = 156). We suspected that some of these individuals misunderstood this category. Accordingly, conservatively, we coded as "STEM education majors" only those who selected STEM education as a major and indicated that they were currently employed in education (n = 64). The academic major of the other 92 respondents who selected STEM education was coded as unknown.

In addition, 146 respondents who indicated that they had engaged in some form of "hands-on" undergraduate research (question 16)[9] were recoded as not having done research. Specifically, after reviewing their responses, we recoded the following groups of individuals into the no-research category:

- 79 respondents who reported that they had done none of the 15 research-related activities listed in question 30.
- 17 respondents who reported that of the listed activities in question 30 they had done only "little or nothing that seemed to me like real research."

[6] See question 4 in the questionnaire (Appendix A) for a full list of included fields.
[7] An analogous survey of graduates in the social, behavioral, and economic sciences was conducted in 2004.
[8] U.S. Department of Education, National Center for Education Statistics, Integrated Postsecondary Education Data System, "Completions" survey (NCES IPEDS). See http://nces.ed.gov/programs/digest/
[9] See Appendix A for the wording of question 16 and its response categories.

- 50 respondents who reported that their only research fell into the “other” category on question 16 and whose activities as described did not appear to be research (lab courses, working as a lab technician, data entry, student teaching, etc.).

REPORT ORGANIZATION

The remainder of this report is organized in a generally chronological sequence, starting with profiles of STEM graduates and undergraduate research participants and then moving from their motivations to participate in undergraduate research to the research activities to perceptions of effects of the experiences (what has been learned/gained, interest in various careers) to academic degree expectations and attainment. Appendix A is the survey questionnaire, and Appendix B comprises survey responses broken out by major study variables. Study recommendations will be included in a subsequent report that summarizes the findings of all project activities.

A note on the reporting of group differences: All group differences reported here are statistically significant at the .05 level. (That is, the odds are less than 5 in 100 that the difference occurred only by chance.)

II. PROFILE OF STEM GRADUATES

This chapter provides a broad description of the demographic and academic characteristics of individuals ages 22 to 35 who received bachelor's degrees in a so-called "hard" science, technology, engineering, or mathematics field. The survey data presented here are based on information provided by a total of 3,410 respondents.

ACADEMIC CHARACTERISTICS

Academic Major

A respondent's inclusion in the study as a STEM major was based on his/her selection of one or more of 11 categories of STEM majors (Table II-1).[10] By far the largest area within STEM was life sciences, including biology and pre-medicine and other health sciences, which comprised 41% of all STEM majors. The next largest was engineering, with 21% of STEM graduates.

Table II-1
STEM Academic Majors

	Number of respondents	Weighted Percentage
Biological/Life sciences	472	20
Chemistry	86	3
Computer science	557	12
Engineering	582	21
Environmental sciences	135	1
Health/Medical sciences	574	21
Interdisciplinary sciences	525	14
Mathematical sciences	268	3
Physical sciences	55	1
STEM education	64	2
Unknown	92	3
TOTAL	3410	101

Notes: Percentages were weighted to parallel the 2000-2001 distribution of graduates across STEM majors as reported by the U.S. Department of Education National Center for Education Statistics, Integrated Postsecondary Education Data System (NCES IPEDS),"Completions" survey. The interdisciplinary category is not included in the NCES IPEDS tables; respondents in this category have a weight of 1.

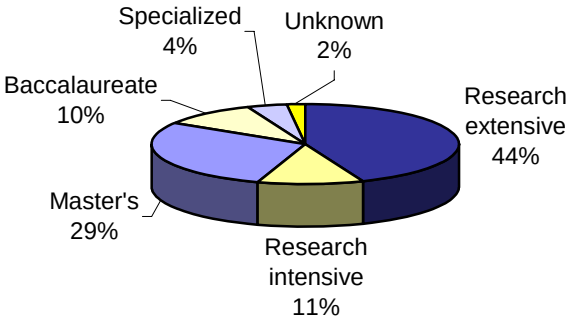
Percentages sum to more than 100 because of rounding

Sources: SRI International STEM graduates survey, 2003; NCES IPEDS

[10] See the survey questionnaire (Appendix A) for a detailed list of the academic majors. For analysis purposes, respondents who selected more than one category were assigned to the "interdisciplinary sciences" category, so that all categories were mutually exclusive. Except for interdisciplinary STEM majors, the categories were weighted to parallel U.S. Department of Education (ED) statistics. There are no interdisciplinary majors in ED statistics (each graduate is required to have a single primary major), so interdisciplinary majors in the survey were treated as self-weighting (that is, they were given a weight of 1.0).

Type of School

Figure II-1
Distribution of STEM Graduates, by Carnegie Classification of Their Alma Mater

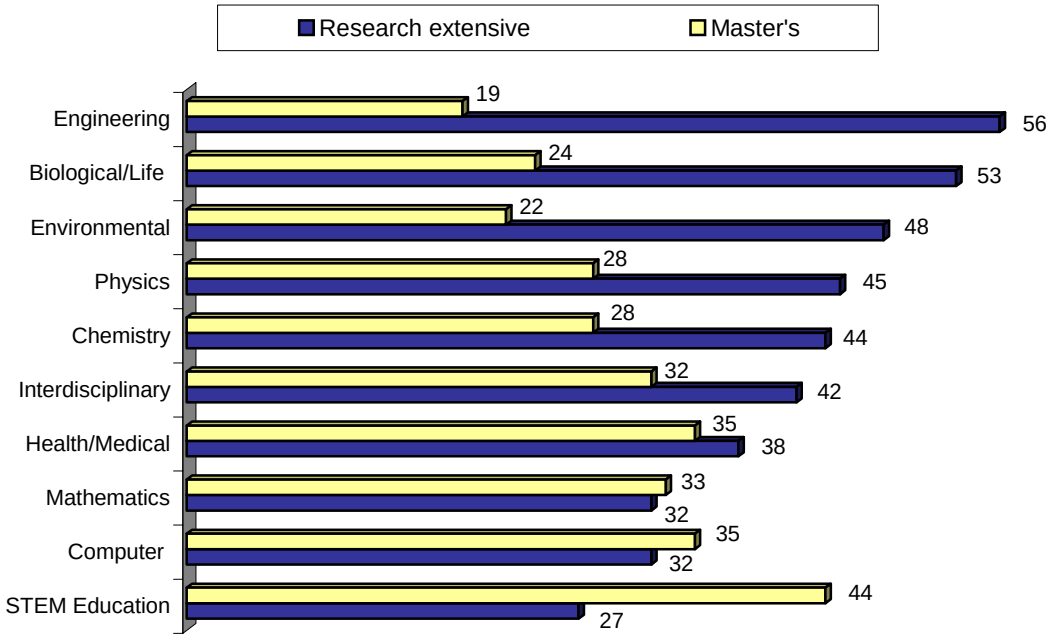


Source: SRI International STEM graduates survey, 2003.

Slightly over half (55%) of STEM graduates received their bachelor's degree from a research university—44% from an institution categorized by the Carnegie classification as research extensive and 11% from a research intensive institution; another 29% graduated from a master's institution (Figure II-1).

The percentages in each academic major who graduated from the two largest categories of institutions—research extensive and master's—are shown in Figure II-2. Engineering and biological/life sciences majors were the most likely to have graduated from a research extensive institution; those who majored in computer science, health/medical science, mathematics, or STEM education were the most likely to have graduated from a master's institution.

Figure II-2
Percentage of Graduates Who Received Their Bachelor's Degree From a Research Extensive or Master's Institution, by Academic Major



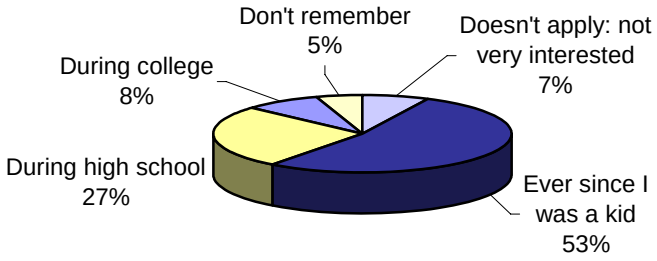
Source: SRI International STEM graduates survey, 2003.

Attendance at a 2-Year College

About one in six STEM graduates (17%) reported having started their undergraduate education at a 2-year college. Students who graduated from master's or research intensive institutions were more likely than average to have done so (24% and 20%, respectively); those who graduated from research extensive and baccalaureate institutions were least likely to have done so (13% and 11%). Across academic majors, those in computer, environmental, and health/medical sciences were the most likely to have gone to a 2-year college (20% to 22% did so); those in engineering, biological/life sciences, and chemistry were the least likely to have done so (10% to 14%). Among racial/ethnic groups, Hispanics/Latinos had the highest blacks 2-year college attendance rate (29%); Asians and blacks had the lowest (9% and 12% respectively). There were no appreciable differences between men and women on this item.

Origins of Interest in STEM

Figure II-3
When STEM Graduates Became Interested in STEM



Source: SRI International STEM graduates survey, 2003.

About half of STEM majors said that they became interested in STEM when they were kids; 26% became interested when they were in high school, and only 8% became interested in college (Figure II-3). There were not very large differences among the racial/ethnic groups on this measure, but men were more likely than women to have been STEM fans since childhood (59% vs. 47%, respectively). Among the academic majors, those in physics were particularly likely to have early STEM fans (73%), whereas those in health/medical science and STEM education were the least likely (44% and 41%, respectively).

