**Time Spent on Research with Undergraduate Students:
Gender Differences among STEM Faculty**

Amber D. Lambert
Research Analyst
Center for Postsecondary Research
Indiana University
1900 E. 10th Street
Eigenmann Hall, Suite 419
Bloomington, IN 47406-7512
E-mail: adlamber@indiana.edu

Amy K. Garver
Project Associate
Center for Postsecondary Research
Indiana University
E-mail: agarver@indiana.edu

Allison BrckaLorenz
Research Analyst
Center for Postsecondary Research
Indiana University
E-mail: abrckalo@indiana.edu

Antwione Haywood
Project Associate
Center for Postsecondary Research
Indiana University
E-mail: amhaywoo@indiana.edu

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Abstract

Undergraduate students participating in research tend to have higher intellectual gains in college, greater retention rates, and stronger mentoring relationships with their faculty. These benefits can only be realized when faculty dedicate time to undergraduate research. Thus, this study explores the characteristics that might make a faculty member more likely or able to spend time mentoring undergraduate students in research. After controlling for various faculty characteristics and the traits of the institutions at which they teach, the results suggest that male STEM faculty spend a significantly greater number of hours than their female counterparts in this activity.

Literature Review

U.S News & World Report rankings now recognize undergraduate research as a distinct category of excellence (Eigren & Hensel, 2006). Undergraduate research serves as a pathway into careers by providing students with professional socialization and mentors (American Council of Learned Societies, 2007; Eigren & Hensel, 2006; Henry, 2005; Hunter, Laursen, & Seymour, 2006; Kuh, Chen, & Nelson Laird, 2007; Lopatto, 2003). In particular, minority students' participation in undergraduate research increases retention in science, technology, engineering, and mathematic (STEM) careers (Bauer & Bennett, 2003; Henry, 2005; Lopatto, 2004). The positive effects of undergraduate research extend beyond retention into their field. Students involved in undergraduate research tend to have higher intellectual gains in college (American Council of Learned Societies, 2007; Bauer & Bennett, 2003; Eigren & Hensel, 2006; Henry, 2005; Hunter, et al., 2006; Kardash, 2000; Kuh, et al., 2007; Lopatto, 2004; Lopatto, 2004; Mabrouk & Peters, 2000; Sabatini, 1997; Seymour, Hunter, Laursen, & DeAntoni, 2004; Zydney, Bennett, Shahid, & Bauer, 2002).

In 1969, the Massachusetts Institute of Technology (MIT) paved the way for undergraduate research by implementing an undergraduate research program, which was the first to span the university (Buckley, Korkmaz, Kuh, 2008; Hakim, 2000; Merkel, 2001). In the years following, the prevalence of campus-wide undergraduate research programs has increased substantially (Hu, Kuh, & Gayles, 2007; Zydney et al., 2002). Thus, the number of students who participate in research as undergraduates ranges by institutional type from 20% to 25% of all seniors (Kuh, Chen, Nelson Laird, & Gonyea, 2007; National Survey of Student Engagement, 2007; Hu et al., 2007; Hu, Scheuch, Schwartz, Gayles, & Li, 2008). With all the gains suggested by research on participants in these undergraduate programs, the far reaching undergraduate program founded at MIT produced decades of benefits for students, faculty, institutions, and society, even beyond what they could have conceptualized.

Undergraduate research has been shown to not only help increase undergraduate graduation rates (Bauer & Bennett, 2003; Henry, 2005; Lopatto, 2004; Nagada, Gregerman, Jonides, von Hippel, & Lerener, 1998), but also the skills and competencies students develop while in college (American Council of Learned Societies, 2007; Bauer & Bennett, 2003; Eigren & Hensel, 2006; Henry, 2005; Hunter, et al., 2006; Kardash, 2000; Kuh, et al., 2007; Lopatto, 2004; Lopatto, 2004; Mabrouk & Peters, 2000; Sabatini, 1997; Seymour, Hunter, Laursen, & DeAntoni, 2004; Zydney, Bennett, Shahid, & Bauer, 2002). A survey of alumni from the University of Delaware's College of Engineering, revealed that students involved in undergraduate research increased their cognitive and personal skills (Zydney et al., 2002). Other studies of science and engineering students found that undergraduate research increased technical skills, problem-solving skills, and professional self-confidence (Kardash, 2000; Mabrouk & Peters, 2000; Sabatini, 1997). Kinkead (2003) suggested that undergraduate research strengthens problem solving skills and cognitive learning in STEM students. Other research showed increases in communication and analytical skills (Bauer & Bennett, 2004; Lopatto, 2004; Mabrouk & Peters, 2000). Finally, and perhaps with the most direct connection, was an increase in inquiry skills (Bauer & Bennett, 2003; Kardash, 2000; Lopatto, 2004; Mabrouk & Peters; NSSE, 2007; Seymour et al., 2004).

