

Requiring Research May Improve Retention In STEM Fields for Underrepresented Women

The United States' current shortage of professionals trained in science disciplines (National Science Board 2010) may be partially attributed to the historical underrepresentation of women and minorities in the sciences (Margolis & Fisher 2001; Preston 1994). Studies examining this issue have shown that, although similar percentages of Caucasian and African-American students begin college with the intention of majoring in a science, the attrition rate is much higher for minorities, even when adjusting for SAT scores and high-school success in science classes (Busch-Vishniac & Jarosz 2007; Maton, Hrabowski III, & Schmitt 2000; Seymour & Hewitt 1997). Similar trends have been observed between male and female students (Seymour & Hewitt 1997).

Factors such as mis-matches between student and faculty expectations for quality of work, and minimal faculty involvement, as well as non-supportive peers, have been cited as contributing to dropout rates (Daempfle 2004; Leslie, McClure, & Oaxaca 1998; Maton, et al. 2000; Seymour & Hewitt 1997). In response, multiple programs have been implemented at universities across the country in an attempt to bolster minority retention in science disciplines. A common feature of these programs is the inclusion of undergraduate research with peer and faculty mentoring, together with the establishment of learning communities centered on undergraduate research (Foertsch, Alexander, & Penberthy 2000; Locks & Gregerman 2008; Nnadozie, Ishimaya, & Chon 2001; Stoecklin & Harmon 1998; Summers & Hrabowski 2006).

Significant evidence indicates that students who participate in undergraduate research are more likely to be retained in science fields during their undergraduate careers, a finding especially pronounced for students from under-represented demographic groups (Bauer & Bennett 2003; Foertsch et al. 2000; Nagda, Gregerman, Jonides, von Hippel, & Lerner 1998; Summers & Hrabowski 2006). Nagda et al. (1998) and Summers and Hrabowski (2006) found that participation in undergraduate research produces higher graduation rates for

African Americans in science majors than is commonly found for universities overall.

Participation in undergraduate research has also been shown to increase retention in science fields after graduation. Bauer & Bennett (2003) found that participating in undergraduate research increases the likelihood of students' attending graduate school (71 to 80 percent among research participants versus 59 percent for their non-participating counterparts). Foertsch et al. (2000) found that participation especially increased graduate-school attendance for African-American students (75 percent of those who participated in research continued on to graduate school compared to only 8 percent of those who did not).

One reason why undergraduate research improves student retention in the sciences is that many students report developing positive perceptions of their fields and of their abilities to be scientists as a result of undergraduate research. Specifically, students report that undergraduate research improves their ability to "think like a scientist" and/or do science (Hunter, Laursen, & Seymour 2007; Kardash 2000; Russell, Hancock, & McCullough 2007; Seymour, Hunter, Laursen, & DeAntoni 2004); increases their intellectual curiosity (Bauer & Bennett 2003); increases their confidence/self-efficacy in their discipline (Hunter et al. 2007; Russell et al. 2007; Seymour et al. 2004); improves their oral communication skills (Bauer & Bennett 2003; Hunter et al. 2007; Kardash 2000; Seymour et al. 2004); improves their ability to write professionally (Kardash 2000); and increases their technical skills (Bauer & Bennett 2003; Kardash 2000). Many students also report that undergraduate research confirms or helps them to refine their career goals (Hunter et al. 2007; Seymour et al. 2004) or increases their interest in attending graduate school (Russell et al. 2007). Thus, a substantial body of evidence suggests that undergraduate research improves retention in science at a time of expanded global demands for science graduates.

For the most part, however, all this research—while providing a wealth of information about why doing research

as undergraduates encourages students to study more science—involved only students who decided on their own to participate in research. Thus these studies did not compare outcomes for students who already believed they would enjoy research versus those who did not think they would or those who had simply never considered participating in undergraduate research (but see Nagda et al. 1998). Much of the research, then, reflects self-selection effects, and little information exists on the potential uses of mandatory research experiences as a mechanism to expand the pool of students retained in science fields.

Further, current data conflict regarding the impact of mandatory undergraduate research. For example, in a nation-wide survey conducted from 2003 to 2005 to assess the benefits of undergraduate research, students were asked about their motivation to conduct undergraduate research (Russell et al. 2007; Russell 2008). Students who cited the need for course credit or departmental requirements as their motivations for participating were less likely to report that the experience was beneficial than were students who chose to conduct research for other reasons; they were also less likely to pursue a PhD (Russell et al. 2007; Russell 2008). Based on these results, Russell (2008) proposed that forcing students to do research might be counterproductive. Blanton (2008) took this interpretation as evidence against requiring research. However, Russell presented only the percentage of students who listed each motivator as “extremely important.” While Russell found that citing course credit/course requirements as *the most important* motivation for engaging in undergraduate research was correlated with perceiving no/low benefit from the experience, this does not mean that requiring students to do research causes them to perceive the experience negatively.

