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Student and Faculty Member Engagement in Undergraduate Research

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Abstract Undergraduate research (UR) is a valued co-curricular activity that has involved an increasing number of students and faculty members in recent years. While there is a growing body of research on student participation in UR, there is less research available examining faculty perceptions of, participation in UR, and how those factors influence student participation in UR. This study examined approximately 110,000 responses to the *National Survey of Student Engagement* and 40,000 responses to the *Faculty Survey of Student Engagement* at over 450 four-year institutions. Findings revealed that individual and institutional characteristics predicted student and faculty member involvement and that the majority of faculty members perceived UR to be of importance. Implications for fostering faculty involvement, student success, and viewing UR as an institutional asset are discussed.

Keywords Undergraduate research · Undergraduate research as co-curricular activity · Faculty member participation in undergraduate research

Introduction

During the past 15 years, undergraduate research has gained increasing prominence as a feature of the American college experience, in large part due to the Carnegie Commission report that urged reform in undergraduate education to make "research-based learning the standard" (Boyer 1998). Because of the calls to better integrate students in research, there has been tremendous expansion of programs at many colleges and universities, and Blanton (2008) proposed that undergraduate research has moved from a 'cottage industry' to a 'movement.'

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The Council for Undergraduate Research (CUR) defines undergraduate research activities as inquiries or investigations conducted by undergraduate students that make an original intellectual or creative contribution to the discipline. This broad definition emphasizes the intellectual content of the scholarly inquiry rather than the structure or format of the experience (http://www.cur.org). Participation in undergraduate research (UR) has positive benefits for student success as well as advantages for faculty and graduate students who serve as mentors to undergraduate students. For students themselves, participation in UR has been found to positively affect analytic and critical thinking (Bauer and Bennett 2008; Kardash 2000; Kuh et al. 2007; Pike 2006; Volkwein and Carbone 1994), increase academic achievement and retention (Cole and Espinoza 2008; Ishiyama 2002; Nagda et al. 1998), clarify choice of academic major (Tompkins 1998; Wasserman 2000; Seymour et al. 2004), and promote enrollment in graduate school (Bauer and Bennett 2003; Hathaway et al. 2002; Seymour et al. 2004; Lopatto 2004; Russell 2008).

Faculty members who work with undergraduates on research have to invest extra time and effort, but they, too, benefit from the experience. Zydney et al. (2002a) and Adedokun et al. (2010) found that faculty mentors report significant benefits to their quality of work and life. Potential future faculty—graduate students—benefit as well. Dolan and Johnson (2010) found numerous benefits for graduate students who serve as mentors to UR students, including greater career preparation, improved teaching and communication skills, and cognitive growth.

While there is a growing body of research on student participation in UR and the benefits of UR for those involved, there is less research available examining faculty perceptions of and participation in UR and how those factors influence student participation in UR. Two studies provide a useful start for the latter work (Eagen et al. 2011; Kuh et al. 2007), but have important limitations in terms of providing a general understanding of faculty participation in UR. The study by Eagen et al. was limited to science, technology, engineering, and mathematics (STEM) faculty, and did not link faculty measures to student participation. Focusing on deep learning, Kuh and Nelson Laird (2007) examined faculty perceptions and participation in UR and did link faculty perceptions to student participation in UR, but they did not report full model results. Also, these studies were limited to a fairly small institutional sample of about 200 institutions. The goal of the current study is to build on previous work that offers insight into faculty perceptions of and participation in UR as well as to examine the link between those faculty measures and student participation in UR. This study also extends previous examination of student and faculty engagement in UR via multilevel modeling that enables us to more precisely examine the contribution of institutional characteristics while holding individual characteristics constant. In this study, we examine factors that influence faculty members working with undergraduate students on research, factors that contribute to faculty perceptions of the importance of research, and factors that influence student participation in undergraduate research. This approach offers a unique opportunity to examine both faculty and student perceptions about UR as well as participation in this well-recognized co-curricular activity.

Literature Review

Growth in Undergraduate Research

Since the Boyer's Commission (1998) call to integrate students in the research experience over a decade ago, there has been a great expansion of formal UR programs across US

colleges and universities, transforming the practice from a "cottage industry to a movement" (Blanton 2008). Although UR was originally considered primarily for students in research universities and had its formal beginning in 1969 at MIT, it has grown widely, and throughout all levels of baccalaureate education (Hunter et al. 2007, 2010). In examining UR programs over the past two decades, Hu et al. (2007) found that undergraduate research programs in liberal arts and doctoral institutions have grown at a faster pace than similar programs at research universities. That growth may be due to curriculum changes or student and faculty interest. Public and private endorsement for UR confirms its importance, and supports students through targeted activities as well as through individual faculty researchers who receive extramural research funding. NSF REU awards in chemistry for 2009 averaged $10,000 per summer UR student (Colon 2009) and one study of 136 universities reported a total investment of $68.2 million for UR activities (Hunter et al. 2010).

As UR has expanded in colleges and universities, so too, has the depth and breadth of experiences that have been included in the scope of UR. The definition used to designate UR determines an institution's participation rate (Webber et al. 2012), and the depth, duration, and kind of UR activity can have a significant impact on the student and faculty gains received (Beckman and Hensel 2009). Mentioned above, the CUR definition for undergraduate research is broad and encompasses a variety of activities. The decision to use a broad definition is advantageous in that it enables students to get involved in some aspect of the inquiry-based process of learning, based on the area of student preference and level of commitment.

UR and Student Skill Development

The fundamental goal for UR activities is to strengthen the skills and abilities for baccalaureate students. Through a variety of short and long-term programs, UR is shown to have multiple benefits for students, including acquisition of analytic and synthetic thinking, increased confidence in ability to make presentations or speak publicly, and assistance with employment and/or graduate school.[1] With both academic year and summer science interns, Kardash (2000) reported that students made significant gains in research skills, including formulation of research hypotheses, data analysis, and written communication. Nagda et al. (1998) found participation in UR to increase African American retention. Consistent with previous findings (Bauer and Bennett 2008; Hu et al. 2008; Nagda et al. 1998). Buckley et al. (2008) found that the nature and extent to which students engage in UR determines the extent of benefit. If students become involved in reviewing the literature, contributing to research questions, methods, data analysis, and presenting findings, they are more likely to report making authentic gains in thinking and skill development compared to students who engage in surface tasks. Because a considerable amount of time and effort can be spent on UR, students participating in other time-intensive activities such as athletics or Greek life may mitigate students' participation in UR. Additionally students engaged in online or distance learning may not as easily make the connections to faculty members that are optimal for UR participation.

