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A SERU Project Research Paper *

Undergraduate Research Participation at the University of California, Berkeley

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ABSTRACT

Although the University of California, Berkeley has increased efforts to involve undergraduates in scientific research, little data exists regarding the number of undergraduate researchers. The University of California Undergraduate Experience Survey (UCUES) presents an opportunity to investigate the extent of undergraduate research involvement at the UC Berkeley. The data (N=5,347) show that the frequency of student participation in research under the direction of a faculty mentor varies significantly based on whether students are receiving course credit, pay, or working as a volunteer. Undergraduate research participation also varies between STEM majors and social science or humanities majors (non-STEM), with slightly more STEM majors participating. The data show that women are participating in STEM research opportunities at a lower rate than men but participating in non-STEM research opportunities at a higher rate than men. The data also show that Asian, Filipino, and Pacific Islanders (AFP students) account for 50% of all undergraduate researchers in STEM fields and 35% of all non-STEM researchers. However, the data also reveal that African American, Chicano-Latino, AFP, White, American Indian, and international students are all participating at almost the exact same rate in undergraduate research (between 24% and 27% by ethnic or racial category). Further analysis regarding the relationship between undergraduate research experience and the highest parental education level reached, as well as high school grade-point average and standardized test scores (SAT I and ACT) is presented. Implications for higher education administrators, education researchers, faculty mentors, and undergraduate students are discussed.

Introduction

Investigating the Pervasiveness of Undergraduate Research

In universities across the country, thousands of students work with faculty to assist in ongoing research projects, often supported by large-scale grant programs. Yet to date, there are few systematic studies surveying the extent to

* The SERU Project and Consortium is a collaborative effort based at the Center for Studies in Higher Education at UC Berkeley and is focused on developing new types of data, analysis, and innovative policies relevant to major research universities. For more information, see <http://cshe.berkeley.edu/research/seru/>

which students are directly involved in these programs.¹ The present research attempts to determine the number of undergraduate students at the University of California, Berkeley engaged in faculty-driven research activities (in any field), the types of compensation students received for those activities (if any), and the backgrounds of student researchers compared with their peers who have not engaged in undergraduate research. A second goal of this project determines the rates of undergraduate research participation with regard to gender, ethnicity, parents' education level, high school grade-point average, and SAT I score.

Literature Review

In 1995, the Carnegie Foundation for the Advancement of Teaching initiated the National Commission on Educating Undergraduates in the Research University, which was later renamed the Boyer Commission.² In its final report, the Boyer Commission recommended ten ways to reform undergraduate education. The first recommendation forwarded by the commission suggested that research-based learning become standard for undergraduates in research universities. Guided by the writings of John Dewey, the authors argued that learning is inherently a discovery process aided by mentors and not simply a transmission of information. The Boyer Commission argued that the lecture should not be the primary mode of instruction at a research university. Instead, the undergraduate academic experience at all levels should focus on learning through discovery-based methods that progress toward forms of independent inquiry similar to those of the first-year graduate student. The Boyer Commission report (1998) stated:

The basic idea of learning as inquiry is the same as the idea of research; even though advanced research occurs at advanced levels, undergraduates beginning in the freshman year can learn through research. In the sciences and social sciences, undergraduates can become junior members of the research teams that now engage professors and graduate students (17).

Inquiry activities that are not part of a recognized lecture course and that are faculty-driven have come to be called undergraduate research experiences and are increasingly supported at the institutional level by university offices of undergraduate research under the auspices of senior university administrators (The Reinvention Center, 2002). These institutional reforms are, at least partially, a result of the Boyer Commission report.

Research universities must justify their participation in the business of undergraduate education when their primary energies are dedicated to the research endeavor. Why should undergraduates attend universities primarily focused on research? Part of the answer may lie in exposing undergraduates to the research process. Engagement with leading researchers and the experience of cutting-edge research techniques are opportunities that have expanded greatly in recent years, but many universities have failed to accurately gauge the number of undergraduates involved in these activities, the compensation students receive for their work, or the backgrounds of the students who undertake these extracurricular projects.

At UC Berkeley, there are a variety of ways undergraduates can become involved in faculty-supported research. The Office of Undergraduate Research in the College of Letters and Sciences identifies two major avenues for student participation in research. First, undergraduates may be selected through a competitive process to work on faculty-initiated research projects. The major program at UC Berkeley connecting faculty with undergraduate researchers is the Undergraduate Research Apprentice Program (URAP). Students have an opportunity to work with faculty on current research projects and can earn up to 4 units of academic credit per term. Students are not paid for their

¹ A 2001 study conducted by the Reinvention Center at the University of Miami (at the time it was located at SUNY at Stony Brook), found that universities have not systematically collected data related to undergraduate research. Responses to the survey and follow-up interviews were largely educated guesses and anecdotal stories (Katkin, 2003).

² The Boyer Commission on Educating Undergraduates in the Research University released a report entitled *Reinventing Undergraduate Education: A Blueprint for America's Research Universities* (1998). The findings of the commission are often referred to as the Boyer Commission report.

participation in URAP, but their participation in the program opens an opportunity to be hired by their faculty mentors during the summer and paid a modest stipend for their research work. The website of the Office of Undergraduate Research lists 37 other programs besides URAP for Berkeley undergraduates to participate in research projects with faculty or staff. These include programs such as the Biology Fellows Program, the AMGEN SCHOLARS Undergraduate Summer Research Program in Sciences and Biotechnology, the McNair Scholars Program, the Miller Scholars Program, the Haas Scholars Program, SURF: Summer Undergraduate Research Fellowships in the College of Letters and Sciences, and research fellowships through numerous autonomous research centers located at Berkeley. An additional 18 programs for off-campus undergraduate research are also listed. These include participation in the Children's Hospital of Oakland Research Institute, research at the Lawrence Livermore National Laboratory, and research with the Department of Energy.