DEMOGRAPHIC CHARACTERISTICS

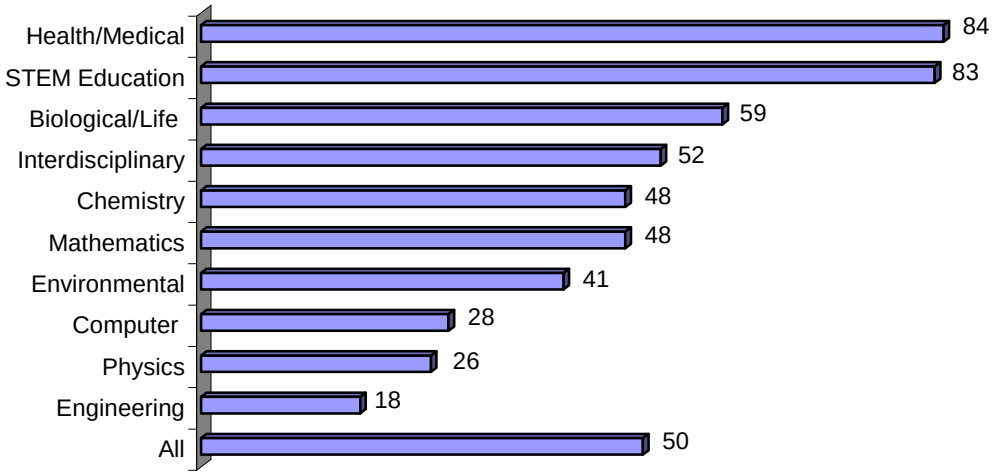
Sex and race/ethnicity

Women and men were equally represented in STEM fields as a whole, but their percentages varied hugely across the various academic majors within STEM. Women dominated STEM education and health/medical majors, comprising 83% and 84% of all those who majored in these fields, but were relatively uncommon in engineering (18%), physics (26%), and computer sciences (28%) (Figure II-4).

Minority groups that traditionally have been underrepresented in STEM fields (American Indians, blacks, and Hispanics/Latinos) continued to be underrepresented among STEM graduates. For example, blacks and Hispanics/Latinos each comprised 12% of the 2002 U.S. population,[11] compared to 9% and 6%, respectively, of recent STEM graduates. Conversely,

[11] At http://www.ameristat.org

Figure II-4
Percentages of STEM Graduates Who Were Women, by Academic Major



Source: SRI International STEM graduates survey, 2003.

non-Hispanic whites and Asians/Pacific Islanders were overrepresented; they comprised 69% and 4%, respectively, of the 2000 U.S. population, compared to 77% and 6%, respectively of recent STEM graduates. Underrepresented minorities had the strongest presence in interdisciplinary STEM majors (20%) and computer sciences (18%), and they were least likely to be found in the environmental sciences (8%).

Household Income

STEM graduates' income levels reflected the typical income advantage that college graduates have over those who have not gone to college. The median income across all U.S. households in 2002, as reported by the U.S. Census Bureau, was $42,400.[12] In contrast, about 6 in 10 respondents had annual household incomes of $60,000 or more, and a third had household incomes of $90,000 or more. Graduates most likely to have household incomes of $90,000 or more were those in health/medical sciences (37%), engineering (35%), and mathematics (35%). Least likely to have incomes of this level were graduates in environmental sciences (20%) and, especially, those in STEM education (11%).

Employment Status and Type of Employer

Eighty-six percent of graduates reported that they were employed either full-time (76%) or part-time (10%), and 10% were still in school. Among those who were employed, by far the largest group (60%) reported that they were employed by a for-profit company. Eleven percent were employed by a non-profit company, 10% by a college or university, and 8% each by an elementary/secondary school or the government (excluding military).

[12] DeNavas-Walt, Carmen, *et al*., U.S. Census Bureau, Current Population Reports, P60-221, *Income in the United States: 2002*. U.S. Government Printing Office, Washington, DC, 2003.

OVERVIEW OF STEM GRADUATES

Among Americans ages 22 to 35 who had received bachelor's degrees in a STEM field, a plurality had received their degree from a research extensive institution. By far the most common STEM majors were the life sciences, including biology, pre-medicine, and other health sciences. Most of the respondents said that they had been interested in STEM since childhood. STEM graduates were equally divided between men and women, but women dominated STEM education and health/medical majors, whereas men dominated the fields of engineering, physics, and computer sciences. Overall, Blacks and Hispanics/Latinos were underrepresented, relative to their representation among the U.S. population as a whole.

III. PARTICIPATION IN UNDERGRADUATE RESEARCH

This chapter describes who participated in undergraduate research, when they did so, and whether any of their research was sponsored by NSF, NASA, or NIH.

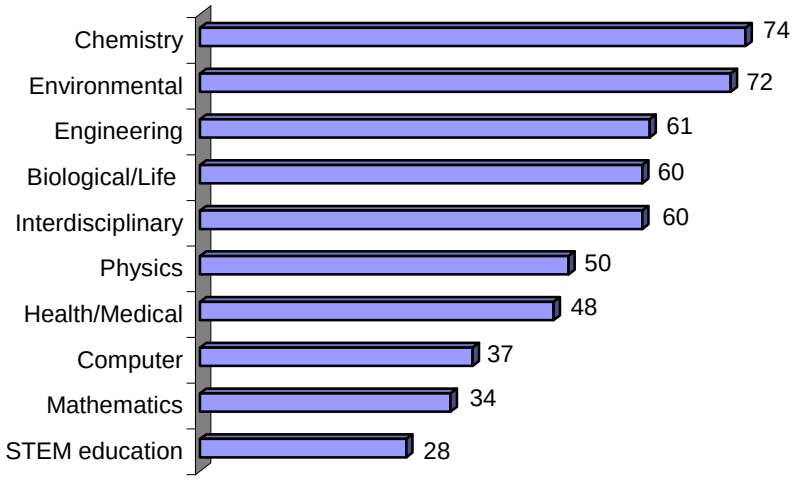
RESEARCH PARTICIPATION RATES

Overall, 53% of 22- to 35-year-old STEM graduates reported that they participated in hands-on research activities as undergraduates or in high school. Two percent did research in high school but not as undergraduates.

We reviewed differences in research participation rates by academic major, type of school, whether the respondent started at a 2-year college, year of graduation, participation in high school math/science fairs, when the respondent first became interested in STEM, and the respondent's sex and race/ethnicity. Findings are summarized below.

The dimension that showed the largest differences in participation rates was academic major (Figure III-1). Rates ranged from a high of about three in four of those who majored in environmental sciences and chemistry to a low of about one in four of those who majored in STEM education. Other majors with relatively low research participation were computer sciences and mathematics—fields in which research activities tend to be atypical.

Figure III-1
Percentage of STEM Graduates Who Participated in Undergraduate Research, by Academic Major



Source: SRI International STEM graduates survey, 2003.

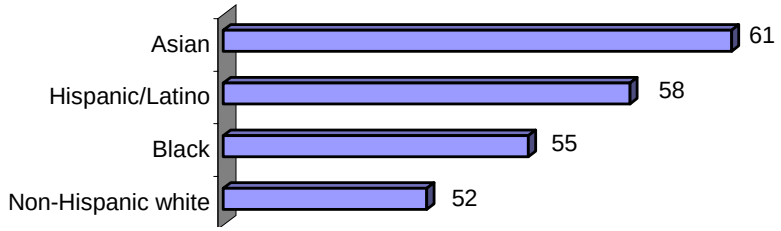
Research participation rates by type of school ranged from 46% of those at specialized schools to 57% of those at research extensive universities and baccalaureate colleges. Individuals who began their college careers at 2-year schools were only slightly less likely than those who did not to have done research (49% vs. 54%).

Consistent with the gradual increase in undergraduate research opportunities, those who graduated more recently were somewhat more likely to participate in research than those who graduated longer ago, increasing from 48% of those who graduated between 1988 and 1992 to 56% of those who graduated since 1998.

Many people believe that the most effective time to interest students in STEM is when they are young. Reinforcing this belief is the finding that students who participated in high school

math/science fairs were considerably more likely than those who did not to participate in undergraduate research (67% vs. 47%, respectively). However, graduates who had been interested in STEM since childhood were only marginally more likely than those who became interested later in life to participate in research (58% vs. 53%).

Figure III-2
Percentage of STEM Graduates Who Participated in Undergraduate Research, by Race/Ethnicity



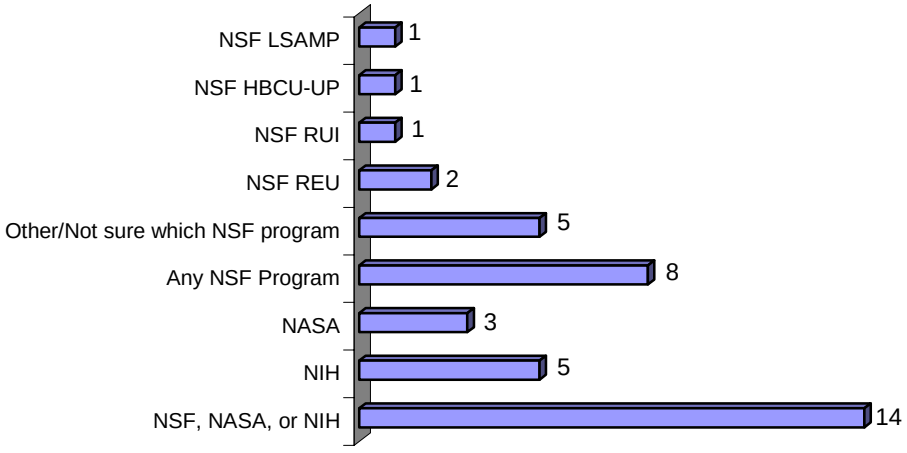
Source: SRI International STEM graduates survey, 2003.

Among the racial/ethnic groups, research participation rates ranged from 61% of Asians to 52% of non-Hispanic whites (Figure III-2). Men were only slightly more likely than women (55% vs. 52%) to have participated in research.

RESEARCH SPONSORSHIP

Many STEM graduates who participated in undergraduate research were unaware of who sponsored it. Asked if NSF, NASA, or NIH sponsored any of their research, about half (47%) said they had no idea. Another 39% said no, and 14% answered in the affirmative. See Figure III-3 for breakdowns by sponsor.

Figure III-3
Percentage of Undergraduate STEM Researchers Who Reported That They Were Sponsored by Listed Agency/Program



Source: SRI International STEM graduates survey, 2003.

Underrepresented minorities were more likely than others to report having participated in sponsored research (that is, sponsored by NSF, NIH, or NASA) (21% vs. 13%). Among the academic majors, those in chemistry (30%), interdisciplinary sciences (19%), and biology/life sciences (17%) were the most likely to report at least some sponsored research.

OVERVIEW OF RESEARCH PARTICIPATION

Overall, about half of STEM majors participated in undergraduate research. The highest participation rates were among chemistry and environmental sciences majors; the lowest were among STEM education majors. Graduates who had participated in high school math/science fairs and those who had been interested in STEM ever since they were kids had higher participation rates than their counterparts. Participation rates increased slightly over the 15-year period covered by the survey. There were small differences among racial/ethnic groups and by type of school and even smaller differences between men and women. Of those who participated in research, 14% reported that at least some of their research was sponsored by NSF, NIH, or NASA. Underrepresented minorities were especially likely to have participated in sponsored research.