In a multi-institution study, Lopatto (2004) found multiple benefits for students, including evidence of critical thinking and strong interest in postgraduate study (Lopatto 2007). In a

[1] We acknowledge that self-selection is a limitation of many articles that address the effects of UR. Without controls or adjustments for self-selection, we cannot be certain if the effects are due to participation in UR or just that the people who participate in UR are those predisposed to get better outcomes.

broad evaluation of NSF's undergraduate research programs (Russell 2005) students reported many positive gains from UR, including increases in understanding aspects of science, confidence about research, achieving better GPAs, graduate school, and acquisition of careers in science. Specifically, Russell reported that 75 % of the respondents reported an increased interest in a STEM career as a result of their participation in UR.

Students' ability to become proficient at inquiry and synthetic thinking are important for deep learning and may be enhanced through UR. To that end, Kuh et al. (2007) found that when faculty members are actively engaged in research and help students to integrate and synthesize information (deep learning), student learning outcomes are greater. Indeed, faculty as mentors are an important component to effective UR and student learning, and Eagen et al. (2011) remind us that faculty member workload varies by type of institution and discipline. These authors found that faculty members in the life sciences were more likely to engage students in UR than peers in other disciplines. They also found that faculty members in HBCUs and liberal arts colleges were more likely to engage students in UR than peers at predominantly White institutions and master's comprehensive institutions, respectively.

Along with gains during college, the benefits of UR appear to last for students well beyond their baccalaureate years. Alumni who participated in UR as undergraduates were more likely to attend graduate school (Bauer and Bennett 2003; Laursen et al. 2010) and remain in contact with research faculty after graduation (Hathaway et al. 2002). Based on survey responses from nearly 1,000 alumni, some of whom had participated in undergraduate research and some of whom had not participated in research as an undergraduate, Bauer and Bennett found that participation in UR was valued by alumni. When asked to rate their satisfaction with and long-term value of their undergraduate experience, alumni respondents who participated in research as undergraduates rated their experience significantly higher than those alumni who did not participate in UR. It is not surprising, then, that 92 % of alumni who participated in UR said the experience was 'very' or 'extremely important' to their overall education (Bauer and Bennett).

The Effect of UR on Faculty Members

While the reasons for and effects of participation in UR on students are paramount, it is also important to examine the rationale for and effects of participation in UR for faculty members. Success in promoting effective UR can be explained in large part by the presence of faculty who engage in UR and research (Zydney et al. 2002b). Some faculty hesitate to become involved in UR because it is time consuming and they may have graduate students or postdoctoral researchers who can complete tasks more quickly than undergraduate students new to the research endeavor. Because undergraduate students need more training and supervision than graduate students, involving undergraduate students in UR requires planning and preparation. However, some faculty members believe that their students receive significant educational benefits from the research experience (Gates et al. 1999; Kardash 2000; Zydney et al. 2002b). In a survey of faculty who participated in UR at one research university, Zydney et al. found that faculty respondents said they believed the research experience contributed substantially to cognitive and affective development of their students, including intellectual curiosity, understanding scientific findings, thinking logically about complex material, and synthesizing information from diverse sources. Similarly, Adedokun et al. (2010) found that faculty members believe undergraduate students contribute positively to research projects and that these interactions with students provide opportunities for collegiality and professional

relationships. These findings follow the position by Chopin (2002): the "tangible, measurable rewards to the professor are overshadowed by the personal satisfaction we gain by playing an active role in personal and professional growth of students" (p. 3).

When such planning can occur, the rewards for faculty members can be positive. In a university where 90 % of STEM faculty members participate in UR, Zydney et al. (2002a) found that three-quarters of faculty respondents who were involved in UR, did so because they had a desire to influence the career of talented young students. In addition, they found that half of the faculty respondents said UR students contributed to the faculty member's research program, and 41 % said UR involvement contributed to the faculty member's quality of life at the institution. Collectively, findings from these studies indicate that many faculty members do become involved in UR and find benefit to themselves or their students.

Conceptual Framework

Student and faculty member involvement in UR can be viewed through the lens of personal motivation for involvement and social exchange. Students may be motivated to participate in UR for personal gain (e.g., course credit, financial reimbursement for work, recommendation for graduate school), whereas faculty members may be motivated to participate in UR for a wider variety of reasons. Faculty members may participate due to personal satisfaction that comes from mentoring students, assistance with research tasks that can lead to a lighter personal workload, or perhaps because they affirm the institution's overarching goal to provide students with academic activities that assist in student success. Interactions with students in a UR activity can be a positive and rewarding experience for both faculty members and students.

Student and faculty member involvement in UR may also be viewed through the concepts of social exchange theory. With major tenets advanced by Blau (1968), Homans (1974), Thibault and Kelley (1959) and Emerson (1976), social exchange theory proposes that actions are contingent on rewarded reactions from others and that interpersonal transactions have the potential to create high-quality relationships. As a form of reciprocity, the more often a person perceives value or is rewarded, the more likely s/he is to perform the action. Through the lens of social exchange theory, it is possible that students become involved in undergraduate research because they believe it will help them to learn a concept or skill more thoroughly, earn better grades, or increase chances for graduate school or post-college employment.

A construct directly related to social exchange theory is perceived organizational support (POS). Eisenberger et al. (e.g., Cotterrell et al. 1992; Eisenberger and Huntington 1986) posit that organizational rewards and favorable job conditions such as pay, promotion, and job enrichment contribute to one's perceived organizational support (POS). The benefits of POS are understood in reciprocal terms; if the employee's POS is high, he or she will be motivated to work to achieve high outcomes. Although POS has not focused on employees in the college or university environment, its tenets can be reasonably applied to examine faculty member decision to participate in the UR activity.

Faculty members may become involved in UR because they believe that, in exchange for academic credit or knowledge acquisition, students can accomplish some tasks that they would otherwise have to do. Because faculty workloads are high, student assistance may make myriad tasks more manageable and provide some relief. Even in cases where faculty members do not find undergraduate student assistance appreciably helpful with their research, faculty members may participate in UR because they believe that sharing

knowledge and skill acquisition with students is a valued role they should perform as a faculty mentor. In this way, faculty members may see their involvement in UR as a 'fair exchange' that enables them to contribute to the development of a young scholar by transferring knowledge or skills about scientific inquiry.