A second avenue for student participation in research is initiated by the student. Every undergraduate major at UC Berkeley offers students the opportunity to do independent study and conduct research in order to write a thesis or senior research project. Student-initiated opportunities refer to student-faculty research partnerships that are primarily focused around the interests of the student as opposed to student participation in ongoing research initiated by the faculty member. Such research arrangements can be informally arranged but students may receive pay, credit, or may volunteer their time for these research activities. Due partially to the prevalence of informal research arrangements between faculty and students, UC Berkeley has not been able to accurately gauge the number of undergraduate researchers.

In the past five years, several articles have suggested that undergraduate research participation offers certain benefits, including learning benefits. However, this research has remained largely qualitative and descriptive in nature due to the difficulties associated in conducting a controlled experiment in this area. In a recent examination of the benefits of undergraduate science research, Seymour, et.al. (2004) identified seven types of benefit reported in 76 interviews with students from four liberal arts colleges (Grinnell, Harvey Mudd, Hope, and Wellesley). Students commented on a checklist of possible benefits during the interviews and offered additional benefits based on their experiences. These benefits were categorized as personal/professional gains, "thinking and working like a scientist," gains in various skills, clarification/confirmation of career plans (including graduate school), enhanced career/graduate school preparation, and shifts in attitudes to learning and working as a researcher.

Lopatto (2003) piloted a study investigating 20 potential benefits of undergraduate internships in conjunction with career plans for undergraduate researchers at the same four institutions originally studied by Seymour. Lopatto (2004) subsequently expanded the study to 1,135 undergraduates representing 41 universities and colleges. Lopatto drew on and combined many of the questions regarding undergraduate research used in the last 10 years. Lopatto developed a survey instrument called the Survey of Undergraduate Research Experiences (SURE), consisting of 44 items regarding learning gains, based on consultation with undergraduate research program directors. Lopatto (2004) found that, first, the general satisfaction and learning of undergraduates participating in research were enhanced. Second, he found that undergraduate researchers interested in careers in science were attracted to, and supported by, undergraduate research internship programs, and third, that the results were similar across ethnic and gender groups. Lopatto (2004) argued that setting up a control group that was prevented from participating in undergraduate research internships was unethical. Therefore, this is not an experimental study and instead provides a further description of potential benefits of research experience.

The benefits outlined by these reports provide some context for understanding why undergraduates might be attracted to working on faculty research projects and why university programs and external funding agencies encourage these collaborations. However, as universities across the country, federal agencies, and private foundations increase efforts to draw undergraduates into research, it is imperative that studies regarding undergraduate research participation do not remain solely at the descriptive level. But in order to build a more rigorous, large-scale comparative study, the field must have access to reliable, updated figures regarding students participating in research activities. The present study attempts to provide investigators with these statistics for the

nation's most prestigious public research university, UC Berkeley, and thus points the way towards a more experimental approach to investigating the benefits of undergraduate research.

Research Methods

This study uses the 2006 University of California Undergraduate Experience Survey (UCUES) database in order to assess the level of undergraduate research at UC Berkeley. UCUES is currently administered at the nine undergraduate University of California campuses. First administered in Spring 2002, UCUES is currently the only census survey of students at a large research university system. The survey is digitally administered and uses an Internet-based questionnaire. The survey response rate in 2006 for the Berkeley campus was 47.8% or 10,717 students. The survey items used in this study were only administered to upper-division students (N=5,347). Some analyses have a smaller n due to missing responses on the items used in the analysis.

The sample group for this study is composed of upper-division undergraduate students who received university credit for their work with faculty on research, received pay for research internships, or who were volunteer researchers. The comparison group is composed of upper-division students who indicated that they had never participated in faculty-driven research for university credit, for pay, or as a volunteer.

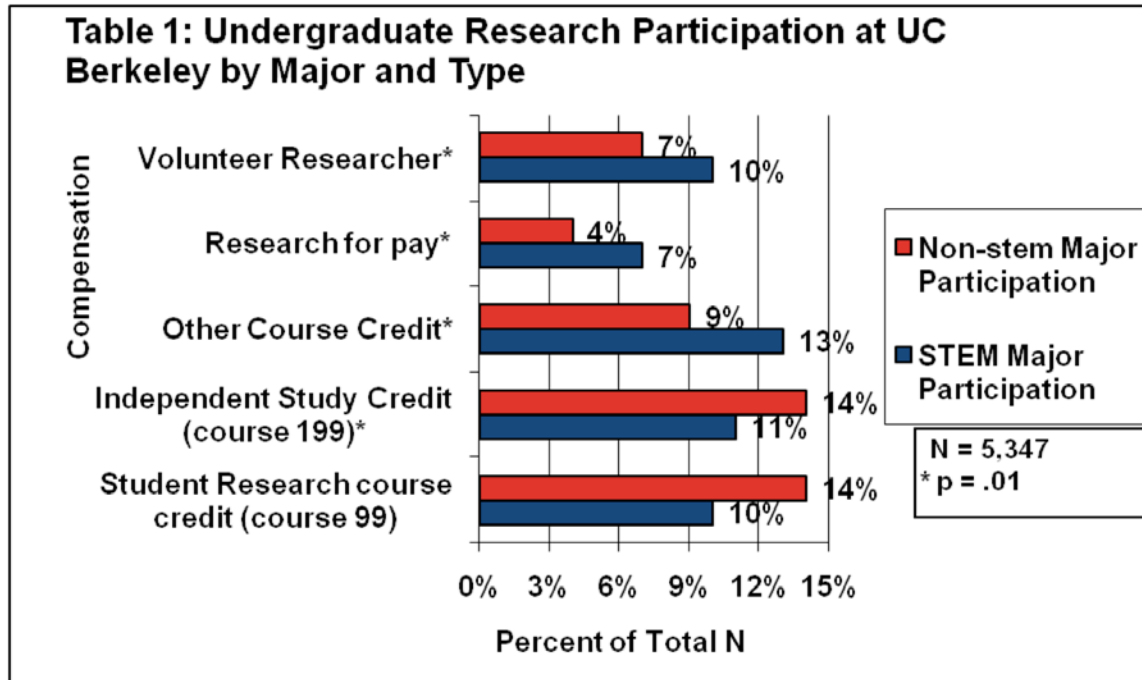
Several analyses were conducted with the primary goal of understanding the landscape of undergraduate research at UC Berkeley. In general, this study investigates how many undergraduates at UC Berkeley engage in research, the demographics of undergraduate researchers, and how these students might differ from undergraduates who do not engage in faculty research. I investigated the overall frequency of research participation broken down by students who take various types of university credit, who conduct research with faculty for pay, and who volunteer their time doing research with faculty. Due to published reports of increased frequency of undergraduate research participation among science, engineering, and math (STEM) majors (Katkin, 2003), I analyzed the frequency and rates of research participation controlling for type of major (STEM vs. non-STEM). I also investigated the rates of participation in undergraduate research controlling for gender, ethnicity, and parental education level. In order to understand if undergraduate researchers differed from non-researchers in traditional academic measures before matriculating to UC Berkeley, I investigated the rates of participation in undergraduate research relative to high school grade-point average and SAT I total score. In each analysis, undergraduate researchers were compared to non-researchers and significance was determined at a Pearson chi-square level $p < .01$.