Russell et al. (2007) surveyed students who did not conduct research and found that many chose not to engage in undergraduate research due to lack of time and/or opportunity. Additionally, some students said that it had never occurred to them to do such research. If students were required to conduct research, lack of opportunity or awareness would not be factors preventing them from engaging in research, and some of them might cite motivations such as interest and desire to learn, as well as

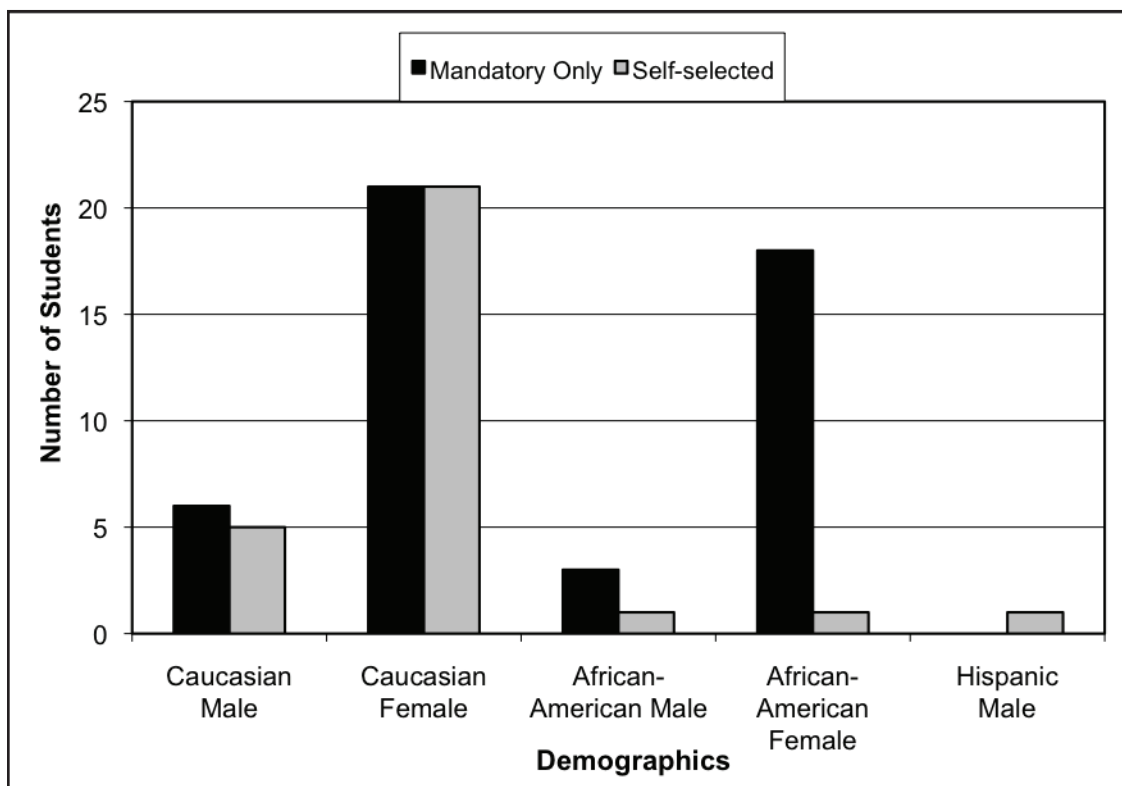
the requirement to participate, in decisions to conduct research. Even if only a small percentage of these students received the benefits of undergraduate research, it would be worth the effort.

To try to clarify the situation, we studied a population of students who are required to conduct research in order to graduate. Since the early 1990s, all biology majors at the University of South Carolina, Aiken (a small teaching-oriented university) have been required to conduct a mentored research project for at least one semester during their senior year. This requirement coincides with a seminar-style class that provides guidance in writing a research proposal, constructing an oral presentation, and writing a research report. The experience culminates with a presentation to the biology faculty and students. Many of these students also present their work at local conferences and/or co-author a published manuscript.

Students are encouraged to speak to several possible research mentors. After doing so, they must initiate a relationship with the mentor of their choosing and work with their mentor to develop a research project. Students also have the opportunity to do independent research projects for any number of semesters before their required senior-year project. This allows motivated students to begin their research experience earlier and to be involved longer. Some students opt to do a variety of projects with several different faculty members.