Purpose of the Study

Clearly, faculty interactions with students in UR can strengthen students' undergraduate success as well as beyond. Faculty time must be stretched across multiple tasks, and faculty research orientation and external funding impact participation (Hu et al. 2007). However, faculty work roles and involvement in UR are critical to student involvement in UR. It can aid in faculty member quality of life but greater understanding of the factors that contribute to faculty involvement in UR is needed. In addition, some students proactively seek participation in UR early in baccalaureate studies, but other students may not make the initial involvement until faculty extend an invitation to participate. Thus, examining faculty perceived importance of UR as well as faculty and student participation can help us increase of understanding of how faculty members help students in this activity. To date, we have few studies that have examined student *and* faculty member reports on participation in and perceptions of benefits gained from participation in UR. Examination of responses from faculty and students at the same institutions can provide a much-needed understanding of the benefits of UR. Specifically, our research questions were as follows.

1. What student demographic and institutional characteristics contribute to student participation in undergraduate research?
2. What individual and institutional characteristics contribute to faculty member perceived value of participation in research with undergraduate students?
3. What demographic and institutional characteristics contribute to faculty member participation in undergraduate research?

Responses from two items from FSSE and one item from NSSE served as the focus in our analyses. The FSSE questions were: (1). *How important is it that undergraduates at your institution work on a research project with a faculty member outside of course or program requirements*; and (2). *How much time do you spend working with undergraduates on research*. The NSSE item asked students if they will have *worked on a research project with a faculty member outside of course or program requirements* by the time they graduated from their institution.

Data and Methods

Data Sources and Samples

Data for this study come from the *National Survey of Student Engagement* (NSSE) and the *Faculty Survey of Student Engagement* (FSSE) The NSSE is a survey chosen by officials at many colleges and universities to examine student participation in college activities and is based on the Seven Principles of Good Practice in Undergraduate Education (Chickering and Gamson 1987). NSSE measures student engagement in activities that have been positively linked to important student learning outcomes (Astin 1993; Chickering and Gamson 1987; Love and Love 2005; Pascarella and Terenzini 2005). Thus, an increase in

engagement in activities, such as undergraduate research, should increase student learning (Kezar 2006).

The FSSE questionnaire was designed to complement NSSE by collecting information about faculty members' expectations and perceptions of undergraduate student engagement in educationally purposeful activities, how faculty members structure their classroom activities and spend their time, and the extent to which faculty promote student learning and development in their courses and interactions with students. There are two options of the FSSE survey, one that focuses on faculty members' responses about the typical first-year or senior that they have taught during the school year, and one that asks faculty to respond to questions based on a course taught during the current academic year. Faculty members that answered either option of FSSE were included in this analysis.

Support for NSSE and FSSE's reliability and validity come from many sources, including scholarly research and work done at individual institutions. Numerous studies support NSSE's and FSSE's reliability and validity (Kuh et al. 2002, 2004; Carini et al. 2001; Pascarella et al. 2010; Umbach and Warwynski 2005).

Data from 5 years of NSSE and FSSE administrations (2007–2011) were combined for use in this study. To be selected, institutions had to participate in both NSSE and FSSE, with only their most recent year of participation included. The resulting datasets included faculty and student responses from 455 institutions from across the U.S. Institutions varied across several characteristics with a little over half being privately controlled, half were master's granting and a third were baccalaureate granting, around three in ten were less competitive and three in ten were very or highly competitive, and nearly half of smaller student population size. After deleting cases for missing data, the sample of students consisted of 111,077 seniors, 19 % of whom reported having participated in research with a faculty member. Approximately a third of the sample was 24 years or older, most were full-time students, two-thirds were female, and a third were students majoring in STEM fields. The majority of respondents were full-time students (83 %) lived off campus, student athletes (6 %), members of a Greek organization (12 %), or international or foreign national students (5 %).

After deleting cases for missing data, the FSSE sample consisted of 39,699 faculty members, 57 % of whom reported spending at least some time in research with undergraduates. With an average of 5.7 courses per academic year, approximately a third of the faculty were 55 years or older, half were female, a third were in a STEM field. The faculty respondents were fairly evenly divided among academic ranks. For more details about the institutional characteristics or student and faculty demographics see Table 1.

Variables Used in this Study

The literature on undergraduate research, student learning, and faculty member work in UR with students discussed above guided the selection of variables included in this study. Faculty and student involvement in research was measured with three items. On NSSE, students were asked whether or not they had worked on a research project with a faculty member outside of course or program requirements. On FSSE, faculty were asked how important it is to them that undergraduates at their institutions work on a research project with a faculty member outside of course or program requirements and how many hours they spend in a typical 7-day week working with undergraduates on research. In addition to being used as dependent measures, the two faculty variables were aggregated to the institution level to examine the link between averages of faculty support for UR and faculty participation in UR in the student models of this study.

Table 1 Select student, faculty, and institution characteristics

Student characteristics (n = 111,077 senior respondents)	%	Faculty characteristics (n = 39,669 faculty respondents)	%
Undergrad research = with a faculty member	19	Undergraduate research (time)—spent at least some time researching with undergraduates	57
Age—24 or older	37	Age—55 or older	38
Race/ethnicity		Race/ethnicity	
Asian	5	Asian	4
Black	8	Black	5
Latino	6	Latino	3
Other	7	Other	11
White	70	White	77
Is a student athlete	6	Emphasis on undergraduate research	
		Very important	20
		Important	34
		Somewhat important	33
		Not important	13
Citizenship—international or foreign national	5	Citizenship—permanent (immigrant visa) or temporary resident of US	6
Full-time enrolled	83	Years teaching—15 or more years	48
First-generation status	47	Doctorate/professional degree	72
Fraternity/sorority member	12	Female	47
Female	65	Academic rank	
College grades		Full professor	27
Mostly As	49	Associate professor	26
Mostly Bs	45	Assistant professor	26
Mostly Cs	6	Full-time lecturers	11
In a STEM major	30	Part-time lecturer	11
Lived on campus	17	In a STEM discipline	32
Enrolled in courses entirely online	8		
Transferred into this institution	44		