Findings and Discussion

Patterns of Undergraduate Research Participation

An evaluation of UCUES 2006 data shows that approximately 2,610 upper-division undergraduate students have participated in research under faculty direction at UC Berkeley. This accounts for approximately half (49%) of upper-division undergraduate respondents to the 2006 UCUES at UC Berkeley. A recent white paper published by the Teagle Foundation using the National Survey of Student Engagement (NSSE) data from 209 four-year colleges and universities in the United States (N= 65,633 randomly sampled senior students) found that only one in five (19%) of senior students nationally had worked on research with faculty (The Teagle Working Group on the Teacher-Scholar, 2007). In comparison with this national assessment, the UCUES data show that UC Berkeley students are conducting research with faculty at a much higher rate than the national average.

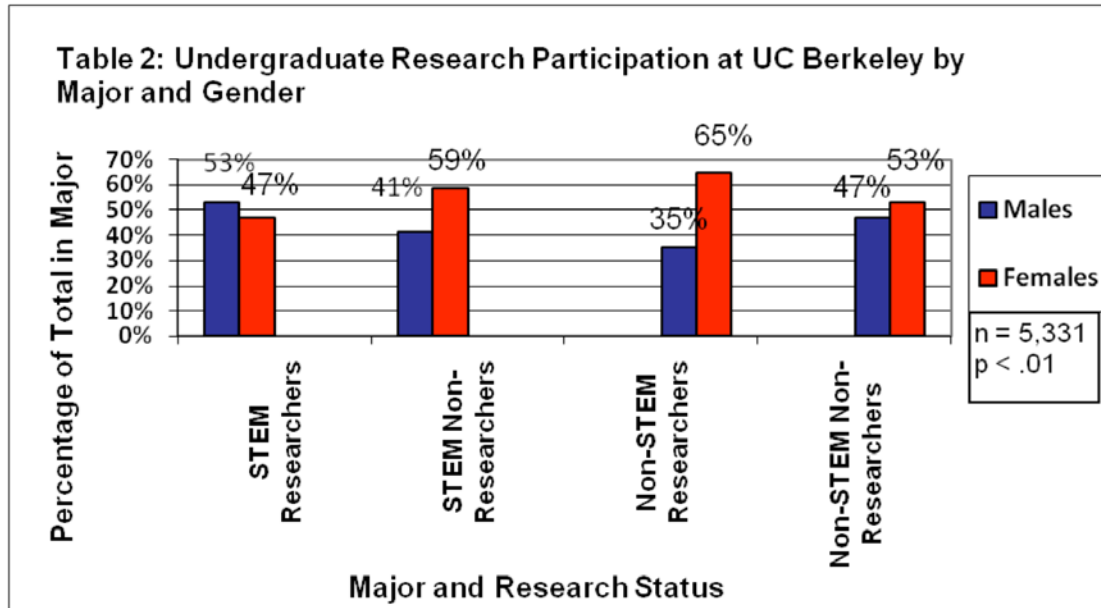
Table 1 shows research participation as a function of the total number of upper-division respondents to the survey by major and by type (credit, pay, or volunteer).



National evaluations show that between 25% - 39% of biology or physical science students participate in research activities by the time they are seniors (The Teagle Working Group on the Teacher-Scholar, 2007). Analysis of the 2006 UCUES data shows that at UC Berkeley, a slightly higher percent of STEM majors (54.3%) than non-STEM majors (44.9%) engage in research opportunities (data not shown). Table 1 shows that STEM majors participate in research as volunteers, for pay, and for credit other than student research credit (course 99 at Berkeley) or independent study credit (course 199 at Berkeley) at significantly higher rates than non-STEM majors ($p=.01$). However, non-STEM majors report engaging in research for independent study credit at a significantly higher rate than STEM majors ($p<.01$). The difference between STEM majors and non-STEM majors with regard to student research credit (course 99 at Berkeley) was not significant to $p<.01$.