IV. REASONS FOR PARTICIPATING OR NOT PARTICIPATING IN UNDERGRADUATE RESEARCH

REASONS FOR PARTICIPATING IN UNDERGRADUATE RESEARCH ACTIVITIES

Respondents who participated in research were asked to rate the importance of each of nine potential reasons for doing so. They used a four-point scale where 1 = not important, 2 = somewhat important, 3 = fairly important, and 4 = extremely important. As shown in Table IV-I, the ratings reflected diverse motivations for research participation, ranging from a desire for fun to being required to participate. The top three reasons overall (based on mean ratings) were "I wanted hands-on experiences to reinforce what I learned in class," "I thought it would be fun," and "I thought it would help me get into graduate/medical school or get a job."

Table IV-1

STEM Researchers' Motivations for Participating in Research (Listed in descending order of mean rating)

Number of respondents: 1786

	Mean	Doesn't Apply/Not Important	Somewhat Important	Fairly Important	Extremely Important
I wanted hands-on experiences to reinforce what I learned in class.	3.09	9%	17%	29%	45%
I thought it would be fun.	2.93	9	21	38	32
I thought it would help me get into graduate/medical school or get a job.	2.67	23	19	26	32
I wanted to learn more about what it's like to be a researcher.	2.49	24	25	29	22
Doing research was more appealing than other kinds of jobs.	2.46	31	18	24	27
I needed/wanted the academic credit I could get from doing research.	2.42	31	20	26	23
I wanted to know if going to grad school in science, math, or engineering was for me.	2.38	31	21	27	21
I wanted to know if science, math, or engineering was for me.	2.31	32	23	25	19
I needed to fulfill my school's/my scholarship's requirements for research.	2.07	49	15	17	19

This table shows, for example, that 9% of STEM graduates who participated in undergraduate research reported that "I wanted hands-on experiences to reinforce what I learned in class" was not important or did not apply to them as a reason for participating in research.

Note: Mean is calculated on a 4-point scale where 1 = not at all important/doesn't apply, 2 = somewhat important, 3 = fairly important, and 4 = extremely important.

Source: SRI International STEM graduates survey, 2003.

Factor analyses of the items were conducted to facilitate analyses of the relationships between types of motivations and other study variables[13]. The analyses showed that seven of the nine items clustered into one of three types of motivations. The items in each cluster were combined in indices, which we have termed "help with a career/academic decision," "personal interest," and "meet requirements." The items comprising each index are as follows:

Help with a career/academic decision

I wanted to know if science or 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 grad school in science or engineering was for me.

Personal interest

I wanted hands-on experiences to reinforce what I learned in class.

I thought it would be fun.

Meet requirements

I needed to fulfill my school's/my scholarship's requirements for research.

I needed/wanted the academic credit I could get from doing research.

For each index, we grouped respondents into four approximately equally sized categories on the basis of their mean rating on items in that index.[14] These categories then were cross-tabulated by a number of respondent characteristics.

There were few appreciable differences between men and women and only small differences among the racial/ethnic groups (Hispanics/Latinos and Asians tended to find the various motivations more important than did blacks or non-Hispanic whites). However, there were quite large differences between those who participated in NSF/NASA/NIH-sponsored research ("sponsored researchers") and those who did not (or were not aware that they did). This was especially true regarding the "help with decisions" index, on which 47% of the sponsored researchers were in the top quartile, compared with only 18% of the non-sponsored researchers. Sponsored researchers also were more likely than their non-sponsored counterparts to rate "personal interest" as important (54% vs. 42% in the top half), but they were less likely to rate "meet requirements" as important (37% vs. 47% in the top half).

There also were sizable differences among the academic-major groups, especially with regard to help with decisions. On this index, the percentage of respondents in the top quartile ranged from 14% of engineering majors to 43% of chemistry majors. The three majors with higher than average percentages of respondents in the top quartile (chemistry, biology/life sciences, and interdisciplinary majors) were the same three that had relatively high percentages of sponsored researchers.

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[13] 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 answer other items in that group as "extremely important."

[14] For each index, we attempted to divide the scores into quartiles, based on all respondents combined. Because many students had the same scores, however, this was not possible. For each of the indices discussed here, the top group comprised the following percentage of respondents: "help with decisions," 22% (ratings of 3.5 to 4.0); "personal interest," 23% (ratings of 4.0); and "meet requirements," 19% (ratings of 3.1 to 4.0).

REASONS FOR NOT PARTICIPATING IN UNDERGRADUATE RESEARCH ACTIVITIES

Respondents who indicated that they had not participated in research were asked, "Which of the following help to describe why you did not participate in any hands-on research activities when you were in high school or a college undergraduate?" The response options are listed below, in descending order of the percentages of respondents who selected them.

(1) I was not interested in doing research 37%
(2) I didn't have time 37
(3) I was not aware that research opportunities were available to me 28
(4) It never occurred to me to do research 19
(5) It didn't pay well enough (or at all) 13
(6) The research opportunities that were available to me weren't interesting 11
(7) Faculty did not conduct research at the school I attended 9
(8) My grades were not good enough 3
(9) I applied/asked about doing research but was turned down 2
(10) Other reasons 1

Overall, it was much more common for students to *choose* not to participate in research than to be *unable* to participate (that is, unable either because research opportunities were not available or because the respondent was turned down): 80% of respondents selected one or more of the "choice" options (options 1,2,4,5,6), and 39% selected one or more of the "unable" options (options 3,7,8,9). Of the "choice" options, the percentage who selected "it never occurred to me" decreased over time: 24% of those who graduated between 1988 and 1992, 21% of those who graduated between 1993 and 1997, and 15% of those who graduated between 1998 and 2003.

Among racial/ethnic groups, Asians and Hispanics/Latinos were less likely than blacks or non-Hispanic whites to report that they didn't have time for research (22% and 28% of Asians and Hispanics/Latinos, respectively, vs. 36% to 38% of blacks and non-Hispanic whites), and Asians were more likely than others to report that it never occurred to them to do research (31% vs. 18% to 22%). Among academic majors, those in mathematics were the most likely to say that research never occurred to them (31% vs. 19% overall). There were only small differences between men and women in their reasons for not participating in research.

OVERVIEW OF REASONS FOR PARTICIPATING OR NOT

The most highly rated reasons for participating in undergraduate research reflected both personal interest in research and a need to meet academic requirements. Sponsored researchers stood out as being considerably more likely than their non-sponsored counterparts to use research to help them make career and academic decisions. Among STEM graduates who did not participate in research, *choosing* not to participate (for example, because "I didn't have time" or "I wasn't interested) was much more common than being unable to participate (for example, because of the unavailability of research opportunities).

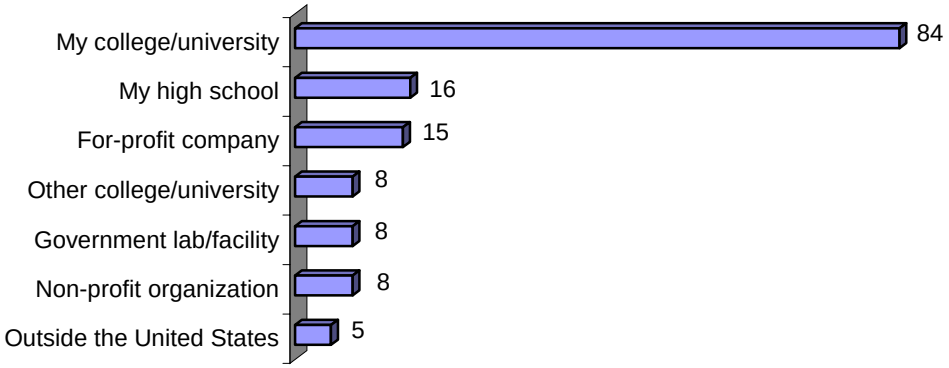
V. CHARACTERISTICS AND ACTIVITIES OF UNDERGRADUATE RESEARCH EXPERIENCES

In this chapter we describe the characteristics of undergraduate research experiences and the activities that comprised those experiences. The relationships between these activities/characteristics and research experience effects are discussed in Chapter VI.

LOCATION OF RESEARCH ACTIVITIES

Among those who participated in research, the vast majority (84%) did so at their own college or university; the next most common locations were the respondent's high school (16%) and a for-profit company (15%); only 8% participated in research at some other college/ university (Figure V-1).

Figure V-1
Percentage of STEM Graduates Who Participated in Undergraduate Research at Each Specified Location



Source: SRI International STEM graduates survey, 2003.

Not surprisingly given the predominance of research at one's own school, students whose school provided undergraduate research opportunities were much more likely to have participated in research than those at schools where there were no such opportunities (70% vs. 33%).

Notable group differences in research locations included the following:

- Computer sciences and engineering majors were the most likely to have done research at a for-profit company (26% and 29%, respectively, vs. 15% overall).
- Reflecting the preponderance of men in computer sciences and engineering, men were twice as likely as women to have done research at a for-profit company (20% vs. 10%, respectively.)
- Underrepresented minorities were more likely than others to have done research at another college/university (12% vs. 7%) or at a government facility (13% vs. 7%). It seems likely that research at both these kinds of locations was sponsored by federal

programs, in which case the racial-group differences here reflect the encouragement that many federal programs give to providing research opportunities for underrepresented minorities.

- Graduates with interdisciplinary majors were the most likely to have participated in research outside the United States (9% did so, vs. 5% overall).

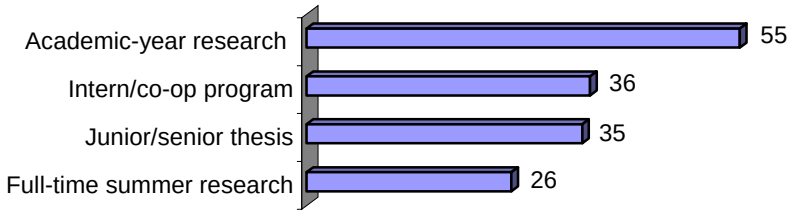
TYPES OF RESEARCH EXPERIENCES

Respondents were asked, "Which kinds of hands-on research activities (if any) did you participate in with a teacher, professor, or researcher, either during high school or while you were an undergraduate in college?" They selected from the following response options:

- Hands-on research with a professor during one or more academic terms, while attending classes.
- Intern or co-op program that involved hands-on research as its main component. Usually, a company or other organization pays you for working on a research project at their site. Sometimes you receive academic credit at your school for this research. May happen any time of year.
- A junior or senior thesis that involves hands-on research (other than library research) as its main component.
- Summer research, other than intern or co-op program. A full-time hands-on research project for the summer with a professor or researcher.
- Other kinds of hands-on research experiences with a teacher, professor, or researcher, in high school or as an undergraduate in college.