Institution characteristics (n = 455 institutions)	%
Carnegie classification	
Doctoral	17
Master's	45
Baccalaureate	39
Private	58
Selectivity (Barron's)	
Highly competitive	9
Very competitive	18
Competitive	44
Non-competitive	29
Size	
Very small	12
Small	37

Table 1 continued

Institution characteristics (n = 455 institutions)	%
Medium	32
Large	17
Not classified/special	3
Undergraduate research—spent at least some time researching with undergraduates	57

Other institution-level characteristics included in the analyses were Carnegie classification, control, selectivity, and size. Faculty-level characteristics included in the models were academic discipline, academic rank, age, citizenship, course load, highest degree earned, race/ethnicity, sex, and years of experience teaching. Student-level characteristics included in models were age, athletic membership, citizenship, enrollment status, first-generation status, fraternity or sorority membership, gender, grades, living situation, major field, online courses, race/ethnicity, and transfer status. For more information on how these variables were coded, see Appendices 1–3.

Analysis

Following an examination of summary statistics, we used hierarchical linear modeling (HLM) and hierarchical generalized linear modeling (HGLM) to answer our research questions. HLM and HGLM were used because scholars agree these analytic procedures are most appropriate in situations like ours where (1) the data consisted of cases (i.e., faculty and students) nested within institutions and (2) estimates of institutional-level effects are central to the research questions (Raudenbush and Bryk 2002; Thomas and Heck 2001). Traditional regression techniques are inappropriate when examining effects at multiple levels because such analyses may result in inaccurate parameter estimates (Hahs-Vaughn 2006; Thomas and Heck 2001). The use of hierarchical modeling overcomes this concern by simultaneously estimating equations for both the individual and institutional effects. In addition, multilevel analyses take clustered data structures into account when producing estimates for within and between-group variances and do not require testing for design effects (Thomas and Heck 2001).

Many scholars who use multilevel models begin with a null model followed by one or more models that incorporate additional variables (Raudenbush and Bryk). The null model includes no predictor variables, but estimates the variance that exists within and between institutions. For the student and faculty indicators of participation in UR outside of class, the null models look like the following:

Level 1

$$\log\left[\varphi_{ij}/\left(1 - \varphi_{ij}\right)\right] = \beta_{0j}$$

Level 2

$$\beta_{0j} = \gamma_{00+}u_{0j}$$

where $\log[\varphi_{ij}/(1 - \varphi_{ij})]$ refers to the likelihood of participation for student or faculty member i at institution j. For the importance faculty members place on UR, the null model was the following:

Level 1

$$Y_{ij} = \beta_{0j} + r_{ij}$$

Level 2

$$\beta_{0j} = \gamma_{00+} u_{0j}$$

For all models, the significant Chi square statistic indicated a non-saturated model and the need to include more variables, thus a broader HLM model was developed to examine the effect of additional factors on UR participation and perceived importance of UR. The full model for student participation in UR with a random intercept and fixed slopes is expressed as follows:

Level 1

$$\begin{aligned}\log\left[\varphi_{ij}/\left(1 - \varphi_{ij}\right)\right] = {} & \beta_{0j} + \beta_1\left(Major{-}STEM\,field_{ij}\right) + \beta_2\left(Mostly\,B\,Grades_{ij}\right) \\ & + \beta_3\left(Mostly\,A\,Grades_{ij}\right) + \beta_4\left(Athletic\,Membership_{ij}\right) \\ & + \beta_5\left(Fraternity/sorority\,Membership_{ij}\right) + \beta_6\left(Age_{ij}\right) \\ & + \beta_7\left(US\,citizenship_{ij}\right) + \beta_8\left(FT\,Enrollment\,Status_{ij}\right) \\ & + \beta_9\left(First\,Generation_{ij}\right) + \beta_{10}\left(Asian_{ij}\right) + \beta_{11}\left(Black_{ij}\right) \\ & + \beta_{12}\left(Latino_{ij}\right) + \beta_{13}\left(Other\,race/ethnicity_{ij}\right) + \beta_{14}\left(Female_{ij}\right) \\ & + \beta_{15}\left(Live\,on\,Campus_{ij}\right) + \beta_{16}\left(Transfer_{ij}\right) \\ & + \beta_{17}\left(Online\,Enrollment_{ij}\right)\end{aligned}$$

Level 2

$$\begin{aligned}\beta_0 = {} & \gamma_{00} + \gamma_{01}\left(Carnegie\,Master's_j\right) + \gamma_{02}\left(Carnegie\,Baccalaureate_j\right) + \gamma_{03}\left(Private_j\right) \\ & + \gamma_{04}\left(Selectivity\,Competitive_j\right) + \gamma_{05}\left(Selectivity\,Very\,Competitive_j\right) \\ & + \gamma_{06}\left(Selectivity\,Highly\,Competitive_j\right) + \gamma_{07}\left(Size\,Small_j\right) + \gamma_{08}\left(Size\,Medium_j\right) \\ & + \gamma_{09}\left(Size\,Large_j\right) + \gamma_{10}\left(Size\,Other_j\right) + \gamma_{11}\left(Faculty\,Importance\,of\,UR_j\right) \\ & + \gamma_{12}\left(Faculty\,Time\,Spent\,on\,Research_j\right) + u_{0j}\end{aligned}$$

The model for faculty members spending at least some time on UR was similar at Level 1, except the variables included were those in Appendix 2. At Level 2, the equations were the same except the aggregated faculty variables were not included in the faculty model.