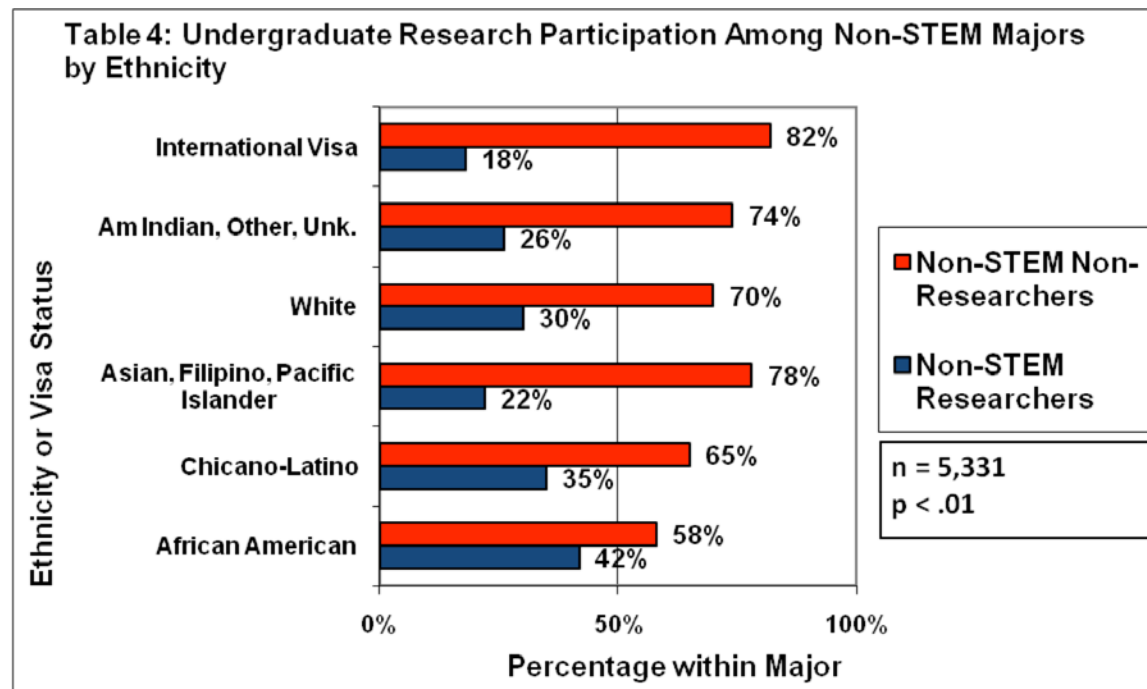
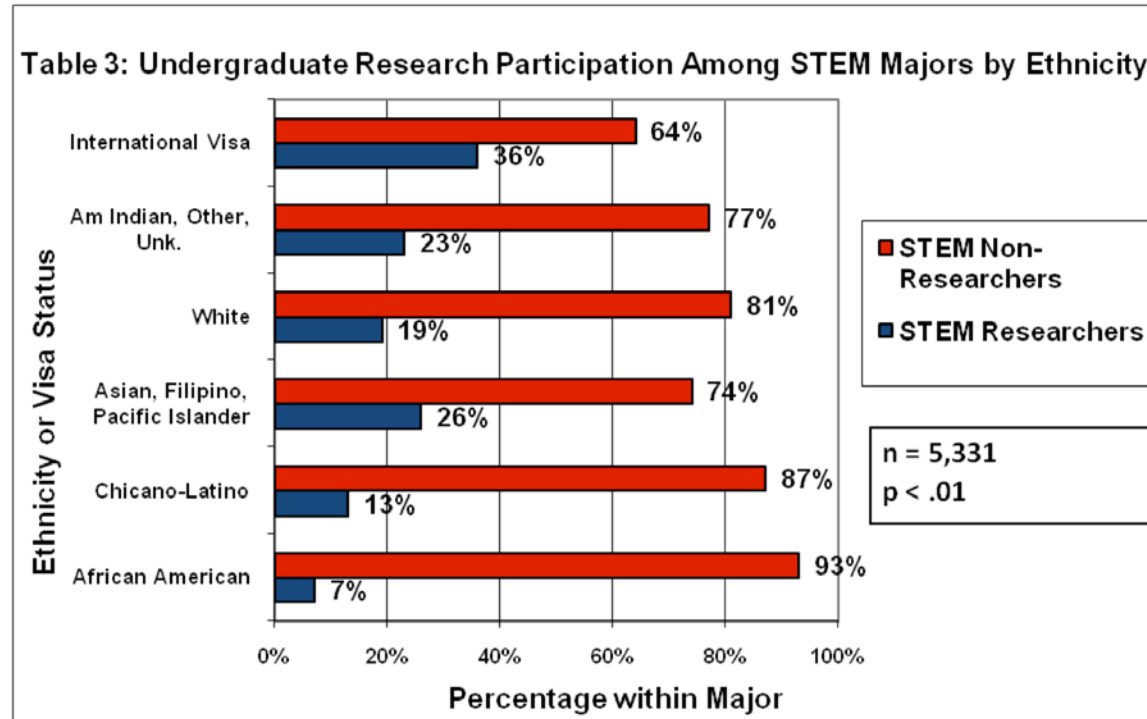
Many national reports and peer-reviewed studies have appeared in the literature regarding the gender and minority gaps in higher education STEM fields (Campbell, 2002; Campbell & Skoog, 2004; Martinez, 2000). One of the ways that the National Science Foundation, private foundations such as the Gordon and Betty Moore Foundation, and universities have attempted to correct this imbalance is by encouraging women and minorities to participate in faculty-driven research internships on the premise that these experiences encourage persistence in the field.³ The data from this study show that there is no significant difference between student researchers and non-researchers by ethnicity or gender when looking broadly at student activities. In fact, when analyzed in the aggregate, the data show that women account for 13% more of the total number of undergraduates doing research at UC Berkeley and that under-represented racial and ethnic groups participate at approximately the same rate (data not shown). However, when analyzed according to type of major, important differences arise.

³ See the National Science Foundation's Research Experience for Undergraduates program at www.nsf.gov.



With respect to gender, Table 2 shows that in the STEM fields, women account for approximately 47% of undergraduate researchers. Less than 20% of all women in STEM fields participate in undergraduate research opportunities (data not shown). Men account for 53% of undergraduate researchers in the STEM fields and 30% of all men in STEM fields participate in undergraduate research. These data indicate that women are participating in STEM research opportunities at a lower rate than men. Table 2 shows that the trend with regard to gender is reversed among non-STEM majors. Women account for nearly 65% of all non-STEM researchers. Put another way, 30% of all women in non-STEM fields participate in undergraduate research opportunities compared to only 21% of men in those fields (data not shown).

