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**Undergraduate Research Experience: Intention and Doing for STEM Majors**

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## Undergraduate Research Experience: Intention and Doing for STEM Majors

### Abstract

This study investigated the effects of undergraduate research (UR) experience on student engagement for STEM majors. Student academic engagement differed significantly by UR participation in the senior year. We examined whether these differences existed in the first-year and found that the differences in academic engagement were there but smaller in size. We also found that some student characteristics differed in student participation in this high impact educational practice. The majority of STEM majors who planned to do UR during first-year actually participated in UR before graduation. We found that there were differences among the planning to do group based on their subsequent participation in UR.

## Undergraduate Research Experience: Intention and Doing for STEM Majors

### Objectives of the study

The objective of this study is to investigate the effects of undergraduate research (UR) experience for STEM majors. Most of the studies that examine the UR experience look at the effects at one point. This study looks at how student academic engagement differs by UR participation. It examines also whether these differences existed in the first-year of college and whether these differences are in similar way for female and minority students (critical group in STEM majors). This study also scrutinizes the students who plan to do undergraduate research in first-year and how these plans and experiences are related to student engagement.

### Theoretical framework

The educational benefits of student participation in undergraduate research (UR) in STEM fields are well known. Students majoring in STEM fields who participate in UR have increased rates of persistence, enhanced confidence and research skills, and higher degree aspirations (Lopatto, 2006; Russell, Hancock, & McCullough, 2007). As a result many federal agencies (NASA, NIH, NSF, etc) and other professional organizations (e.g., AASE) encourage undergraduate research for students majoring in STEM fields as a means for increasing degree completion, ultimately the number of scientists, engineers, and other professionals trained to work in a STEM career.

Undergraduate research in STEM fields is of particular importance. Similar to students in other majors, students majoring in STEM fields who participate in UR have increased rates of persistence, enhanced confidence and research skills, and higher degree aspirations (Hunter, Larsen, & Seymour, 2006; Lopatto, 2007; Russell, Hancock, & McCullough, 2007). As a result of the many studies showing the benefits of undergraduate research, many federal agencies

(NASA, NIH, NSF, etc) and other professional organizations (e.g., AASE) encourage undergraduate research for students majoring in STEM fields as a means for increasing the number of scientists, engineers, and other professionals highly trained to work in a STEM career.

Though the benefits of UR are well-accepted, what is still in question is how to increase participation in UR. It has been suggested that to increase participation in UR it is important to develop that expectation and “enthusiasm” as early as possible (Russell, Hancock, & McCullough, 2007). Though little is known about how the expectation to participate in UR relates to actual participation, prior research has established that developing expectations are important precursors to actual behavior. Expectations influence the upcoming choices (major, course selection, etc) students make as their first year of college progresses. As Konings, Brand-Gruwel, van Merriënboer, and Broers (2008) claimed, “Expectations affect students’ motivation, engagement, and investment of effort in learning” (p. 536).

This longitudinal study will investigate expectation of first-year STEM college students to participate in UR and their actual participation UR by the spring of their senior year. It is hypothesized that those first-year students who report an expectation to participate in UR are more likely by the spring of their senior year to persist as a STEM major, actually participate in UR, and report greater levels of academic engagement.

### Method

This study utilizes data from the *National Survey of Student Engagement* (NSSE); a questionnaire that measures the degree to which first-year and senior students engage in educationally meaningful experiences (Chickering & Gamson, 1987; Kuh, 2001, 2003). Since its inception in 2000, more than two million undergraduate first-year and senior students enrolled at

more than 1,300 four-year institutions have completed the NSSE survey of colleges and universities throughout the United States and Canada.