The most common type of undergraduate research was working with a professor or researcher during the academic year, reported by 29% of STEM graduates (Figure V-2). Intern/co-op programs and thesis work in which research was the main component each were reported by 19% of graduates, and summer programs were reported by 14%.

Figure V-2
Percentages of STEM Researchers Who Participated in Each Listed Type of Undergraduate Research



Source: SRI International STEM graduates survey, 2003.

Summer research was far more common among sponsored than non-sponsored researchers (60% vs. 21%, respectively). Academic-year research also was more common among sponsored researchers than their non-sponsored counterparts, but the difference was not nearly as large (71% vs. 53%).

Among the racial/ethnic groups, non-Hispanic whites were less likely than others to have participated in summer research (12% of non-Hispanic whites vs. 20% to 24% of Asians, blacks, and Hispanics/Latinos). There were no appreciable differences between men and women in their participation rates in the various types of research experiences.

DURATION OF RESEARCH EXPERIENCES

Among those who engaged in each type of research, graduates reported spending an average of 9.0 months on academic-year research, 6.8 months on thesis research, 8.9 months in research-related intern/co-op programs, and 4.7 months on summer research. Overall, the average number of months of research was 11.8.[15]

The dimensions that showed the largest differences in research duration were research sponsorship and academic major. Sponsored researchers reported an average of 20 months of research experience, compared to 10 months for non-sponsored researchers. Among academic majors, research experience duration ranged from a high of 19 months among chemistry majors to a low of 8 months among mathematics majors. Research duration differences among racial/ethnic groups and types of schools were quite small, and there were no statistically reliable differences on this measure between men and women or by year of degree.

RESEARCH ACTIVITIES

The questionnaire asked whether respondents did each of the following as part of any of their research experiences:

Had a choice of projects to work on

Had primary responsibility for designing the project that they worked on

Provided input to designing their project (someone else had primary responsibility)

Wrote a proposal describing the research they planned to do

Collected and/or analyzed data or information to try to answer a research question

Had input to or responsibility for decisions about what to do next

Had input to or responsibility for decisions about research techniques/materials

Gained increasing independence over the course of the research

Was able to complete their project

Understood how their work contributed to the "bigger picture" of research in that field

Went on research-related field trip(s) (to other labs, etc.)

Attended student conference(s) that included students from other colleges

Attended professional conference(s) (conferences not specifically for students)

Prepared a poster presentation describing their research and results

Prepared a final written research report describing their research and results

Delivered an oral presentation describing their research and results

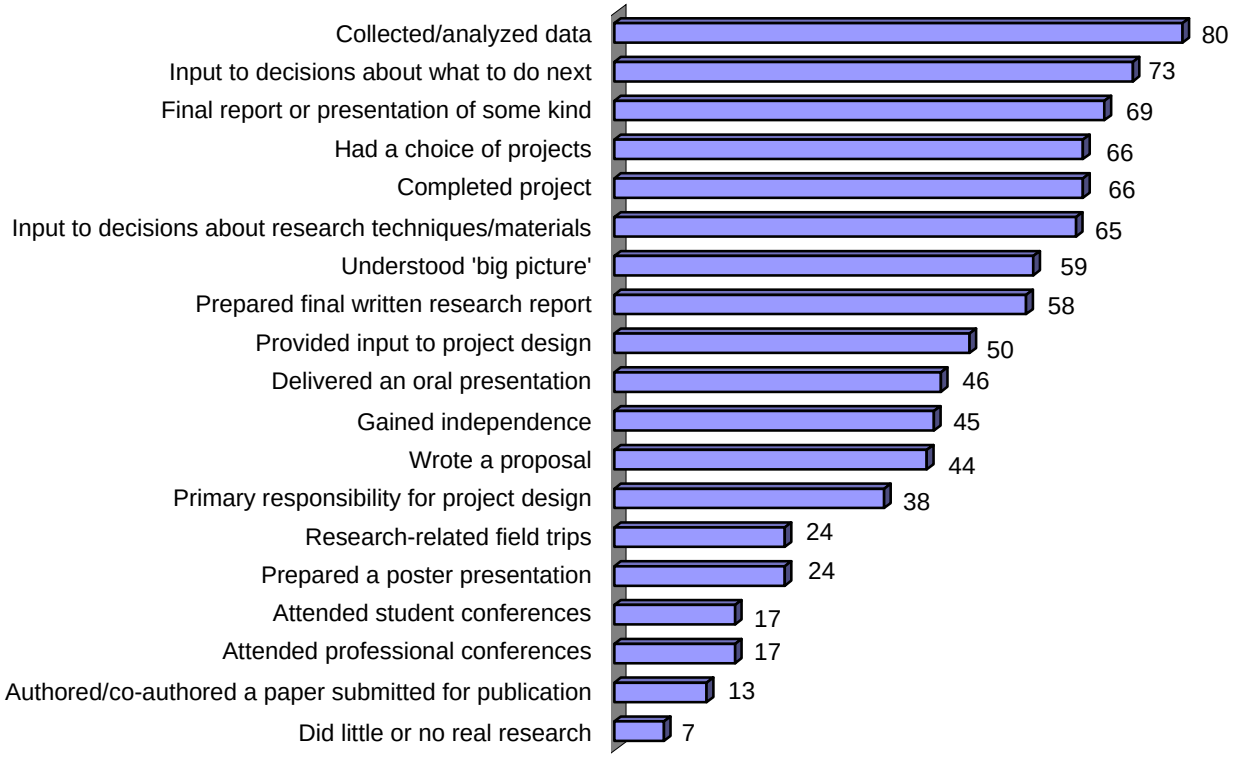
Authored or co-authored a paper that was submitted for publication in a professional journal.

Did little or nothing that seemed to be real research

[15] Note that this is a very crude measure of the amount of research conducted, because there was undoubtedly considerable variation in the hours spent on research over the duration of the research experience.

The percentages who reported doing each are shown in Figure V-3. Of the 17 activities/ experiences listed (excluding "did little or nothing that seemed to be real research"), undergraduate researchers participated in an average of 7.7. Only 7% felt that they did little or nothing that seemed to be real research.

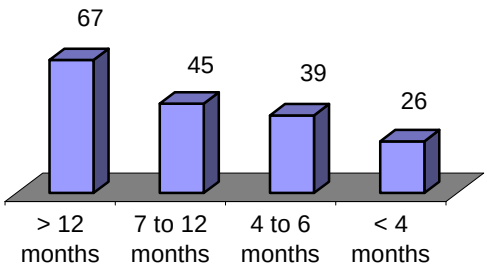
Figure V-3
Percentage of STEM Researchers Who Reported Engaging in Each Listed Undergraduate Research Activity



Source: SRI International STEM graduates survey, 2003.

Not surprisingly, the longer a student participated in research, the greater the likelihood that s/he had any given research experience. For example, the percentages of respondents who reported that they gained increasing independence over the course of their research ranged from 26% of those with less than 4 months of experience to 67% of those with more than 12 months experience (Figure V-4). Longer research duration was correspondingly associated with participation in a greater number of different activities. Thus, those who participated in research for less than 4 months averaged 6.2 activities, whereas those who participated for more than 12 months averaged 9.4 activities.

Figure V-4
Percentage of STEM Researchers Who Gained Increasing Independence, by Duration of Undergraduate Research



Source: SRI International STEM graduates survey, 2003.

There also were substantial differences between sponsored and non-sponsored researchers: sponsored researchers engaged in an average of 9.4 activities, whereas non-sponsored researches engaged in an average of 7.4. These differences mostly—but not entirely—reflected the fact that the average duration of sponsored researchers' experiences was twice as long as that of non-sponsored researchers (20 months vs. 10 months). When we compared sponsored researchers with the group of non-sponsored students who had more than 12 months research experience ("high-experience non-sponsored researchers"), we found that the differences narrowed. The two groups' participation rates were statistically reliably different for only 5 of the 16 activities, and the mean number of research activities was only slightly higher for sponsored researchers than the high-experience non-sponsored group (9.4 vs. 8.8).

The sponsored- vs. non-sponsored-research differences were reflected in differences among racial/ethic groups: relative to non-minorities, higher percentages of underrepresented minorities (who were more likely than others to be sponsored researchers) engaged in most of the activities done by relatively high percentages of sponsored researchers, such as field-trips, conferences, poster presentations and oral presentations.

There were interesting differences in research experiences across types of schools. Students at research-extensive universities were less likely than average to have been involved in 11 of the 16 types of activities listed. In contrast, students at baccalaureate colleges were more likely than average to have been involved in 9 of the 16 activities, and they were not lower than average on any activities. Overall, these findings seem to support the argument made by faculty and administrators at baccalaureate colleges that they are able to provide a richer, more meaningful research experience than is available at the big research universities.

Table V-1 shows the percentage who participated in each activity, by academic major. Graduates in interdisciplinary fields were more likely than average to have been involved in 14 of the 16 activities. At the other end of the distribution, graduates in environmental fields were less likely than average to have been involved in 11 of the activities.

There were relatively few appreciable differences between the research activities of men and women, but those that existed supported traditional stereotypes: women were more likely than men to report that their mentor made the decisions about what techniques/materials were used (41% vs. 29%) and about what to do next (33% vs. 22%), and they were less likely to report that they had primary responsibility for project design (33% vs. 42%).

ACADEMIC CREDIT AND PAY FOR UNDERGRADUATE RESEARCH

Overall, 70% of STEM graduates reported that they received academic credit for at least some of their undergraduate research activities and 41% reported that they received pay for at least some of their research. Sponsored researchers were only somewhat more likely than their non-sponsored counterparts to have received credit (76% vs. 69%), but they were much more likely to have received pay (70% vs. 37%). Non-Hispanic whites were slightly less likely than others to have received either academic credit or pay; there were no appreciable differences between men and women on either item.