Tables 3 and 4 illustrate the relationship between type of major and ethnicity as a function of the percentage of students in the type of major.

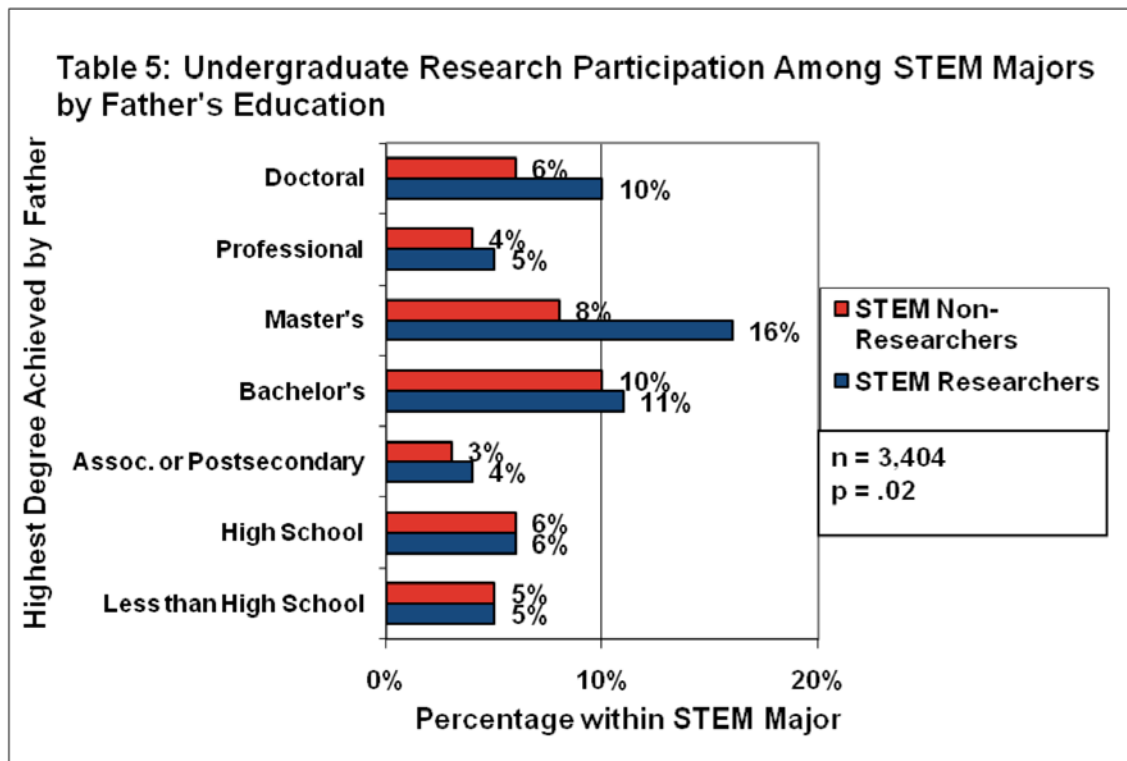


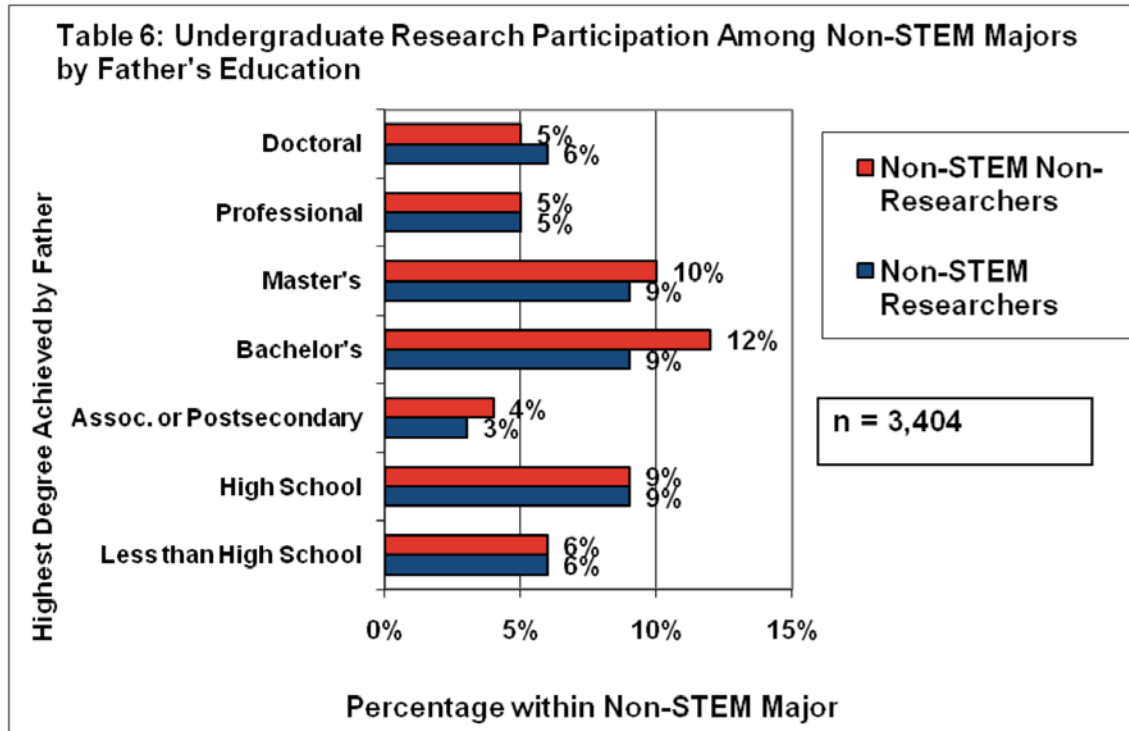
Asian, Filipino, and Pacific Islander (AFP) students account for 50% of all the undergraduate researchers in STEM fields, with Whites a distant second at 27% (data not shown). However, as Table 3 shows, the rate of participation in undergraduate research between ethnic groups is not as drastic as that initial statistic would suggest. International students actually participate at a higher rate than AFP students and students who identify as American Indian, Other, or Unknown participate at nearly the same rate as AFP students. Table 3 shows Chicano-Latino students and African American students participate at lower rates than other ethnic groups (13% and 7%, respectively).