The full model for the importance faculty members place on UR, a variable treated as continuous in our analyses, is expressed as follows:

Level 1

$$\begin{aligned}Y_{ij} = {} & \beta_{0j} + \beta_1\left(Academic\,Discipline\,STEM\,Field_{ij}\right) + \beta_2\left(Rank\,Associate\,Professor_{ij}\right) \\ & + \beta_3\left(Rank\,Assistant\,Professor_{ij}\right) + \beta_4\left(Rank\,FT\,Lecturer/Instructor_{ij}\right) \\ & + \beta_5\left(PT\,Lecturer/Instructor_{ij}\right) + \beta_6\left(Age_{ij}\right) + \beta_7\left(US\,Citizenship_{ij}\right) \\ & + \beta_8\left(Course\,Load_{ij}\right) + \beta_9\left(Doctoral\,Degree_{ij}\right) + \beta_{10}\left(Asian_{ij}\right) + \beta_{11}\left(Black_{ij}\right) \\ & + \beta_{12}\left(Latino_{ij}\right) + \beta_{13}\left(Other\,Race/Ethnicity_{ij}\right) + \beta_{14}\left(Female_{ij}\right) \\ & + \beta_{15}\left(Years\,teaching_{ij}\right) + r_{ij}\end{aligned}$$

Level 2

$$\begin{aligned}\beta_0 = {} & \gamma_{00} + \gamma_{01}\left(Carnegie\,Master's_j\right) + \gamma_{02}\left(Carnegie\,Baccalaureate_j\right) + \gamma_{03}\left(Private_j\right) \\ & + \gamma_{04}\left(Selectivity\,Competitive_j\right) + \gamma_{05}\left(Selectivity\,Very\,Competitive_j\right) \\ & + \gamma_{06}\left(Selectivity\,Highly\,Competitive_j\right) + \gamma_{07}\left(Size\,Small_j\right) + \gamma_{08}\left(Size\,Medium_j\right) \\ & + \gamma_{09}\left(Size\,Large_j\right) + \gamma_{10}\left(Size\,Other_j\right) + u_{0j}\end{aligned}$$

All independent variables were grand mean centered before entering the analyses. Missing data were removed through list wise deletion, and there were no outliers present in the data.

Results

Participation in UR

Two hierarchical models were run to examine variables that predict student and faculty participation in UR. Shown in Table 2, a variety of student and institution characteristics were predictive of whether students were more likely to participate in undergraduate research. Regarding personal characteristics, full-time students, students of color (particularly African American students), and students less than age 24 were more likely than their peers to participate in UR. The coefficients for the other personal characteristics, gender, citizenship, and first-generation status, were small, but statistically significant, thus indicating that women, international, and first generation students do not participate in UR as much as men, US citizens, and non-first generation students, respectively. Students with certain college experiences such as those in STEM fields, those with higher grades, and those students who did not transfer or take their courses online, were much more likely to participate in UR than their respective peers. Students in fraternities and sororities and students living on campus were only slightly more likely than their peers to participate.

Institutional characteristics were generally less predictive than student characteristics, but some differences were found. Compared to students at doctoral-granting institutions, those in master's-granting institutions did not participate in UR as much, and students at less competitive institutions did not participate as much as peers at highly competitive institutions. Size of institution also had an effect; being at a small institution increased the likelihood of participation in UR. Not surprisingly, the proportion of students participating in UR was much higher at institutions where a greater percentage of faculty members spent at least some time on UR and where faculty found UR to be more important.

To learn more about what predicts both faculty time spent and importance placed on UR, we ran models on those faculty variables. Table 3 shows predictors related to faculty member participation in UR. As shown, a variety of faculty characteristics, but only one institutional characteristic, predicted faculty likelihood of spending at least some time on UR. Looking at personal characteristics, faculty of color (particularly African American faculty) and those with their doctorate were more likely to participate in UR than their colleagues. Younger (less than age 55) and male faculty members were slightly more likely than their older and female colleagues, respectively, to participate. Work-related characteristics of faculty were also predictive of participation. Full and associate professors were much more likely to participate, particularly when compared to their non-tenure-track colleagues. Faculty with larger course loads and faculty with <15 years of teaching experience were slightly more likely to participate in UR than their colleagues. Interestingly, though STEM students are more likely to participate, the difference in participation between STEM faculty and their colleagues in other fields is negligible. Also shown in Table 3, neither Carnegie category, institution type (private or public), nor size had much influence on faculty participation. However, institutional selectivity did. Results show that

Table 2 HGLM model predicting student participation in undergraduate research (full model)

	Coefficient	SE	Sig.
Intercept	−3.715	.226	***
Institution characteristics			
Carnegie classification			
Doctoral	*Reference group*		
Master's	−.102	.040	*
Baccalaureate	−.039	.055	
Private	−.011	.037	
Selectivity			
Less comp.	*Reference group*		
Competitive	.055	.039	
Very comp.	.076	.048	
Highly comp.	.224	.061	***
Size			
Very small	*Reference group*		
Small	−.064	.079	
Medium	−.205	.089	*
Large	−.307	.095	***
Other	−.352	.128	**
Aggregate faculty importance placed on research	.651	.093	***
Aggregate faculty time spent on research	1.158	.188	***
Student characteristics			
Major field (STEM)	.645	.024	***
Grades			
Mostly Cs	*Reference group*		
Mostly Bs	.342	.042	***
Mostly As	.790	.049	***
Athletic membership	−.055	.035	
Frat/soro member	.120	.029	***
Age (24 years or older)	−.260	.030	***
Citizenship (U.S.)	.108	.039	**
Full-time enrolled	.394	.034	***
First-generation	−.128	.018	***
Race			
White	*Reference group*		
Asian	.167	.042	***
Black	.268	.038	***
Latino	.194	.037	***
Other	.189	.031	***
Female	−.132	.023	***
Living on campus	.067	.025	**
Transfer	−.319	.021	***
Online education	−.425	.061	***

Level-2 variance from null model = 0.294. ICC = 0.026. Reliability estimate = .833

* $p \leq .05$, ** $p \leq .01$, *** $p \leq .001$

Table 3 HGLM model predicting faculty spending at least some time on undergraduate research (full model)

	Coefficient	SE	Sig.
Intercept	.303	.124	*
Institution characteristics			
Carnegie classification			
Doctoral	*Reference group*		
Master's	.009	.051	
Baccalaureate	.115	.077	
Private	−.072	.052	
Selectivity			
Less comp.	*Reference group*		
Competitive	.128	.046	**
Very comp.	.274	.067	***
Highly comp.	.569	.099	***
Size			
Very small	*Reference group*		
Small	−.156	.098	
Medium	−.193	.108	
Large	−.184	.119	
Other	−.435	.149	**
Faculty characteristics			
Academic Disc. (STEM)	.001	.030	
Rank			
Full professor	*Reference group*		
Associate professor	−.074	.033	*
Assistant professor	−.289	.040	***
FT lecturer/Instr	−.900	.057	***
PT lecturer/Instr	−.942	.064	***
Age (55 years or older)	−.195	.026	***
Citizenship (U.S.)	.066	.046	
Course load	.041	.005	***
Doctorate degree	.238	.032	***
Race			
White	*Reference group*		
Asian	.270	.057	***
Black	.363	.059	***
Latino	.264	.069	***
Other	.243	.037	***
Female	−.147	.023	***
Years teaching (15 plus)	−.080	.031	*

Level-2 variance from null model = 0.157. ICC = 0.007. Reliability estimate = .689

* $p \leq .05$, ** $p \leq .01$, *** $p \leq .001$

faculty at more selective institutions are more likely to spend at least some time on UR. Compared to the least competitive four-year institutions, the likelihood that faculty would spend time on UR increased incrementally, with the greatest likelihood occurring at highly competitive institutions.