This longitudinal study used data from four and five year intervals of NSSE administration. The institutions that participated in multiple years of NSSE were identified from 2004 through 2010. Seven year patterns were used to identify students who have done NSSE as first-year and seniors: 2004-2007 (4-year group- 15%), 2004-2008 (5-year group-4%), 2005-2008 (4-year group-13%), 2005-2009 (5-year group- 1%), 2006-2009 (4-year group-27%), 2006-2010 (5-year group- 5%), and 2007-2010 (4-year group-36%). Student-level matched data identified for 14,895 STEM majors enrolled at 412 institutions. Thirty-four percent of the institutions were public, 17% doctoral, 45% masters, and 35% baccalaureate granting institutions. Sixty-two percent of the students were female. The designation as a STEM major was based on student self-reporting. Also, only institutions where there was an opportunity to participate in UR were included in the study. We removed from the study institutions where no STEM student (or very low percentage) reported participating in UR. Obviously for these institutions the opportunity for UR did not even exist. We want to exclude those students who did not participate in UR who were enrolled at institutions where the opportunity did not even exist.

A majority (83.6%) of the sample was White, 6.5% Asian American or Pacific Islander, and the remaining (3% African American and 3% Hispanic) were identified as underrepresented minority. Eighty-five percent lived on campus in first-year and 35% during senior year. About 30% reported as first-generation college student (neither parent has a baccalaureate degree from a college). Thirty-six percent of the sample has participated in undergraduate research.

The survey included one item about undergraduate research participation, whether students had worked on a research project with a faculty member outside of course or program requirements. The response options were done, plan to do, do not plan to do, and have not decided. Gender, ethnicity, SAT score, and class were provided by institutions. The remaining demographics and engagement behaviors were taken from the survey. Three “Benchmarks of Effective Educational Practice” were created using other NSSE items. These benchmarks, Level of Academic Challenge (LAC), Active & Collaborative Learning (ACL), and Student Faculty Interaction (SFI), indicate different types of academic engagement (Kuh, 2003). NSSE has been suggested by the US Department of Education's Commission on the Future of Higher Education (the “Spellings Commission”) (2006) as one of the exemplar tool in student learning assessments.

## Results

It is expected that first-year STEM students who have an expectation to participate in undergraduate research with faculty will more likely persist as a STEM major through their senior year. Data from this longitudinal study found that students who plan to participate in UR persisted in STEM fields slightly higher than those who have not decided and those who do not plan to do. First-year expectation slightly favors plan-to-do and not decided groups over those who do not plan to participate in UR (Figure 1).

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INSERT FIGURE 1

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It is also expected that FY students who have the expectation for UR will in fact participate in UR at a higher rate than those students who do not. Based on first-year expectations, a majority of the students (47%) planned to do UR while thirty-seven percent did not decide whether or not they will participate in UR. Around sixteen percent of the FY STEM students indicated that they did not plan to participate in UR at any point prior to graduation. However, as indicated in figure 2, those who planned to do undergraduate research were much more likely to do so (54%) by the end of their senior year compared to first year students who reported that they did not plan to do or have not decided (21% and 30%, respectively).

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INSERT FIGURE 2

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Clearly the expectation of FY students to participate in UR is slightly linked with persistence in STEM, but is related with their subsequent participation in UR. As noted previously, the educational benefits of UR are becoming increasingly known. However, what is still not clear is the link between UR and the students' academic engagement as indicated by their participation in academically challenging activities (LAC), active and collaborative learning (ACL), and student-faculty interaction (SFI).

Two things are clear from the results presented in figures 3, 4, and 5. One is that participation in UR is related with increased levels of academic engagement (as indicated by LAC and ACL) and student-faculty interaction. Regardless of first-year intentions, all students who participated in UR reported significantly higher levels of engagement. For instance, as shown in figure 3, students who intended to participate in UR since their first year of college and did participate in UR by their senior year reported significantly higher levels of engagement in

academically challenging activities ( $M_{diff}=3.1; p<.001$ ). However, even students with no intention to participate in UR who subsequently did by their senior year reported significantly higher levels of engagement in LAC compared to their peers ( $M_{diff}=3.3; p<.001$ ). Similar differences for ACL are reported in Figure 4. Maybe not surprising is that the largest mean differences are found in student faculty interaction (figure 5). Clearly involving students in undergraduate research results in students have significantly higher levels of interaction with faculty.