Looking broadly at the population of undergraduate researchers in non-STEM fields, AFP and White students are the predominate ethnicities (35% for AFP and 36% for White, data not shown). However, the participation rates of the different ethnic groups illustrated in Table 4 tells a more nuanced story. In a complete reversal of the undergraduate research trends in STEM fields illustrated in Table 3, Table 4 shows that African American students and Chicano-Latino students participate in undergraduate research in non-STEM majors at a *higher* rate than any other ethnic group (42% and 35% respectively). AFP and students with international visas participate in undergraduate research in non-STEM majors at the lowest rates (22% and 18% respectively).

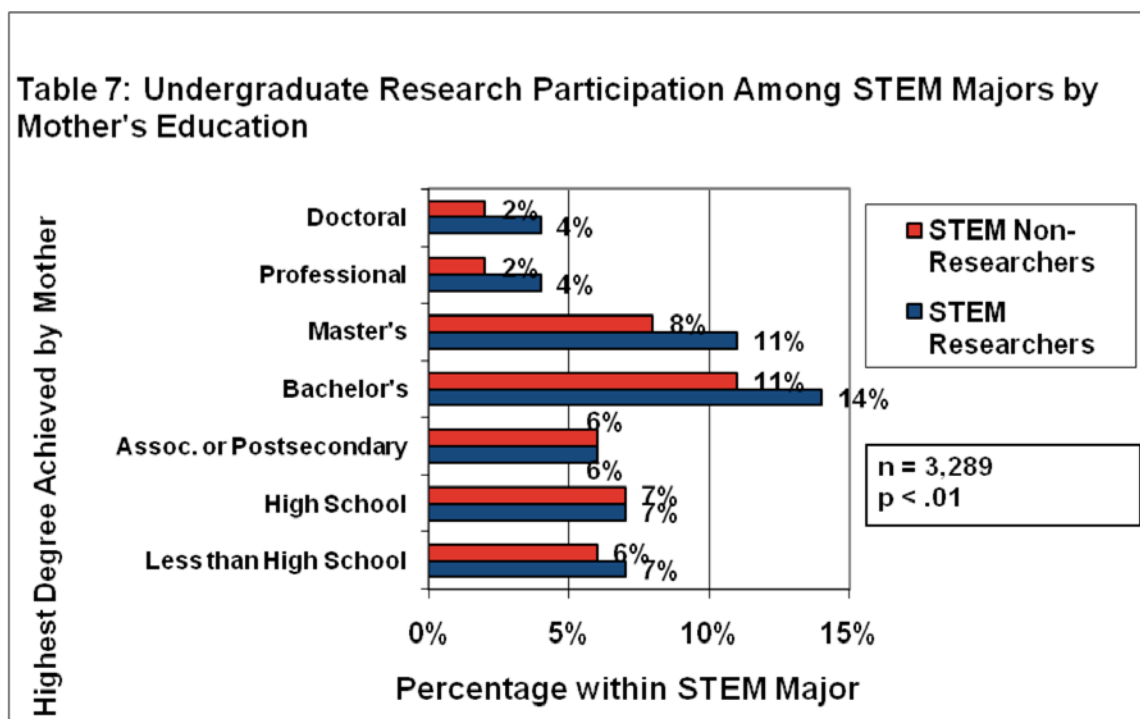
Tables 3 and 4 display ethnicity statistics that are remarkably parallel to the story told in Table 2 regarding gender and type of major. In STEM fields, women, Chicano-Latinos, and African Americans participate at the lowest rates. In non-STEM fields, women, Chicano-Latinos, and African Americans participate at the highest rates. This is remarkable given the fact that there are a number of high profile university, department-based, and external programs and interventions aimed at encouraging women and minority students to participate in undergraduate research in STEM fields. For example, the Biology Scholars Program supports over 500 under-represented students to gain access to research internships in the sciences. These data show that the Biology Scholars Program and other programs with similar missions should continue to be supported and encouraged in order to equalize the undergraduate research participation rates of women and minorities in STEM fields.

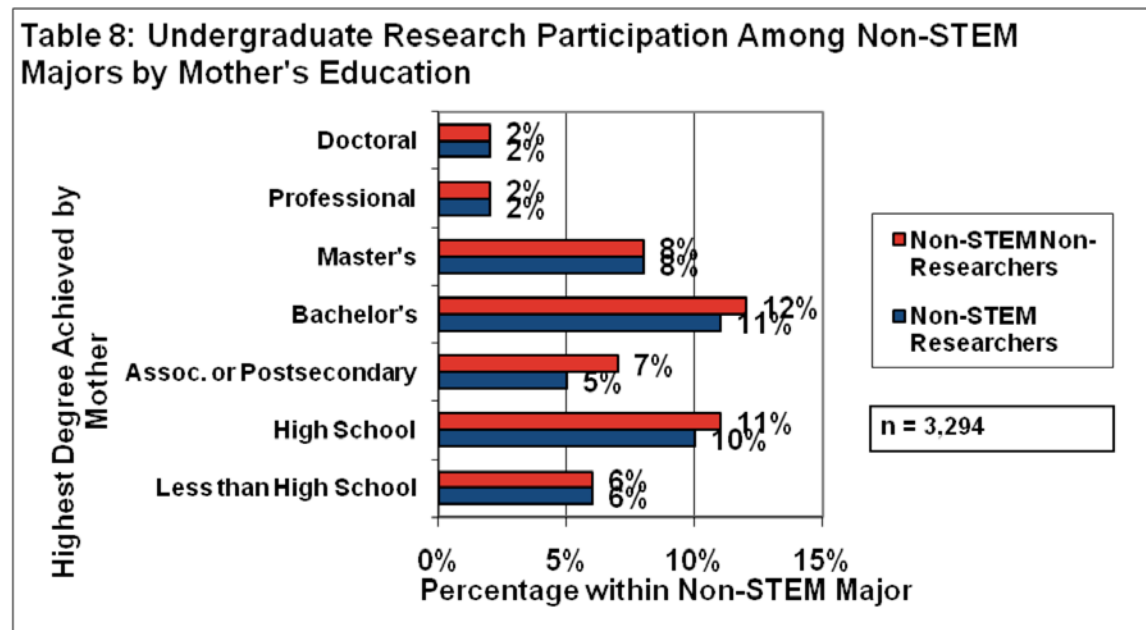
Some education researchers have argued that academic achievement is, at least in part, driven by the achievements of one's parents (Fordham & Ogbu, 1986; Pearce, 2006; Waters, 2000). This may be especially true for students on a path towards research-oriented careers, such as higher education faculty positions. For this reason, I analyzed the relationship between the rate of undergraduate research participation and the highest education level for the student's father and mother.