The purpose of this study was to gather preliminary data on perceived benefits and possible detriments of a mandatory undergraduate research requirement, by conducting a survey of recent biology graduates. It was hypothesized that students who would otherwise decide on their own to do research would experience no negative consequences from a required program and that students who would not have previously considered doing a research project would receive some of the same benefits as the self-selecting students. It was also hypothesized that there would be a racial bias, in that fewer racial minorities would decide on their own to participate in research. Thus, we hypothesized that minority students would receive the most benefit from mandatory participation in undergraduate research, given that fewer minorities are retained in the sciences and that minority students are less likely to decide independently to do undergraduate research.

Figure 1. Frequency of undergraduates who decide on their own to participate in research, by ethnicity and gender versus those who conducted only mandatory research.



Research Methods and Design

Using enrollment data from the registrar, we identified the number of biology graduates from spring 2007 to fall 2009 who only participated in the one semester of mandatory research, as well as those who participated in undergraduate research prior to the required senior semester. Demographic information was collected on each graduate. A chi square analysis was conducted to determine whether there were significant differences in the rate of self-selection to participate in research by gender or race.

A survey, constructed by the first author, was emailed to alumni who participated in undergraduate research between spring 2007 and fall 2009. The survey was composed of open-ended questions designed to gather demographic data and to solicit perceived benefits and challenges of participation in the required undergradu-

ate research program. The survey included the following questions:

1. What race/ ethnicity and gender do you consider yourself to be?
2. Were you the first person in your family to go to college? Did your parents go to college?
3. Why did you choose biology as a major? For how long have you been interested in biology?
4. Before finding out about the research requirement, did you ever think about doing a research project? Why or why not?
5. What benefits, if any, did you gain from doing a research project?
6. What were the best parts about doing your research project?

7. What were the worst parts about doing your research project?
8. What are your current career or further education goals?
9. Do you think that doing a research project helped in your career or further education? If so, how?
10. In your opinion, was the research experience worthwhile?

The responses to each item were compiled and reviewed for underlying themes. From there, taxonomies (Spradley 1980), such as *benefits of engaging in undergraduate research*, were created by categorizing responses to each interview question (e.g. *What benefits, if any, did you gain from doing a research project*). The coding scheme was then reviewed for internal consistency and codes that were not mutually exclusive or that failed to provide sufficiently unique information were combined; when needed, new codes were added. After all the survey responses were coded, the frequency of each code was computed. This process of quantifying qualitative data assisted in identifying patterns in the data and in maintaining analytical integrity (both common reasons for engaging in data conversion; see Teddlie & Tashakkori 2009).

Results and Discussion

Descriptive statistics are presented regarding the demographics of students who participated only in the mandatory research requirement during their senior year versus those who voluntarily conducted additional semesters of undergraduate research. Chi-square analysis was used to detect differences in the rate of voluntary participation in undergraduate research by gender and race. Finally, results from analyses of survey responses are described.

Demographics

University records revealed that, during the three years for which data were collected, 36.4 percent (28 out of 77) of the biology graduates initiated research prior to the mandatory one semester of the senior-year research. This is consistent with data from the National Survey of Student Engagement that surveyed 209 four-year col-

leges and universities in the United States and found that 39.4 percent of biology majors participated in research with a faculty mentor (American Council of Learned Societies 2007). Of the 28 students who decided on their own to begin participation in research, only three were not Caucasian—one African-American female, one African-American male, and one Hispanic male. Since 31 percent (24 of 77) of the students in our sample were African American or Hispanic, but only 11 percent (3 of 28) of the students who self-selected came from those groups, Caucasian students appear to initiate research much more readily than non-Caucasian students.

Almost universally, African-American females in this study did not participate in research experiences unless required to do so (Figure 1). In contrast, half of the Caucasian females decided independently to participate in research. A chi square analysis was conducted to test whether these differences were statistically significant. An average rate of participation of 36.4 percent was used as the expected value if race were not a factor, because that was the overall percentage of graduates who decided on their own to participate in research. The Caucasian female and male students who self-selected research did not differ significantly from the expected level (χ^2 expected values = 2.28 and 0.372 students respectively). Since only one African-American female decided on her own to do research, however, this was significantly fewer than the expected number of eight students (p -value <0.05).

Perceived Benefits

To supplement the participation data, a survey was sent to all alumni who had graduated from the biology department from 2007 to 2009. Ten students responded (for a 13 percent response rate). All ten respondents were female (which is not surprising since 79 percent of the biology graduates were female); five were Caucasian and five were African American. Three of the 10 respondents were first-generation college students. Of the respondents, six reported the desire to conduct undergraduate research before learning of the requirement and four reported not wanting to do research. Of those who did not desire to do research, all were African-American

females. Two of them said that they had little prior interest in conducting research; one said it had never crossed her mind, and one noted low confidence in her ability to conduct research. The African-American student who reported a desire to conduct research was the same student noted as having participated in more than one semester of undergraduate research.