The other conclusion that can be drawn from figures 3, 4, and 5 is that intentions to participate in UR matter. In all instances, first-year students that intend to participate in UR but did not by their senior year, reported significantly higher levels of engagement compared to their peers who did not share the same intentions. For instance, FY students who intended to participate in UR but did not reported a mean level of student faculty interaction in their senior year of 51.2 compared to an SFI mean score of 46.4 for first year students who did not intend to participate in UR and did not by their senior year ( $M_{diff}=4.8; p<.001$ ). This provides evidence that not only participation in UR facilitates other forms of academic engagement, but also the intention to participate in UR is significantly related with increased levels of engagement. Together these two factors contribute to the highest levels of engagement in LAC, ACL, and SFI.

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INSERT FIGURES 3, 4, and 5

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Discussion and Significance of the Study

National reports and scholars are of one mind in recommending engaging students in research experiences to enrich the undergraduate experience (AAC&U, 2007; Boyer Commission, 1998, 2002; Council on Undergraduate Research [CUR] & National Conference for Undergraduate Research, 2005; Hu et al., 2008; Karukstis & Elgren, 2007). The findings from this study point to couple of conclusions about undergraduate research and student expectations. As noted by Russell, Hancock, and McCullough (2007) it is important to foster interest and expectations early in the students' career for participating in undergraduate research. These results provide additional evidence that developing expectations early matter. According to these results, students who had expectations to participate in undergraduate research during their first year had slightly higher retention percentages and were more likely to actually participate in UR compared to their peers. In addition, students who participated in UR reported higher levels academic engagement in their senior year regardless of their first-year plans. However, there is an added value for those student students who not only had the expectations to participate in UR but also did participated. Individually, they both contributed to engagement. But collectively the expectation and the subsequent behavior were linked with the highest levels of engagement. Higher expectation in first-year yielded more dividends in every aspect of engagement based on this longitudinal data set. We saw that differences in student engagement widened when students participated or not participated in UR. Overall, this study concurs with the importance developing expectations to participate in research during the first year of college.

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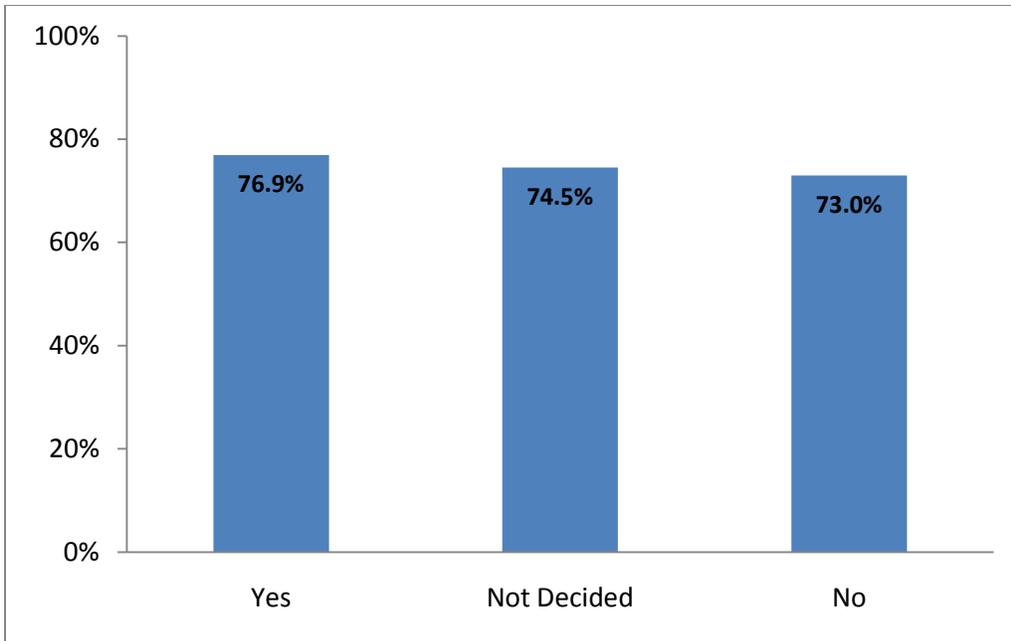


Figure 1. First-year students that planned to participate in UR and the percent that persisted as STEM major through their senior year.