Table V-1

Undergraduate Research Activities and Experiences, by Academic Major: Percentage Who Did Each (Listed in descending order of the "All" column)

	Computer Science	Environmental Sciences	Engineering	Health/Medical Sciences	Biological/ Life Sciences	Mathematics	Chemistry	Interdisciplinary Sciences	All
Number of respondents	*205*	*98*	*358*	*278*	*288*	*91*	*64*	*324*	*1788*
Collected/analyzed data	66*	82**	78	82	86**	72*	94**	80	80
Input to decisions re: what to do next	81**	69*	82**	61*	62*	77	81	78**	73
Had a choice of projects	64	65	65	67	64	58*	65	74**	66
Completed project	73**	70**	74**	64	53*	71	63	70**	66
Input to decisions re: what research techniques/materials were used	78**	56*	73**	56*	52*	70	76**	71**	65
Understood "big picture"	49*	58	53*	60	67**	49*	67	60	59
Prepared final written research report	53*	51*	64**	58	52*	60	59	65**	58
Provided input to project design	54	37*	57**	37*	48	39*	49	57**	50
Delivered an oral presentation	44	36*	53**	43	34*	45	58**	54**	46
Gained independence	39*	34*	40*	39*	53**	40	64**	49**	45
Wrote a proposal	43	41*	51**	42	36*	43	42	47	44
Primary responsibility for project design	47**	34*	48**	33*	24*	36	34	42**	38
Research-related field trips	17*	43**	24	17*	27	15*	23	30**	24
Prepared a poster presentation	17*	22*	19*	25	24	25	34	34**	24
Attended student conferences	14	13*	14*	13*	17	15	18	26**	17
Attended professional conferences	13*	21**	15	15	16	13*	17	27**	17
Authored a paper submitted for publication	6*	10*	10*	9*	14	10	27**	19**	13
Did little or no real research	11**	3*	7	6	6	11**	7	10**	7

This table shows, for example, that 66% of computer science majors who participated in research reported that they collected/analyzed data as part of their undergraduate research experiences.

Note: The "All" column includes respondents with unknown major and those in physics and STEM education. Results for physics and STEM education majors are not shown because there were too few respondents (n = 27 and 18, respectively).

*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 ($p < .05$).

Source: SRI International STEM graduates survey, 2003.

RELATION BETWEEN RESEARCH AND COURSEWORK

Almost all STEM graduates reported that most of their research was in the same academic field as their major (89%) and at least somewhat related to the courses they took in their major (93%—53% "closely related," 40% "somewhat related.") There were no appreciable differences on either item among the racial/ethnic groups or between men and women. Not surprisingly, graduates in mathematics were less likely than others to have participated in research that was related to their coursework.

OVERVIEW OF UNDERGRADUATE RESEARCH CHARACTERISTICS AND ACTIVITIES

The vast majority of undergraduate research was done at one's own school, was in the same field as one's major, and was at least somewhat related to one's coursework. Seven in 10 researchers received academic credit for at least some of their research, but only 4 in 10 received pay for any of it. Research was most commonly conducted with a professor or researcher during the academic year. Overall, only about a fourth of researchers participated in summer programs, but 60% of sponsored researchers did so. On average, STEM researchers spent a total of almost 12 months doing research. Eight in 10 STEM researchers collected/analyzed data to try to answer a research question, most prepared some kind of final report or presentation, and most had at least some input to project decisions.

VI. PARTICIPANTS' PERCEPTIONS OF UNDERGRADUATE RESEARCH

Effects of undergraduate research assessed in this survey were based on self-reports of the respondents. The kinds of effects covered included gains students believed that they had made on various dimensions as a result of their undergraduate research experiences, perceived effects of research on respondents' career decisions, and increased or decreased interest in several related career areas.

PERCEPTIONS OF GAINS IN UNDERSTANDING, CONFIDENCE, AND AWARENESS

Respondents were asked to rate the extent to which their undergraduate research experiences had increased their understanding, skills, confidence, etc. on various dimensions. They used a 4-point scale where 1 = not at all, 2 = somewhat, 3 = a fair amount, and 4 = a great deal. Table VI-1 shows the individual items asked and the percentage distribution of responses.

About 80% or more of respondents indicated increases of at least "somewhat" on all dimensions listed. Dimensions that showed the greatest impact were skill/abilities in working independently (76% reported increases of a fair amount or a great deal) and understanding of how to conduct a research project (75%). Dimensions that produced the least impact (with about 50% reporting increases of a fair amount or a great deal) related to awareness of career options, the variety of STEM fields available, and what graduate school is like.

Factor analyses of the items showed that most fell into one of three clusters:

Increased 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.

How scientific knowledge is built

Increased confidence:

Confidence in your research skills generally

Confidence in your ability to succeed in grad school

Qualifications for jobs in related fields

Increased awareness:

Career paths of the faculty in the program (how they got to where they are now)

What graduate school is like

The variety of STEM fields you could specialize in

Career options in STEM

Table VI-1

STEM Graduates' Perceptions of Gains on Various Dimensions as a Result of Undergraduate Research Experiences (Listed in descending order of mean rating)

Number of respondents: 1786

		How Much Each Increased:				
	Mean	Not At All	Some-what	A Fair Amount	A Great Deal	Have No Idea
Your skills/abilities in working independently	3.09	4%	19%	41%	35%	1%
Your understanding of how to conduct a research project (U)	3.06	4	20	40	35	1
Your understanding of how to plan a research project (U)	2.99	6	23	37	33	2
Your understanding of the nature of the job of a researcher	2.97	6	23	38	31	2
Your skills/abilities in working collaboratively with others	2.97	7	21	38	33	1
Your confidence in your research skills generally (C)	2.96	4	24	42	29	1
Your understanding of how to deal with setbacks, etc. (U)	2.91	6	25	38	29	2
Your understanding of how to formulate a research question (U)	2.89	7	25	38	28	2
Your qualifications for jobs in related fields (C)	2.89	8	23	38	28	3
Your understanding of how scientific knowledge is built (U)	2.88	7	25	40	26	2
Your awareness of career paths of the faculty you worked with (A)	2.85	9	26	36	28	2
Your confidence in your ability to succeed in grad school (C)	2.74	12	24	35	24	4
Your awareness of career options in science/math/ engineering (A)	2.53	16	32	30	19	3
Your awareness of the variety of science/math/ engineering fields you could specialize in (A)	2.48	18	31	30	17	3
Your awareness of what graduate school is like (A)	2.46	21	28	29	18	4

This table shows, for example, that 4% of STEM graduates who participated in undergraduate research indicated that their skills/abilities in working independently were "not at all" increased by their research experience.

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

Source: SRI International STEM graduates survey, 2003.

Each cluster of variables listed above was used to create an index.[16] For each index, respondents were grouped into four approximately equally sized categories on the basis of their mean rating on items in that index.[17] These categories were used in group comparisons and

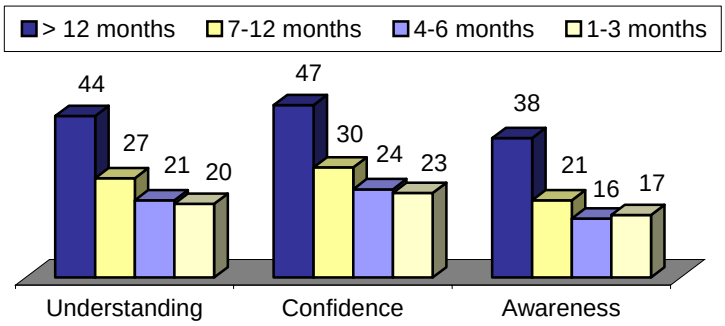
[16] Three items—your skills/abilities in working independently, your skills/abilities in working collaboratively with others, and understanding the nature of the job of a researcher—did not correlate highly with any of the other items nor with each other, so they were not included in an index.

[17] Because many students had the same scores, sorting into exactly equally sized quartiles was not possible. The top group of the awareness index, with ratings of 3.2 to 4.0, comprised 23% of respondents; the top group of the

analyses of the relationships between the indices and other variables. Individuals with scores in the top category/quartile of each index are termed "high gainers." For the most part, subgroup comparisons are based on comparisons of the percentages who are high gainers. This is a less precise measure than mean scores, but it is more intuitive.

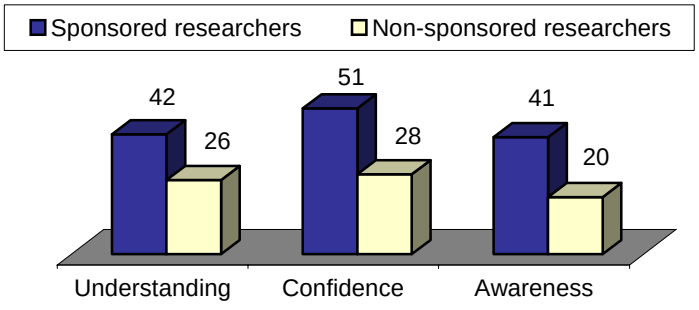
Dimensions for which subgroup comparisons were made included those for which other findings have been reported: research duration and sponsorship, sex, race/ethnicity, academic major, and type of school. In addition, we looked at the relationship between gains and many other study variables, including motivations for participating in research, undergraduate grade point average (GPA), when the respondent became interested in STEM, participation in high school math/science fairs, importance of research to one's career decision, whether academic credit and/or pay was received for research activities, relationship to coursework, and specific research activities. Findings from these analyses are reported below, first for the "basic" analysis variables and then for the additional ones.

Figure VI-1
Percentage of STEM Researchers Who Were High Gainers in Understanding, Confidence, and Awareness, by Duration of Research



Source: SRI International STEM graduates survey, 2003.

Figure VI-2
Percentage of STEM Researchers Who Were "High Gainers" in Understanding, Confidence, and Awareness, by Research Sponsorship



Source: SRI International STEM graduates survey, 2003.

Both research duration and sponsorship were positively related to gains, with about 20-point differentials between high and low groups. For example, 47% of high-experience researchers were high confidence gainers, compared with 24% of those with only 1 to 3 months experience (Figure VI-1), and 51% of sponsored researchers were high confidence gainers, compared with 28% of non-sponsored researchers (Figure VI-2).