Faculty Perceived Importance of UR

Our third and final hierarchical analysis examined predictors related to faculty perceived importance of UR. As shown in Table 1, the majority of faculty said that it was important for undergraduate students to participate in UR, a finding that may indicate that the institutional culture can reinforce student participation. As shown in Table 4, the results for perceived importance were similar to those for spending some time on UR (this is not a surprise since the two dependent measures were strongly related—as indicated by their correlation $r = 0.58$). Results show that faculty of color, U.S. citizens, those with doctorates found UR participation more important, on average than their White, non-U.S. citizen, and non-doctorate earning colleagues, respectively. Younger (under age 55) and male faculty placed slightly more importance on UR than their colleagues than older and female faculty members. Also, full professors and faculty with <15 years of teaching experience placed more importance on participating in UR. The second largest effect in the model was for STEM faculty. Faculty in STEM fields found UR to be more important than their non-STEM colleagues, which likely plays a role in our finding that STEM students are more likely to participate in UR, since STEM faculty were not more likely than their non-STEM colleagues to spend time on UR. Another small, but noticeable difference in findings is that although faculty with larger course loads are more likely to spend at least some time on UR, it is faculty with smaller course loads that find UR more important. Similar to findings presented in Table 3, faculty characteristics were more predictive of the importance placed on UR than institutional characteristics. Selectivity was the only significant institution-level predictor of importance placed on UR (with faculty at more selective institutions placing more importance on UR).

Discussion

Due to several prominent publications over the past two decades, UR has gained increasing prominence as a feature of the American college experience. Many scholars have studied and confirm the benefits of student participation in UR. Findings from this study reaffirm student and faculty reported interest in and perceived value from participation in UR and parallel findings for Eisenberger and Huntington's (1986) notions of perceived organizational support. In addition, results reinforce Kuh and Laird (2007) finding that the importance that faculty members place on UR is positively related to the proportion of students who participate in UR, even after controlling for faculty time spent on UR and select institutional characteristics. In general, most faculty members engage in their role as mentor, and may see UR as one good way to help students succeed. Students who are better prepared for college work may grasp new assignments quickly and may need less long-term supervision, and may help in faculty research productivity (Harvey and Thompson 2009).

Predictors that are associated with student participation in UR are consistent with some previous studies (e.g., Russell 2008) that find UR participation is higher for students with better grades, enrolled full-time, and from highly competitive institutions. It is noteworthy that compared to White peers, minority students in this study report higher participation in UR, as do men, those who live on campus, and those who do not enroll in online education courses. Consistent with findings by Hu et al. (2007) and Eagen et al. (2011), being in a large research university does not necessarily equate to higher participation rates in UR by

Table 4 HLM model predicting the importance faculty placed on undergraduate research (full model)

	Coefficient	SE	Sig.
Intercept	2.581	.058	***
Institution characteristics			
Carnegie classification			
Doctoral	*Reference group*		
Master's	.030	.023	
Baccalaureate	.047	.035	
Private	−.038	.024	
Selectivity			
Less comp.	*Reference group*		
Competitive	.033	.024	
Very comp.	.053	.031	
Highly comp.	.130	.039	***
Size			
Very small	*Reference group*		
Small	−.008	.045	
Medium	.025	.051	
Large	−.046	.054	
Other	−.086	.088	
Faculty characteristics			
Academic Disc. (STEM)	.258	.011	***
Rank			
Full professor	*Reference group*		
Associate professor	−.068	.014	***
Assistant professor	−.049	.016	**
FT lecturer/Instr	−.082	.021	***
PT lecturer/Instr	−.048	.021	*
Age (55 years or older)	−.059	.012	***
Citizenship (U.S.)	.206	.021	***
Course load	−.014	.002	***
Doctorate degree	.180	.013	***
Race			
White	*Reference group*		
Asian	.140	.024	***
Black	.360	.027	***
Latino	.338	.030	***
Other	.049	.015	**
Female	−.086	.010	***
Years teaching (15 plus)	−.077	.012	***

Variance components of the null model: level-1 = .869, level-2 = .043. ICC = .047. Reliability estimate = .741

* $p \leq .05$, ** $p \leq .01$, *** $p \leq .001$

faculty members or students. Shown in Tables 3 and 4, after controlling for institution type and Carnegie classification, institution size (smaller) and selectivity (more selective) make a difference in UR participation and perceived value. These findings seem to indicate that faculty may put more effort in getting students involved when they know the activity is

valued. As well, these findings indicate that institutional leadership may play a role in determining priorities for resource and faculty time allocations to activities like UR.

Consistent with previous findings, students in STEM majors were more likely to participate in UR. Overall, faculty participation in UR was the most important predictor in student involvement in UR. Although faculty members in STEM disciplines were not more likely to participate in UR, they did perceive it to be more important than non-STEM colleagues. This finding supports the notion that culture matters. The results for differences in faculty perceptions reinforce the notion that non-participant faculty play an important and powerful role as mentors in getting students involved in academic activities. STEM students were much more likely to participate in UR, but not because STEM faculty participated at a rate greater than non-STEM faculty. The difference between STEM and non-STEM faculty was in the importance placed on UR.

Findings in Table 2 show that women and first generation students report lower participation in UR than male and peers who are not of first generation to attend college. While the coefficients indicate a small finding, the result is statistically significant and thus urges us to point out the need to invest even greater attention to women and underrepresented students in UR. We know that specific programs such as the McNair Scholars Program, NIH's Targeted Infusion Program (TIP), NIH's summer internship program for undergraduate students, and NSF's ADVANCE program have increased opportunities for women and minorities in research and we believe these are worthy of continued support. Along the same line, perhaps consideration and resources can be given to academic information sessions to help first-generation students become quickly acquainted with their new college environment and become involved in activities such as UR.