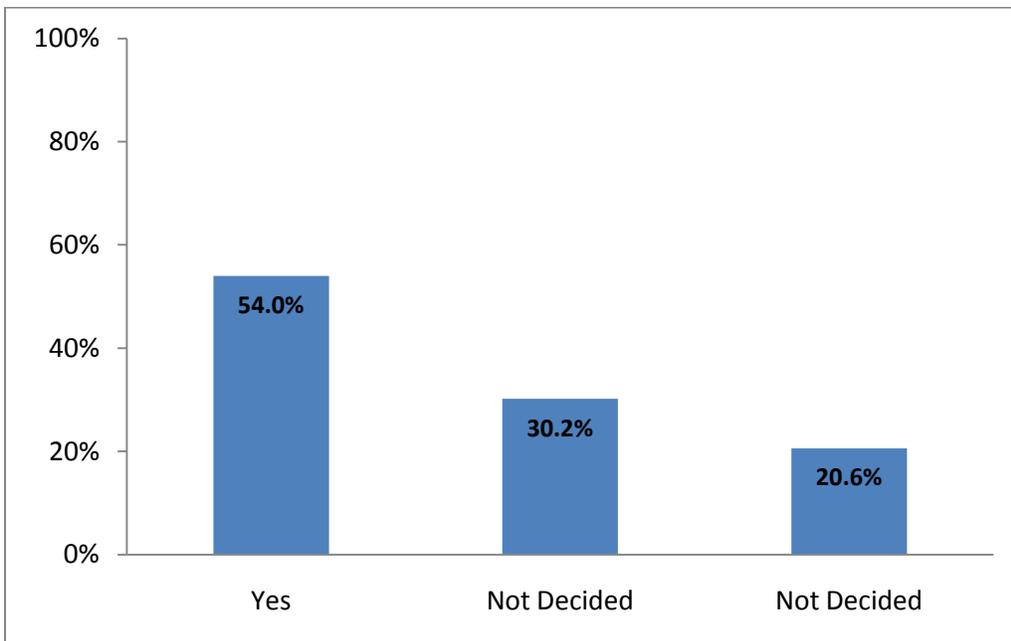


Figure 2. First-year student that planned to participate in UR and the percent that did participate during or before the senior year.

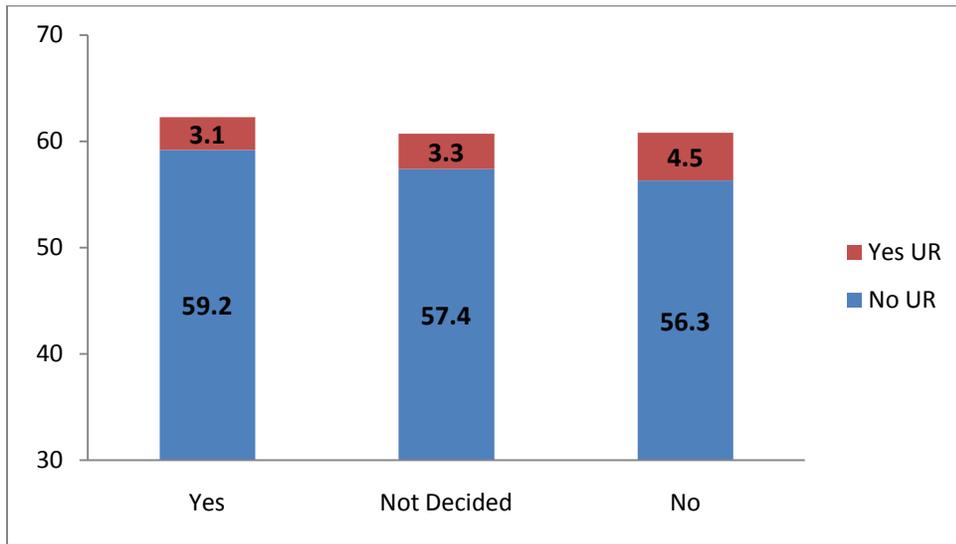


Figure 3. Increase in LAC for those students who participated in UR by their FY intentions.