There were no statistically reliable differences between men and women in their perceived gains from their research experiences, but there were differences among racial/ethnic groups. Blacks and, especially, Hispanics/ Latinos were more likely than Asians or non-Hispanic whites to have shown gains on all three indices (Figure VI-3). Looking at male-female differences within each of the racial groups, we found that among blacks only the men had relatively high gains. In other racial/ethnic groups, men's and women's ratings were similar.

Response patterns for the three indices by academic major were

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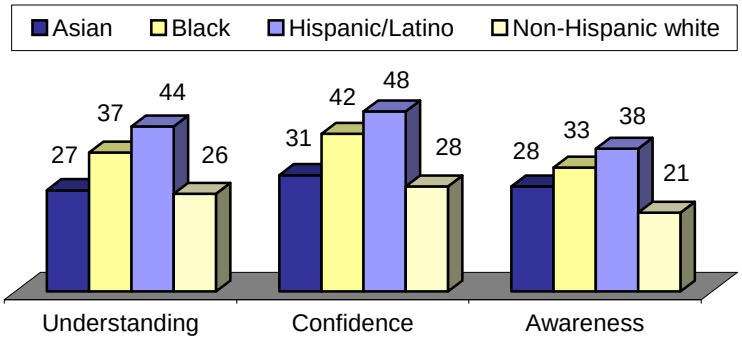
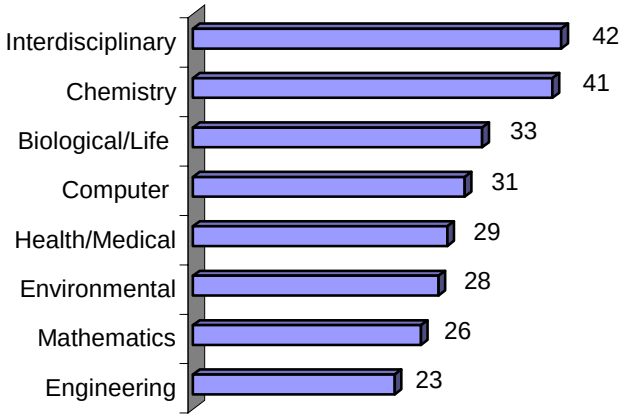
understanding index, with ratings of 3.6 to 4.0, comprised 28% of respondents; and the top group of the confidence index, with ratings of 3.1 to 4.0, comprised 31% of respondents.

Figure VI-3
Percentage of STEM Researchers Who Were "High Gainers" in Understanding, Confidence, and Awareness, by Race/Ethnicity



Source: SRI International STEM graduates survey, 2003.

Figure VI-4
Percentage of STEM Researchers Who Were "High Gainers" in Confidence, by Academic Major



Source: SRI International STEM graduates survey, 2003.

similar. Figure VI-4 summarizes the results for the confidence index. Respondents who had interdisciplinary majors had higher than average gains on all three indices, and engineering majors had lower than average gains on all three indices. Chemistry majors also tended to have relatively high gains and math majors tended to have relatively low gains, but because of the small number of chemistry and math respondents, the differences for these groups were not statistically significant.

Graduates of baccalaureate colleges had slightly higher mean gains in understanding than did graduates of other kinds of schools. Otherwise, there were no appreciable differences in the gains scores by type of school.

For the most part, other study variables that were related to one of the gains indices also were related to the others at a similar level. To simplify reporting, we will limit our discussion of these relationships to correlates of the confidence index.

Variables that had the strongest relationships with gains in confidence measured intensity of interest/involvement in the research process: the importance of several reasons for participating in research,[18] the importance of undergraduate research to one's career decision, and number of research activities. Other variables that had strong relationships with confidence gains included research activities that

[18] It is interesting that feeling strongly about most reasons for participating in research were so strongly related to confidence gains. We suspect that these relationships reflect enthusiasm (or lack thereof) about the research experience that was generalized to both the antecedents and outcomes of the experience. That is, respondents who thought they gained a lot from their research experiences felt strongly about why they participated, whereas those who didn't think research taught them much did not ascribe much significance to their reasons for participation. It is also interesting that participating in research to meet academic requirements did not correlate nearly as strongly with perceived gains as did participating because of personal interest or to help make an academic/career decision. We interpret this finding as suggesting that research participation is most likely to be an effective motivator when it is done voluntarily.

bring students into the research community: authoring articles for professional journals, attending student/professional conferences, and poster presentations; gaining increased independence; and undergraduate GPA.

Table VI-2 lists each of the variables noted above. It illustrates the relationship between each variable and the index of increased confidence by showing, for contrasting groups, the percentages who were high gainers on the confidence index. For instance, the table shows that 58% of students for whom personal interest was very important as a reason to participate in research were high gainers on the confidence index, compared to only 15% of those for whom personal interest was not an important reason.

Table VI-2

Selected Correlates of Perceived Increases in STEM Researchers' Confidence

	Group with the Largest Percentage of High Confidence Gainers		Group with the Smallest Percentage of High Confidence Gainers	
Why participate in research: personal interest (index)	Very important	58%	Not important	15%
Why participate in research: needed help with a career/academic decision (index)	Very important	59	Not important	16
Importance of undergraduate research to career decision	Extremely important	50	Not important	8
Why participate in research: thought it would help me get into graduate/medical school or get a job	Very important	53	Not important	14
Number of research activities	10+	51	< 6	16
Why participate in research: doing research was more appealing than other kinds of jobs	Very important	64	Not important	30
Attended professional conferences	Yes	54	No	26
Attended student conferences	Yes	53	No	27
Authored/co-authored professional journal article	Yes	51	No	28
Gained increasing independence	Yes	44	No	20
Undergraduate grade point average	3.90+	42	< 3.0	21
Why participate in research: needed to meet academic requirements (index)	Very important	49	Not important	28
Prepared a poster presentation describing research and results	Yes	47	No	26

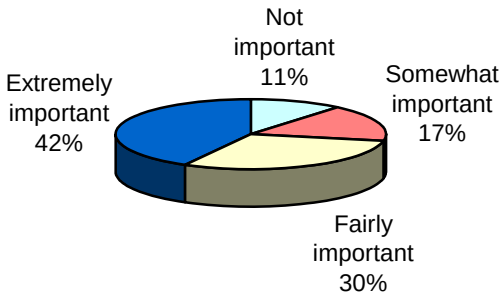
This table shows, for example, that 58% of students for whom personal interest was very important as a reason to participate in research were high gainers on the confidence index, vs. only 15% of those for whom personal interest was not important.

Notes: "High confidence gainers" are those in the top 31% of ratings on the index of increased confidence. "Personal interest," "needing help with a career/academic decision," and "needing to meet academic requirements" are indices comprising two or three items. For each, the "very important" groups are those in the top group (approximately the top quartile) of ratings on each index; "not important" groups are those in the bottom group/quartile of ratings.

Source: SRI International STEM graduates survey, 2003.

EFFECT OF RESEARCH EXPERIENCES ON RESPONDENTS' CAREER DECISIONS

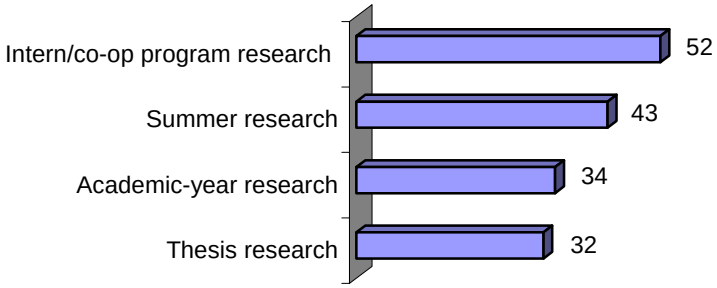
Figure VI-5
Importance of Undergraduate Research to STEM Researchers' Career Decisions



Source: SRI International STEM graduates survey, 2003.

Respondents were asked how important each type of research that they engaged in was to their career decision. On a 4-point scale where 1 = not important, 2 = somewhat important, 3 = fairly important, and 4 = extremely important, about 4 in 10 respondents reported that at least one of the types of research they engaged in was extremely important to their career decision (Figure VI-5). Only 11% said research was not important. Research in an intern or co-op program tended to be the most influential: 52% who did research as part of an intern or co-op program rated it as extremely important (Figure VI-6).

Figure VI-6
Percentage of STEM Participants in Each Type of Research Program Who Rated That Research as Extremely Important to Their Career Decision



Source: SRI International STEM graduates survey, 2003.

Sponsored researchers rated all types of research as more influential than did non-sponsored students. Among non-sponsored students, however, the "high-experience" researchers (those with more than 12 months research experience) gave influence ratings that were similar to those provided by the sponsored students. For example, 64% of sponsored researchers and 38% of non-sponsored researchers said their research was extremely important to their career decision, but among the non-sponsored group, the percentage who thought their research was extremely important ranged from 63% of those with more than 12 months experiences to 28% of those with 1 to 6 months experiences.

Among racial/ethnic groups, Hispanics'/Latinos' ratings were slightly higher than those of other groups (mean rating = 3.20 vs. 3.00 to 3.13). Mean ratings by academic major ranged from 2.85 among health/medical sciences majors to 3.3 among chemistry majors; interdisciplinary and environmental science majors also had relatively high means (3.17 and 3.15, respectively). There were no appreciable differences in influence ratings between men and women or by degree year or type of school.

CHANGES IN INTEREST IN VARIOUS CAREERS

Respondents who participated in research 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: science, math, or engineering; medicine; research; and teaching. Respondents provided their ratings on a 5-point scale where 1 = decreased a lot, 2 = decreased somewhat, 3 =

no effect, 4 = increased somewhat, and 5 = increased a lot. A "have no idea" response option was also provided. Table VI-3 summarizes responses to these questions.

Table VI-3

Effect of Undergraduate Research Experiences on 1988-2003 STEM Graduates' Interest in Careers in Various Areas (Listed in descending order of mean rating)

	Mean	Decreased	No effect/ Have no idea	Increased somewhat	Increased a lot
Science, math, or engineering	3.75	5%	35%	39%	22%
Research	3.43	20	32	29	19
Teaching	3.39	11	50	24	15
Medicine	3.28	8	63	16	12

This table shows, for example, that 5% of STEM graduates reported that their interest in a career in science, math, or engineering decreased as a result of all their research experiences.

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

Source: SRI International STEM graduates survey, 2003.