The data reveal a significant difference between STEM researchers and non-researchers with regard to the education level of their father (see Tables 5). Overall, significantly more STEM researchers report that their fathers hold a masters, professional, or doctoral degree than non-researchers ($p=.02$). However, Table 6 shows that in non-STEM fields, a father's education level is not predictive of undergraduate research activity. This same trend between STEM and non-STEM researchers and non-researchers holds when investigating participation rates relative to the education level of students' mothers.

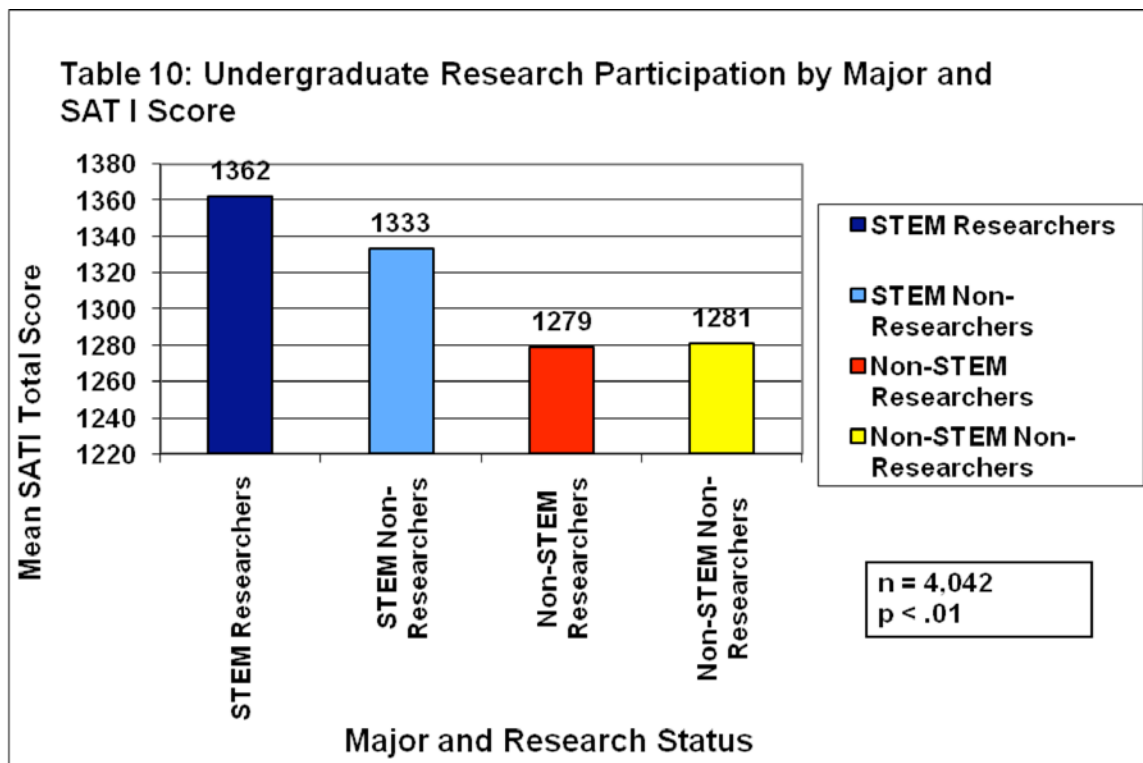
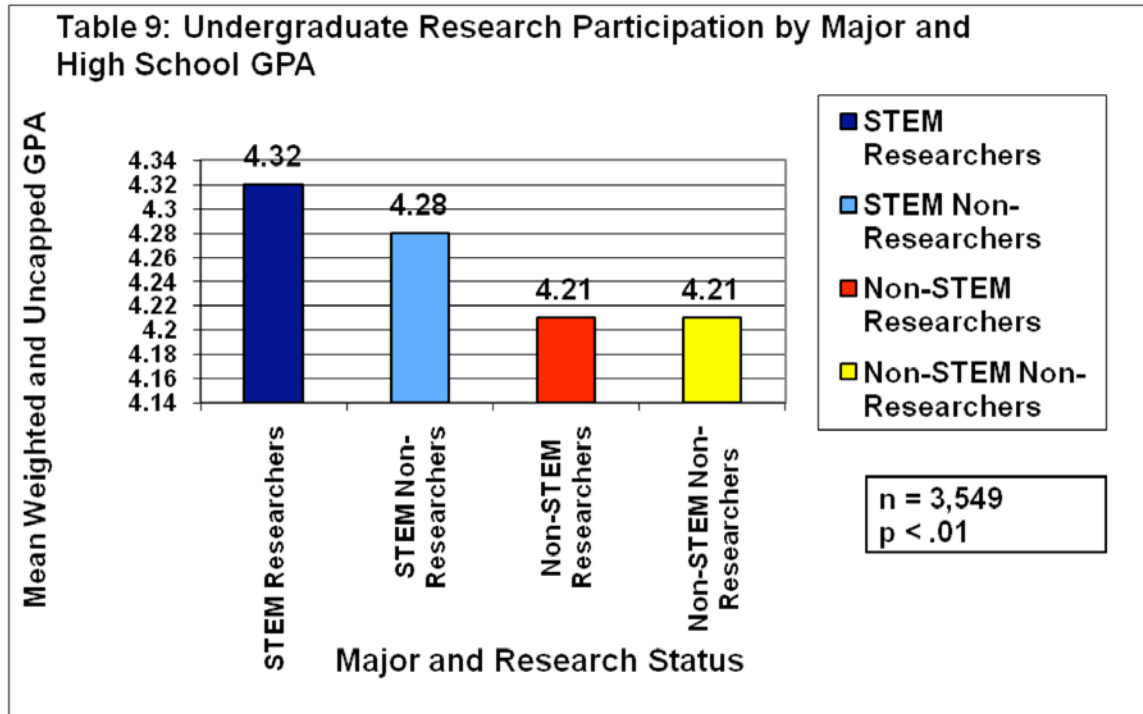