All ten respondents reported that the experience had been worthwhile and helpful in achieving post-graduation goals, with five reporting increased knowledge, three reporting an increased sense of professionalism regarding careers or graduate school, and one reporting an increase in self-esteem. Of the four students who reported no desire to conduct research beforehand, two subsequently enrolled in a master's degree program, one enrolled in pharmacy school, and one was applying to graduate programs at the time of the survey. The following quotes are from the four African-American females who had no interest in conducting research prior to participating in the mandatory experience:

I was able to become more familiar with the vast components of biology beyond what was discussed within a class. I was able to apply classroom knowledge to my work in the lab. I was also able to better understand processes that I considered to be confusing in the past. I believe this experience has already granted me the opportunity ... many undergraduates did not have. I feel that the experience was worthwhile. I now feel more confident overall in studying biology. (This respondent was applying to graduate schools at the time of the survey.)

I never thought about doing a research project because it seemed to be boring having to work in a lab doing research. I realized the many types of research that could be done and [their] importance. I learned many techniques and terms that will be beneficial to a career choice in public health. (This respondent was enrolled in a master's degree program in public health.)

I have never had a great interest in working in a laboratory type of setting. I definitely think that doing a research project ... will help me in my career. I feel a good sense of accomplishment after

completing my research project and presentation. (This respondent was enrolled in a pharmacy doctoral program.)

I never thought about doing a research project because I thought it would have been hard to accomplish. The benefits that I gained through this research were having the ability to try something different and feeling good about myself because the experiment was a success. Doing a research project helps because it gives you the experiences of doing hands on work, teaches you what to expect, and how [to] learn from your own mistakes. (This respondent was enrolled in a master's degree program in biology.)

These results, while preliminary, strongly suggest that mandatory research experiences may be a significant mechanism for engaging African-American females in the science, technology, engineering, and mathematics (STEM) pipeline—students who might otherwise have been lost to it. Given that these four students had not conducted research prior to their senior year, it is likely that without the mandatory experience, they would have graduated without realizing they might be interested in research. Their quotes further indicate that, were it not for the mandatory research experience, they would not have pursued of higher degrees in STEM-related fields.

Conclusions and Recommendations

Undergraduate research experiences clearly have been shown to be important for retention of underrepresented groups in science. Such experiences can increase the percentage of participants attending graduate school (Bauer & Bennett 2003; Foertsch et al. 2000) and reduce attrition in the undergraduate years, with African-American students with lower entry scores receiving the greatest benefit (Nagda et al. 1998) and being twice as likely to graduate (Summers & Hrabowski 2006). What has been less studied is whether mandatory research experiences increase access to science fields for underrepresented groups.

Preliminary results from this study suggest that mandatory research experiences may be an effective mech-

anism for increasing access to STEM careers, particularly for African-American females. Caucasian students were as likely to self-select into research as not, but African-American females almost uniformly would have avoided research were it not for the mandatory requirement. Our survey of recent graduates suggests that students required to do research perceived the same benefits as those cited by Russell et al. (2007). All respondents strongly agreed that their research experiences helped them in their future careers and graduate studies in science fields. Of those surveyed, all Caucasian respondents indicated that they had thought of doing research before knowing about the requirement (and in fact all of them had done more than just the one semester of research), but only one of the African-American respondents said she would have done research if it had not been required.

Two conclusions can be drawn from this study. First, requiring a research experience in no way diminished the benefits perceived by students, whether or not they decided on their own to do research. Thus institutions or programs that desire to increase the number of underrepresented students in STEM fields may wish to consider implementing mandatory research experiences for targeted populations. Second, mandatory research appears to retain minority women more than other under-represented groups. Thus funding agencies and policy-setting bodies concerned with increasing retention in STEM fields after the baccalaureate degree may wish to consider providing incentives or rewards for institutions and programs that institute mandatory research requirements.

This work represents one institution in a state with a high percentage of minority students and focuses on a single STEM field. Other institutional contexts may result in stronger or weaker effects and warrant investigation. Additionally, this mandatory research experience occurred quite late in the students' undergraduate careers. For those programs that have the capability, requiring students to participate in research at an earlier point in their undergraduate years might yield even greater retention and perceived benefits. We hope this study will initiate conversations and future research on the potential of mandatory research for increasing the representation of minority females in the STEM pipeline.

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