About 6 in 10 graduates said that their interest in a career in science, math, or engineering (STEM) was increased somewhat or a lot, and 22% said that their interest increased a lot. Fewer reported that their interest increased somewhat or a lot in careers in research (48%), teaching (39%), or medicine (28%). As with other measures of research effects, sponsored researchers reported stronger effects than did non-sponsored researchers, but among non-sponsored researchers, the responses of those with high experience were similar to those of the sponsored researchers. For example, sponsored researchers' mean rating of changed interest in a STEM career was 4.01, compared to 3.71 for non-sponsored researchers overall and 4.03 for the high-experience group; the percentages who reported their interest increased somewhat or a lot were 76%, 57%, and 73%, respectively.

There were sizable differences among the various academic majors in the effects of research on interest in the four types of careers (Table VI-4). However, there were only small differences in career interest ratings between men and women, among the racial/ethnic groups, and by degree year and type of school.

Table VI-4

Effect of Undergraduate Research on Interest in Different Types of Careers, for Selected STEM Academic Majors

	Above-Average Effect		Below-Average Effect	
Career in:	**Academic Major**	**Mean**	**Academic Major**	**Mean**
Science, engineering, or math	Computer science	3.87	Health/medical sciences	3.44
	Engineering	3.87		
	Environmental sciences	3.81		
Research	Chemistry	3.80	Engineering	3.26
	Interdisciplinary STEM	3.63	Health/medical sciences	3.30
	Biological/life sciences	3.54		
Teaching	Interdisciplinary STEM	3.61	Engineering	3.13
	Mathematics	3.53	Environmental sciences	3.33
	Health/medical sciences	3.51		
Medicine	Health/medical sciences	3.69	Environmental sciences	2.95
	Interdisciplinary STEM	3.37	Computer science	2.99
			Engineering	3.01
			Mathematics	3.06

This table shows, for example, that computer science majors reported above-average increases in interest in a career in science, engineering, or math as a result of their undergraduate research experiences (mean rating = 3.87).

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

Source: SRI International STEM graduates survey, 2003.

OVERVIEW OF PERCEPTIONS OF UNDERGRADUATE RESEARCH

Undergraduate STEM researchers had very positive perceptions of their research experiences:

- Almost all felt that they had gained at least somewhat on all dimensions of understanding, confidence, and awareness that were covered in the questionnaire.
- About 7 in 10 said their research was extremely or fairly important to their career decision, and 6 in 10 said that their interest in a career in STEM had increased at least somewhat as a result of their research experiences.

Research duration and sponsorship were positively related to all these variables. Other dimensions that were positively related to perceived gains included feeling strongly about any of several reasons for participating in research (especially personal interest and needing help with an academic or career decision); participating in a variety of research-related activities; participating in activities that tend to bring the student into the academic/research community, such as attending conferences and writing professional papers; and gaining increasing independence over the course of the research experience.

Blacks and, especially, Hispanics/Latinos were more likely than Asians or non-Hispanic whites to have shown gains in understanding, confidence, and awareness, but the groups' ratings of the influence of research on their career decisions were not very different from one another. There were no statistically reliable differences between men and women either in their perceived gains or in their ratings of the influence of research.

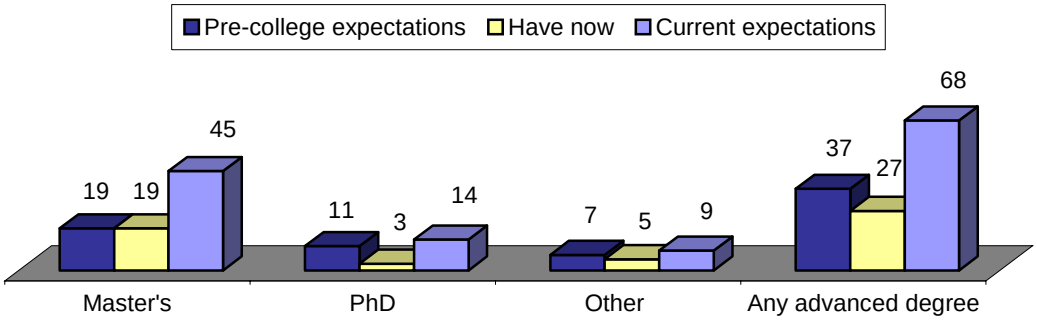
VII. ACADEMIC DEGREES AND EMPLOYMENT SECTORS

One of the major objectives of undergraduate research—or at least that of most of the sponsored programs—is to increase the number of students who pursue a PhD and a career in the scientific/academic community. In this chapter, we discuss findings regarding respondents' highest degree expectations before they started college,[19] the highest degree they had completed at the time of the survey, and the highest degree they expected to have 10 years in the future.[20] We also report on respondents' current employment sector.

ACADEMIC DEGREE EXPECTATIONS AND ATTAINMENT

According to their self-reports, 37% of survey respondents had pre-college expectations of obtaining an advanced degree (master's, PhD, [21] or other doctorate). At the time of the survey, 27% had obtained an advanced degree, and 68% expected that they would have an advanced degree in 10 years (Figure VII-1). Thus, the college experience in general tended to raise

Figure VII-1
Percentages of STEM Graduates Who Expected/Attained Advanced Degrees



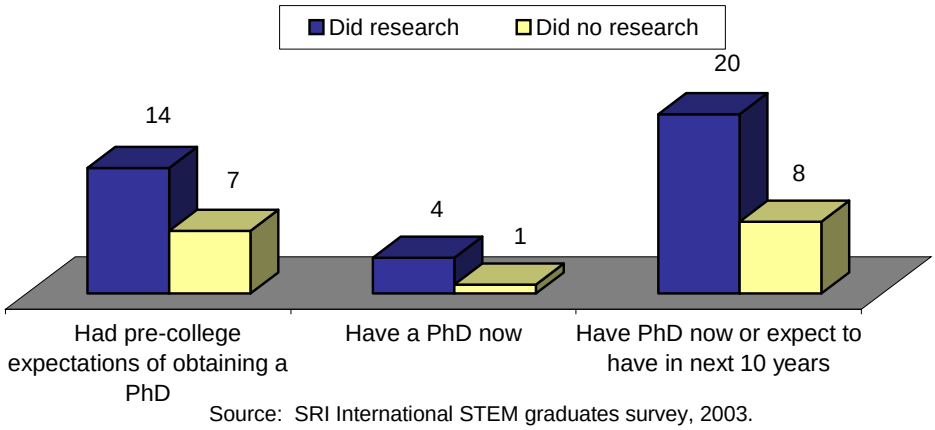
Source: SRI International STEM graduates survey, 2003.

students' degree expectations, although many had not yet achieved those expectations. Even among the earlier graduates in the sample, there were a fair number who expected further academic achievement. For example, 5% of the 1988-1992 graduates had obtained a PhD, but another 7% still expected to obtain one.

Undergraduate research was positively related to both expectations and attainment of a PhD. The percentages of STEM researchers who expected/attained a PhD were at least twice as large as those of non-researchers (Figure VII-2). For example, at the time of the survey 20% of researchers either had a PhD or expected to obtain one in the next 10 years, compared with only 8% of non-researchers. The differences are even larger when sponsored researchers and high-experience non-sponsored researchers are considered separately: at the time of the survey, 33% of sponsored researchers and 27% of the high-experience non-sponsored group had a PhD

[19] Respondents who had participated in undergraduate research were asked, "Before you participated in any undergraduate research, what was the highest degree you expected to receive?"
[20] We noted in the questionnaire, "This may be a degree you have already completed."
[21] PhD expectations include those who expected to receive *either* an MD or PhD (were not sure which one) and those who expected to obtain *both* an MD and a PhD.

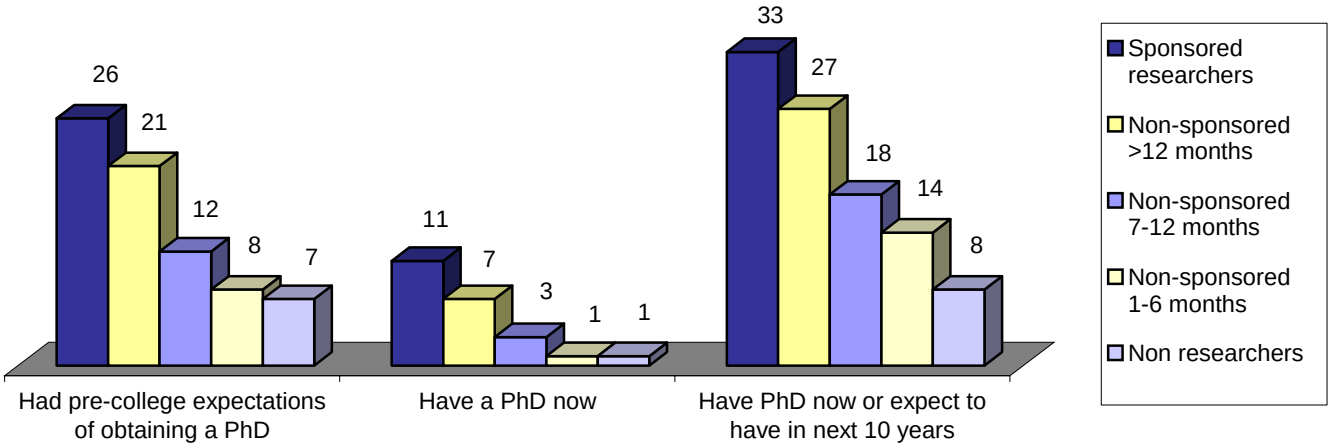
Figure VII-2
Percentages of STEM Graduates Who Expected/Obtained a PhD, by Participation in Undergraduate Research



Source: SRI International STEM graduates survey, 2003.

or expected to obtain one in the next 10 years, compared with 8% of those who did no research (Figure VII-3).