In addition to the benefits during and leading to graduation from college, undergraduate research increases a student's likelihood of pursuing graduate education and remaining in their chosen field (Russell, Hancock, & McCullough, 2007; Zydney et al., 2002). Perhaps participation in undergraduate research increased their likelihood to get an advanced degree because this activity had reduced their uncertainties about graduate school (Russell, Hancock, & McCullough, 2007). Projects involving students with research support a shared understanding and investment towards the given discipline (Birnbaum, 1988; The Boyer Commission on Educating Undergraduates in the Research University, 1988; Burk & Cummins, 2002; Buckley, et al.; Kinkead, 2003). In addition, students are more comfortable with their discipline (Bauer & Bennet; 2003; Buckley, Korkmaz, Kuh, 2008). For those STEM students, undergraduate research seems to increase their interest in jobs in the STEM fields (Russell, Hancock, & McCullough, 2007). Through the socialization and mentoring provided during undergraduate research, students feel more prepared and are more likely to choose a job in their field or go on to graduate education (American Council of Learned Societies, 2007; Eigren & Hensel, 2006; Henry, 2005; Hunter, Laursen, & Seymour, 2006; Kuh, Chen, & Nelson Laird, 2007; Lopatto, 2003).

In particular, minority students' participation in undergraduate research increases retention in STEM careers (Bauer & Bennett, 2003; Henry, 2005; Lopatto, 2004). In addition, undergraduate research had a direct affect on their self-esteem and relationship with the faculty member (Jonides, von Hippel, Lerner, & Nagda, 1992; Seymour, Hunter, Laursen, DeAntoni, 2003). The benefits of undergraduate research to minority students seems to be even stronger than the effects for white students (Russell, Hancock, & McCullough, 2007) and is of particular interest because of the low success rate of undergraduate engineering programs to attract and graduate sufficient numbers of minority students (Congressional Commission on the Advancement of Women and Minorities in Science Engineering and Technology Development, 2000; Harper, Lambert, & Lattuca, 2006; National Science Foundation, 2006).

The benefits of undergraduate research can only be realized when faculty dedicate time to creating these mentoring relationships. Thus, understanding the characteristics that might make a faculty member more likely or able to spend time mentoring undergraduate students in research, especially in the STEM fields, will help programs encourage and assist faculty in doing so. For example, Kuh, Chen, and Nelson Laird (2007) found that faculty in engineering, biological, physical, and social sciences were more likely to value undergraduate research. Gender also seems to play a role in the time faculty spend working with undergraduate research (Johnson, Kuykendall, & Nelson Laird, 2005; Kuh, Chen, and Nelson Laird, 2007; Kuh, et al., 2007). Nelson Laird, Garver, & Niskodé, (2007) found that the challenges professors had in teaching and research was related to gender and that attitude toward gender in disciplines might have an impact on student-faculty interaction. If gender does affect the time faculty members spend with undergraduate research, the underrepresentation of female faculty in STEM fields (Centra & Gaubatz, 2000) might suggest some inherent differences in the faculty who participate in undergraduate research between the STEM and non-STEM fields. This study explores whether the difference between the time male and female faculty spend working with students on their research varies between STEM and non-STEM fields and whether other faculty characteristics might explain any differences.

Purpose of the Study

The purpose of this study is to explore the differences among men and women faculty in their time spent working with undergraduate students on research. Based on previous research, it is likely that we will find men and women spending their discretionary time differently even after controlling for a host of other faculty characteristics and institutional factors. The aim of this study, however, is to further examine if the gender gap varies among faculty in the STEM and non-STEM fields. By understanding the effect of gender on faculty members' decision to work with undergraduate students on research, particularly in the STEM fields, it may serve to develop future programs that encourage and assist faculty in this area.