Findings reported herein on student participation in UR are consistent with general knowledge of student success and understanding why students may choose to participate in UR. Students with certain characteristics such as being in a STEM major and having higher grades participated in UR more often than non-STEM students and those with lower grades. It seems plausible that students who engage in undergraduate research do so because they realize that it will strengthen their intellectual skills and subsequent academic performance. Relatedly, these findings are plausible in their alignment with perceived organizational support (POS) applied to students. Although we did not include questions that specifically ask about student reasoning for UR involvement, it seems possible that they acknowledge the reward may come through lab work, academic credit, recommendation for graduate school, or financial stipend. Students may also want and become involved in UR to deepen their knowledge about a specific topic. In reciprocal terms, students may see their interactions with faculty members and involvement in UR as beneficial for their current and future knowledge and education goals. Findings for faculty participation in and value of UR also affirm notions of POS. If faculty believe their work will be enhanced through UR, they may be more likely to participate. Faculty member perception of enhancement may be achieved in one of several ways—through student assistance on research projects that lighten the faculty member's time, through feelings of satisfaction in serving as a mentor to help students learn, and/or in feeling satisfaction in helping to achieve the institution's goals related to student graduation and preparation for graduate school.

Findings revealed that faculty of color participated at a higher rate and perceived UR of importance more so than their White peers. This paralleled the finding for student participation in UR. Students and faculty members of color were more likely to participate, and faculty of color were more likely to perceive UR as an important activity. These

findings suggests that institutional emphasis on bringing students of color into UR may be working, but institutions may be disproportionately relying (intentionally or unintentionally) on faculty of color to get students of color involved. Though institutions have encouraged women students to be involved in UR, our results show that women still lag behind men in participation among students and faculty. Again, institution or student subgroup culture may play a role in emphasizing student involvement. Our finding for faculty of color greater participation is inconsistent with those of Eagen, et al. (2011), and calls for additional study.

Limitations

A few limitations are acknowledged in this study. First, data reported herein were captured from self-report surveys. Respondents could have indicated higher use or value of UR than what actually occurred. Inaccurate self-reports could affect the size or strength of statistical findings, thus possibly leading to type I errors. However, self-reported data is generally purported to be reasonably accurate (Tourangeau et al. 2000) and we believe the survey items used to identify participation in and value of UR are written clearly, minimizing the chance for misinterpretation by the respondents. Further, based on work including that of Pike (1995, 1999), self-reported information is appropriate to use in studies like ours where the main focus is on understanding the relationships among variables and not finding point estimates. In other words, if our goal was to determine the proportion of students and faculty who truly participated in certain types of undergraduate research, self-reported data may not produce precise enough estimates, but results examining predictors of participation are unlikely to differ substantially between self-reported and other forms of data (e.g., institutional records, which can have error as well).

Second, like other studies of UR, self-selection may play a role in our findings. Students who choose to become involved in a particular activity may do so, expecting positive benefits. However, since we are not studying the effects of UR, we suggest that the possible role of self-selection affects our study differently. Since we are predicting UR participation and the importance faculty place on UR, student and faculty self-selection into the involved institutions and into certain experiences (e.g., fraternity or sorority membership) could influence our findings. Instead of interpreting our results as causal, they should primarily be understood as establishing relationships between independent variables and dependent variables, controlling for the effects of other independent variables (e.g., fraternity or sorority membership does not necessarily cause students to participate in UR at higher rates; rather, our study merely establishes differences in participation rates between members and non-members).

Institutional self-selection into NSSE and FSSE could limit the generalizability of the findings to institutions beyond the sample in the study. However, our sample of 455 institutions represents institutions at all Carnegie levels that provide adequate variability. Lastly, questions to the NSSE and FSSE surveys do not allow us to gauge motivation per se or other variables that may explain potential interest in UR. The literature on intrinsic motivation and social exchange theory aligns well in our understanding of student and faculty participation in UR, and thus intuitively fits our use of NSSE and FSSE items. If students or faculty who responded to these surveys were more motivated, generalization of our findings would be jeopardized, thus caution is warranted when interpreting the results. Future studies may wish to include a measure of motivation to control for this important construct.

Implications

Findings from this study support the notion that participation in undergraduate research has positive benefits for student success as well as advantages for faculty who serve as mentors to undergraduate students. Even with recent budget reductions, institution officials who wish to maximize student success should continue to invest resources in this activity. Because of the benefits found for UR participation, faculty members who are not currently involved, may want to recommend it to their students, or find ways to get involved at a minimal level.

Continued investment in UR may contribute to positive social exchange for faculty members. Our findings are consistent with previous reports of increased quality of faculty member work life from UR (Bauer and Bennett 2008; Hu et al. 2008), that can affect work satisfaction and faculty turnover. If faculty members perceive support from their department chair and senior administrative officials, they may be more satisfied, develop greater loyalty, and be more likely to remain at the same institution rather than seeking employment elsewhere. In addition, faculty member involvement in academic advising is equally important, and those who know UR deeply, can share their knowledge with student advisees. In some cases, new undergraduates have detailed ideas on how they wish to get involved in college activities, but in many cases, students do not know and can benefit from the advice and counsel of informed faculty who know the kinds of skills needed to begin, as well as the kind of skills that can be gained from UR participation.

We agree with Pike et al. (2006) that institutional expenditures can make a difference in positive outcomes, and believe our findings reaffirm the need for institution officials to continue allocation of resources for in-class and co-curricular discovery-based learning activities. We also agree with Kuh et al. 2005 in that engagement requires a broad-based commitment from many people across the institution that work together to shape expectations and the campus culture. That STEM faculty perceived UR of greater importance than non-STEM peers supports the notion that culture matters. It might also signal that involvement with students in UR is personally rewarding for faculty mentors and can be beneficial in the completion of research tasks.

The finding that non-tenure-track faculty are less engaged seems logical since research is not part of their duties, but it is encouraging that differences in importance were less than one-tenth of a standard deviation. Institutional officials may want to examine institution policies and reward structures so that part-time and non-tenure-track faculty can become more involved in UR. For example, faculty members may be asked to volunteer with one or more student clubs or interact with students over meals, at which time important conversation about faculty and student research could take place. Full-time or part-time faculty may also be rewarded for service or community-based learning that tangibly helps students see the connections between research and the world around them. Such service or community engagement also contributes to Boyer's (1990) call for a broader application of scholarship.