Figure VII-3
Percentages of STEM Graduates Who Expected/Obtained a PhD, by Research Sponsorship and Duration

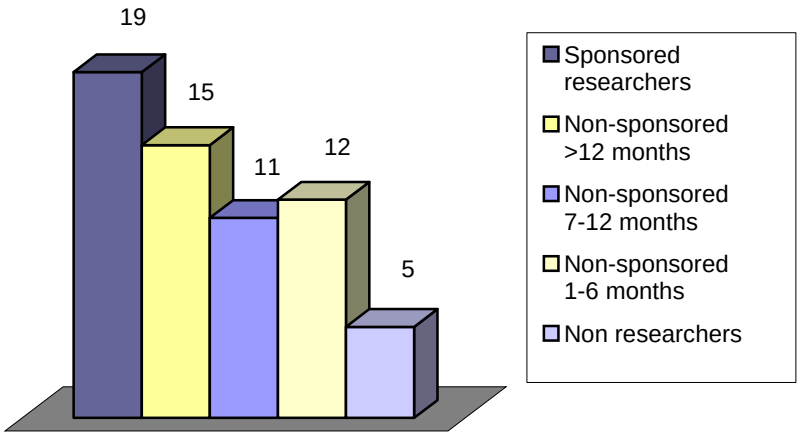


Source: SRI International STEM graduates survey, 2003.

We also found that students who participated in research were much more likely than non-researchers to have "new" expectations of obtaining a doctorate (that is, they did not have pre-college expectations of a PhD, but at the time of the survey they either had one or expected they would obtain one): 13% vs. 5%, respectively. Sponsored and high-experience non-sponsored researchers were somewhat more likely average to have new PhD expectations, but the differences by research sponsorship and duration were not very large (Figure VII-4).

Taken together, the findings on degree expectations suggest that undergraduate research—especially sponsored research—tends to attract those who are already relatively highly academically motivated, but it also helps to encourage even those who were not originally motivated to obtain a doctorate to go ahead and do so.

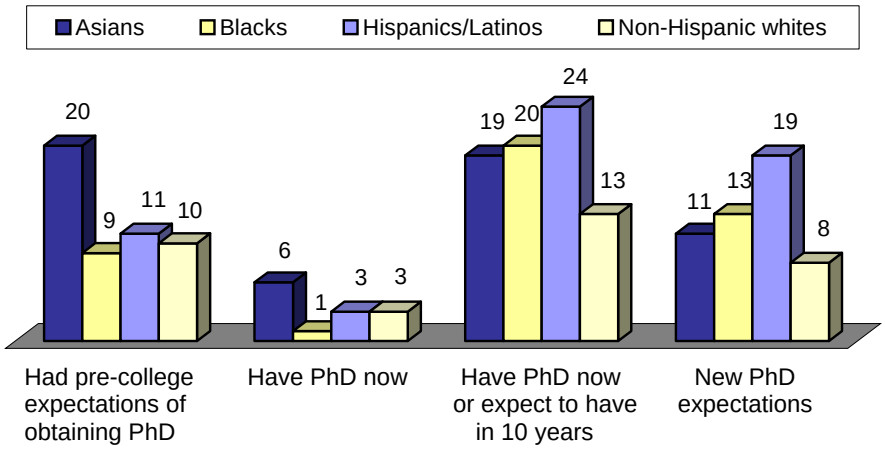
Figure VII-4
Percentage of STEM Graduates Who Had "New" PhD Expectations, by Research Sponsorship and Duration



Source: SRI International STEM graduates survey, 2003.

Racial/ethnic group patterns differed on the various measures of degree expectations (Figure VII-5). Asians were considerably more likely than others to have pre-college expectations of a PhD; they also appear to be more likely than others to have obtained a PhD, but the difference is not statistically significant. Blacks and, especially, Hispanics were more likely than average to have/expect a PhD in 10 years and to have new PhD expectations. And non-

Figure VII-5
Percentages of STEM Graduates Who Expected/Attained a PhD, by Race/Ethnicity



Source: SRI International STEM graduates survey, 2003.

Hispanic whites were less likely than average to have had pre-college PhD expectations, to have/expect a PhD in 10 years, or to have new PhD expectations.

Among academic majors, computer science majors had lower than average percentages on all PhD expectation/attainment measures, whereas interdisciplinary STEM majors had higher than average percentages on all measures. Chemistry majors were notable in being considerably the most likely to have obtained a PhD (17%, vs. 0% to 5% among the other majors); they also had higher than average percentages who had expectations of a PhD in the next 10 years and new PhD expectations. Differences between men and women on the PhD expectation/attainment measures were not statistically significant, and there were only small differences by type of school.

As noted in Chapter VI, researchers' perceived gains in confidence, understanding, and awareness were positively related to increased interest in STEM careers. Correspondingly, perceived gains also were positively related to expectations of obtaining a PhD. For instance, 19% of high confidence gainers had new PhD expectations, compared with 8% of those in the bottom gains quartile. Interestingly, however, perceived gains were not related to whether a PhD had already been obtained.

Other academic and research measures with appreciable relationships to PhD expectations/ attainment are summarized below.

- *Undergraduate GPA.* (Base: all respondents) Positively related to all measures of PhD expectations and attainment except new expectations.

	Undergraduate GPA		
	<3.0	3.5 to 3.69	3.9+
Had pre-college expectations of a PhD	7%	13%	21%
Completed PhD at time of survey	1	3	9
Have now or expect PhD in 10 years	10	16	26

(This table shows, for example, that 7% of respondents with GPAs of less than 3.0 had pre-college expectations of obtaining a PhD.)

- *Needing help with academic/career decisions as a reason to participate in undergraduate research.* (Base: those who participated in research) Positively related to all measures of PhD expectations and attainment.

	Index: need help with decisions	
	Bottom quartile	Top quartile
Had pre-college expectations of a PhD	8%	24%
Completed PhD at time of survey	2	9
Have now or expect PhD in 10 years	12	37
New expectations of a PhD	8	22

- *Authored or co-authored a paper submitted for publication in a professional journal.* (Base: those who participated in research) Positively related to all measures of PhD expectations and attainment.

	Authored paper?	
	No	Yes
Had pre-college expectations of a PhD	12%	25%
Completed PhD at time of survey	3	8
Have now or expect PhD in 10 years	18	36
New expectations of a PhD	12	20

- *Attended student conferences.* (Base: those who participated in research) Positively related to all measures of PhD expectations, but not to current attainment of a PhD.

	Attended student conferences?	
	No	Yes
Had pre-college expectations of a PhD	12%	21%
Have now or expect PhD in 10 years	18	32
New expectations of a PhD	12	18

- *Perceived importance of research experiences to one's career decision.* (Base: those who participated in research) Positively related to all measures of PhD expectations, but not to current attainment of a PhD.

	Importance of undergraduate research to your career decision			
	Not	Somewhat	Fairly	Extremely
Had pre-college expectations of a PhD	9%	9%	13%	17%
Completed PhD at time of survey	1	2	3	6
Have now or expect PhD in 10 years	12	12	19	27
New expectations of a PhD	8	7	13	16

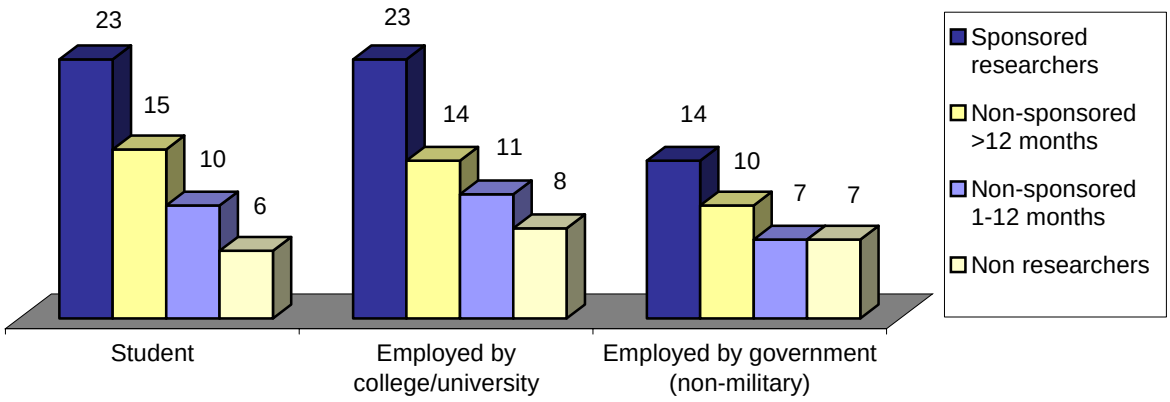
- *Starting college at a 2-year school.* (Base: all respondents) Slightly negatively related to pre-college expectations of obtaining a PhD (7% of those who started at a 2-year institution had pre-college expectations of a PhD, vs. 11% of those who started at a 4-year institution). However, the two groups had virtually identical percentages on the other PhD expectation/ attainment measures.

CURRENT EMPLOYMENT STATUS AND SECTOR

The survey did not attempt to assess the precise nature of respondents' employment, but we did ask about employment status and sector. Responses to these questions indicated that participation in undergraduate research, research sponsorship, and research duration all were positively related to current participation in endeavors that are likely to be scientific or academic in nature. Comparing researchers with non-researchers, we found that the former were more likely than the latter to still be students (13% vs. 6%) and to be employed by a college or university (13% vs. 8%) or government, other than military (9% vs. 7%). As with measures of PhD expectations/attainment, when we added the dimensions of research sponsorship and duration, the differences became larger. Sponsored researchers were especially likely to be students (23%), employed by a college or university (23%), or employed by the government (14%) (Figure VII-6).[22]

[22] Although the percentages who are students and who are employed by a college/university are the same, these are not the same individuals. Among sponsored researchers, 20% of those employed by a college/university are also students; the corresponding percentage among all researchers is 21%.

Figure VII-6
STEM Graduates' Current Employment Status and Sector, by Research Sponsorship and Duration



Source: SRI International STEM graduates survey, 2003.

OVERVIEW OF ACADEMIC DEGREES AND EMPLOYMENT IN ACADEMIA

Undergraduate research tends to attract those who want to obtain a PhD but it also encourages those who did not originally have PhD expectations. Researchers were more likely than non-researchers to have obtained a PhD at the time of the survey, to have had pre-college expectations of obtaining one, and to have current expectations of obtaining one. Most compelling, researchers were almost three times as likely as non-researchers to have new expectations of a PhD, and they were more likely to still be in school or to be employed in academia or government. These outcomes were especially common among sponsored researchers and those who had engaged in research for more than 12 months. Among researchers, likely precursors of PhD expectations/attainment included earning an undergraduate GPA of 3.9 or higher, authoring papers submitted to professional journals, attending student conferences, and needing help with an academic/career decision as a reason for participating in research.