Tables 7 and 8 show that STEM researchers are more likely to have a mother with a bachelor's degree, master's degree, professional degree, or doctorate than STEM non-researchers but between non-STEM researchers and non-researchers there is no significant difference in the mother's education level.

These findings suggest that students, especially STEM majors, who are taking advantage of opportunities to participate in research projects may be doing so because their families are familiar with the nature and the benefits of such work. Furthermore, these data imply a "culture difference" between STEM and non-STEM fields. Highly educated parents of STEM students may be encouraging their children to participate in undergraduate research because the experience may help their child gain access to graduate level, professional education, and eventually careers in STEM fields. Highly educated parents of non-STEM students, on the other hand, may not feel the need to suggest undergraduate research to their children because it may be less important for graduate work or non-STEM careers. These data suggest that the university could do a better job educating all undergraduates regarding what undergraduate researchers do and the benefits of undergraduate research participation.

One important critique of previous attempts to understand the benefits of undergraduate research experience is that undergraduate researchers appear to be more likely to do well and to persist in college and go on to graduate study and careers, since they are more talented or better motivated students in the first place, and not because of their undergraduate research internships. This represents the problem of sorting out self-selection bias in evaluating research opportunity programs. With this critique in mind, it is important to know whether the population of researchers and non-researchers at UC Berkeley are significantly different with regard to their incoming high school grade-point average and standardized test scores (SAT I). This analysis shows that researchers and non-researchers are in fact significantly different with regard to these measures (see Table 9 and 10).



As with many of the other analyses in this study, when looking in the aggregate, significantly more researchers have a 4.25 or above, weighted, uncapped high school grade-point average ($p=.01$) and a total SAT I score of 1360 or above ($p<.01$). However, these findings are nuanced when accounting for type of major. While it is true at UC Berkeley that STEM students with high high school GPA and SAT I scores appear more likely to participate in

undergraduate research, there is no relationship between high school GPA or SAT I score and non-STEM undergraduate research participation.

These data are further evidence of a cultural difference in undergraduate research participation between the STEM and non-STEM fields. These data suggest several possibilities regarding the sources for these discrepancies. For instance, it is possible that research internships in STEM fields are more competitive than in non-STEM fields and that STEM faculty use traditional measures of academic success (GPA, standardized test scores, etc) to eliminate students they are not interested in working with. However, the students in this study were all upper-division students, so it is unlikely that high school GPA and test scores would completely determine their chances for an STEM research internship. Another possibility is that students who were traditionally successful in high school are more likely to seek out internship arrangements. However, this hypothesis does not hold true in non-STEM fields. A third possibility is that STEM students who were traditionally successful in high school are better prepared for STEM majors in college and are more able to integrate these time-consuming extra-curricular activities to their schedule without jeopardizing their college GPA than lower achieving STEM students. This hypothesis could be tested by investigating the relationship between college GPA and rate of undergraduate research participation. There are many other hypotheses that could explain these data. These findings also highlight the need for program evaluators and researchers in this field to control for previous academic achievement when evaluating the benefits of undergraduate research participation, especially in the STEM majors.

Limitations

There are several limitations to this analysis. For one, solely using UCUES responses to determine research status may not be sufficient to establish whether a student is an undergraduate researcher or not. It is vitally important that students who have conducted faculty-supported research are not included in the comparison group with non-researchers. In order to rigorously evaluate some of the purported benefits of undergraduate research internships, it is important to have an outside means to verify research status. Transcripts and undergraduate research program rolls (such as those of the Biology Scholars Program or the Undergraduate Research Apprentice Program) might provide such a verification.

Another limitation of this analysis is that it only makes use of one year of data (2006) and is limited to a single University of California campus. The UCUES database stretches back to 2002 and includes all nine undergraduate campuses. It is conceivable to conduct this analysis by making more extensive use of the database.

Conclusions and Implications

This study provides a foundation for understanding the extent and possible implications of undergraduate research participation at the most prestigious public research university in the country, the University of California, Berkeley. These data show that nearly half of upper-division students have participated in undergraduate research. This is a significant accomplishment for a university of this size. Furthermore, it is also a significant accomplishment for a large public university that there appears to be relative racial and gender parity in research participation. However, a detailed analysis shows that the university could do more to recruit women and minorities into STEM research internships, men and minorities into non-STEM research internships, students from less well-educated families into STEM internships, and students with low or average previous academic achievement into internships. These results also highlight the importance of controlling for GPA and SAT I scores when evaluating the impact of undergraduate research experiences in the STEM fields.

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