In addition to contributing to better understanding the roles and values of faculty members, these findings have implications for student success. There is consistent evidence that UR promotes increased critical thinking, and select skill development. If students are aware of differences based on the use of these techniques, students may wish to enroll in co-curricular programs that include UR activities. Academic activities that assist in undergraduate student success may encourage able students to consider graduate education. UR can help a student prepare for graduate school where skills such as the scientific

method, synthetic and deductive thinking, and the ability to work with others are even more important for success.

We were surprised to find female students participating in UR less than male peers. This finding may be due to the fact that proportionally more men major in STEM fields or see fewer female faculty members as role models. We believe that continued support via programs such as the McNair Scholar Program and NSF's STEP and ASPIRE Programs are merited. Continued support for, and monitoring of female students and faculty in STEM fields is important to ensure gender equity in these disciplines in the future.

Appendix 1 Student-related variable information

Student-level characteristics	
Undergraduate research	Have done work on a research project with a faculty member outside of course or program requirements = 1; Plan to do, do not plan to do, or have not decided = 0
Age	24 or older = 1; 23 or younger = 0
Athletic membership	Student athlete = 1; Not a student athlete = 0
Citizenship	International or foreign national = 1; US citizen = 0
Full-time enrolled	Full-time enrollment = 1; Part-time enrollment = 0 (Institution reported)
First-generation status	No parent has a baccalaureate degree = 1, At least one parent has a baccalaureate degree = 0
Fraternity/sorority membership	Member of a social fraternity or sorority = 1; Not a member = 0
Female	Female = 1; Male = 0 (Institution reported)
Grades	What most of their grades have been up to now at this institution = 1; A = A, A-; B = B+, B, B-; C = C+, C, C- or lower *Mostly Cs served as reference group*
Living on campus	Dormitory, other campus housing, fraternity or sorority house = 1; Residence within walking or driving distance, none of the above = 0
Major field	In a science, technology, engineering, or math (STEM) major = 1; not in a science, technology, engineering, or math (STEM) major = 0
Online education	Taking all courses entirely online = 1; Not taking all courses entirely online = 0
Race/ethnicity	In group = 1; Not in group = 0; Asian = Asian, Asian American, or Pacific Islander; Black = Black of African American; White = White (non-Hispanic); Latino = Mexican, Mexican-American, Puerto Rican, Other Hispanic or Latino; Other = American Indian, other Native American, Multiracial, Other, I prefer not to respond *White served as reference group*
Transfer	Started college elsewhere = 1; Started college at current institution = 0

Appendix 2 Faculty-related variable information

Faculty-level characteristics	
Undergraduate research (emphasis)	Importance placed on undergraduates at their institution working on a research project with a faculty member outside course or program requirements; 1 = not important, 2 = somewhat important, 3 = important, 4 = very important
Undergraduate research (time)	At least some time researching with undergraduates = 1, No time spent researching with undergraduates = 0

Appendix 2 continued

Faculty-level characteristics	
Academic discipline	In a science, technology, engineering, or math (STEM) field = 1; not in a science, technology, engineering, or math (STEM) field = 0
Academic rank	In group = 1; Not in group = 0; Assoc = Associate Professor; Asst = Assistant Professor; Ftlect = Full-time lecturer or instructor, Ptlect = Part-time lecturer or instructor; Full = Professor
	Full professors served as reference group
Age	55 or older = 1; 54 or younger = 0
Citizenship	Permanent (immigrant visa) or temporary resident of the US = 1; US citizen = 0
Course load	Number of graduate or undergraduate courses have taught/will teach this academic year (response options range from 0 to 18 or more)
Doctorate degree	Highest degree earned is a doctoral degree or professional degree = 1; Highest degree earned is Associate's, Bachelor's, Master's, or other degree = 0
Race/ethnicity	In group = 1; Not in group = 0; Asian = Asian, Asian American, or Pacific Islander; Black = Black of African American; White = White (non-Hispanic); Latino = Mexican, Mexican-American, Puerto Rican, Other Hispanic or Latino; Other = American Indian, other Native American, Multiracial, Other, I prefer not to respond
	White served as reference group
Female	Female = 1; Male = 0
Years teaching	15 or more years of teaching experience = 1; 14 or less years of teaching experience = 0

Appendix 3 Institution-related variable information

Institution-level characteristics	
Carnegie classification	In group = 1; Not in group = 0; Doctoral = Doc RU-VH, Doc RU-H, Doc DRU; Masters = Masters-L, Masters-M, Masters-S; Bacc = Bac-AS, Bac-Diverse, Other
	Doctoral left out as reference group
Private	Private control = 1; Public control = 0
Selectivity (Barron's)	In group = 1; not in group = 0; LessComp = Not available/special, Noncompetitive, Less competitive; Comp = Competitive, Competitive Plus; VeryComp = Very Competitive, Very Competitive Plus; HighComp = Highly Competitive, Highly Competitive Plus, Most Competitive
	Less competitive institutions served as reference group
Size	In group = 1; not in group = 0; VS (Very Small) = VS4/C, VS4/R, VS4HR (< 1,000 degree seeking students); S (Small) = S4/C, S4/R, S4/HR (1,000–2,999 degree seeking students); M (Medium) = M4/C, M4/R, M4/HR (3,000–9,999 degree seeking students); L (Large) = L4/C, L4/R, L4HR (at least 10,000 degree seeking students); O (Other) = special focus institution, not classified
	Very small institutions served as reference group

Appendix 3 continued

Institution-level characteristics	
Aggregate importance on undergraduate research	Aggregated faculty-level variable *fimpr05*. Represents the institution's faculty's average importance placed on undergraduate research *fimpr05*: Importance placed on undergraduates at their institution working on a research project with a faculty member outside course or program requirements; 1 = not important, 2 = somewhat important, 3 = important, 4 = very important *Included in the student model only*
Aggregate time spent on undergraduate research	Aggregated faculty-level variable *Zfresearc*. Represents the percentage of an institution's faculty that spend at least some time researching with undergraduates *Zfresearc*. At least some time researching with undergraduates = 1, No time spent researching with undergraduates = 0

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