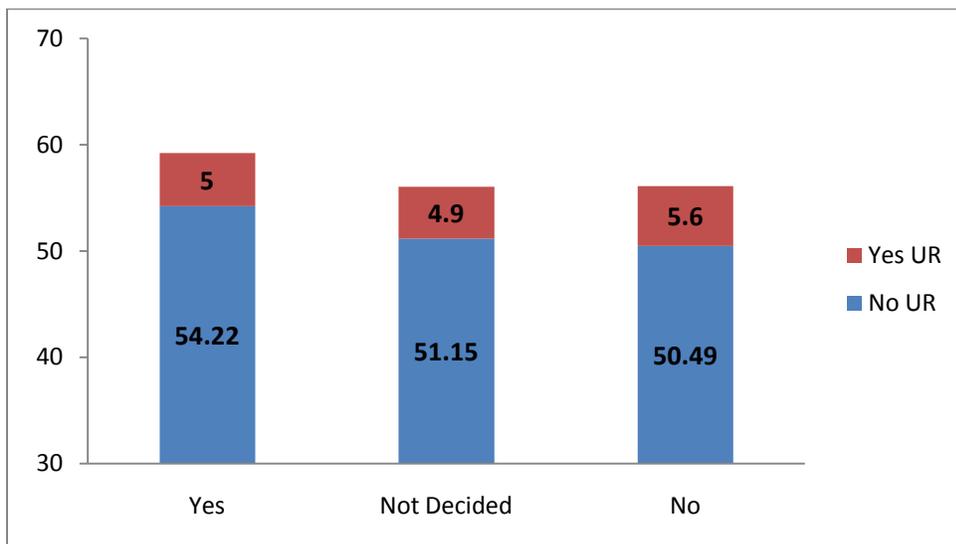


Figure 4. Increase in ACL for those students who participated in UR by their FY intentions.

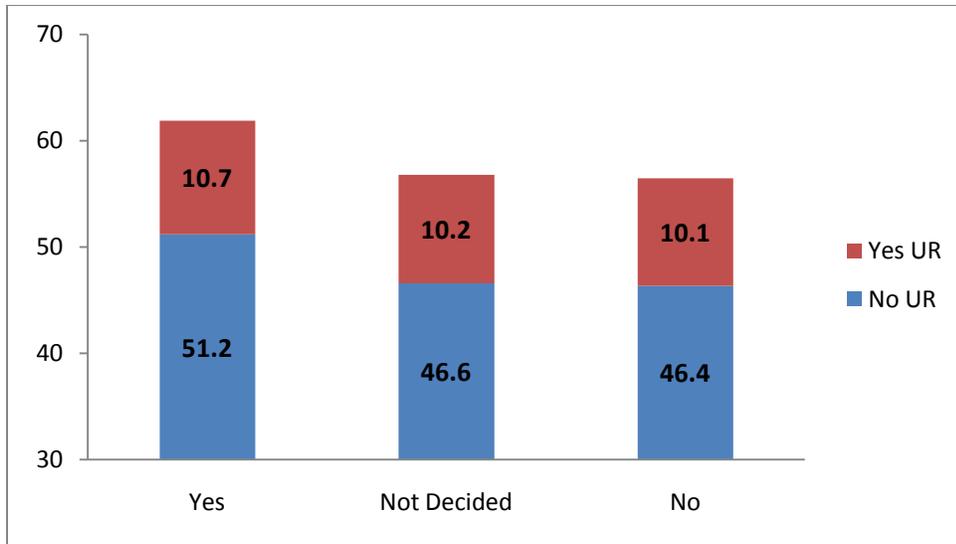


Figure 5. Increase in SFI for those students who participated in UR by their FY intentions.