Methods

Data Source

The data for this study come from the 2008 administration of the Faculty Survey of Student Engagement (FSSE). The FSSE is an annual survey designed to complement findings from students who participated in the National Survey of Student Engagement (NSSE) in current or previous academic years. The survey collects information about faculty members' expectations and perceptions of students as well as information about how they structure their classroom activities to encourage desirable learning outcomes and behaviors, and how they organize their discretionary time on other professorial activities (e.g. research, teaching, advising, and service).

The FSSE is administered online, requiring about 15 minutes to complete. Faculty members were contacted up to four times and their responses were kept anonymous to their institutions to encourage participation. Survey design, content, and administration elements contribute to the relatively high response rates observed at participating institutions. After adjusting for faculty who could not be reached (usually because of incorrect email addresses), a response rate (total number of responses divided by the total number of faculty contacted) is calculated for each FSSE institution. In 2008, the average institutional response rate was 49%, with a range from 19% to 85%. The response rate for FSSE across all institutions was 41%.

Sample

Over 23,000 faculty from 160 baccalaureate-granting institution responded to the survey in 2008. After the deletion of missing data, the removal of non-U.S. institutions, and institutions that participated in the typical student option, the resulting sample included 9,862 faculty members from 112 institutions. The sample represented a wide cross-section of the U.S. faculty population with a few notable exceptions (Faculty Survey of Student Engagement, 2008). For example, large master's and public institutions were slightly overrepresented in FSSE compared to the U.S. pool of institutions. Women (48%) and faculty working full-time (83%) were also moderately overrepresented (respectively, 40% and 66% nationally). However, the minority population closely resembled national averages (e.g. Asian 5%, African American 5%, Hispanic 3%). Also faculty in the sample, on average, had 15 years of prior teaching experience, and taught approximately six courses during the 2007-08 academic year. Out of the 9,862 faculty, 33% were male non-STEM faculty, 20% male STEM faculty, 33% female non-STEM faculty, and 14% female STEM faculty.

Outcome Measure

Several questions on FSSE ask how faculty members spend their time in and outside of the classroom. For this study, the criterion measure was derived from an item that asked faculty how many hours per 7-day week they spent working with undergraduates on research. Faculty had the option to select from an eight-point scale (0, 1-4, 5-8, 9-12, 13-16, 17-20, 21-30, More than 30) and their responses were coded as the mid-points of each of the given ranges of eight response categories. Consequently, the mean represented the average hours per week they spent working with undergraduates on research.

Data Analyses

Hierarchical, ordinary-least-squares multiple regression was the primary analytical procedure. Analyses proceeded in three blocks. The first block regressed the hours per week spent working with undergraduates on research on faculty characteristics (e.g., gender, rank, employment status, race/ethnicity). The second block added to the model the characteristics of the institutions (e.g. Carnegie Classification and control) at which the faculty member teaches. The exact list of faculty and institutional characteristics are described in Table 1.

-- Insert Table 1 About Here –

The final block added the interaction terms between gender and whether or not the faculty member was in a STEM field. The interaction terms were created as a cross product of gender and a dummy-coded variable representing the discipline (STEM vs. non-STEM). The change in the percent variance explained was analyzed in order to determine if the interaction terms explained any additional variance with statistical significance. If statistical significance was found, a graphic representation was created to analyze differences between male and female faculty in the STEM and non-STEM fields.

Limitations

Since faculty respondents are not randomly sampled, and they are from institutions that chose which faculty to survey in 2008, results from this study should be generalized with caution. Fortunately, the 112 institutions included in this study represent a wide cross-section of U.S. four-year colleges and universities where, in nearly all instances, all undergraduate teaching faculty or simply all faculty members were surveyed. In addition, response rates for nearly all campuses were respectable (greater than 30%). Although similar, a study done on faculty from a particular segment of institutions (e.g., elite research universities) might produce quite different results, it would be surprising if other studies done on faculty from U.S. institutions in general did not find similar results.

Findings

The interaction between gender and discipline (STEM vs. non-STEM) added statistically significant explanatory power in predicting faculty members' involvement in undergraduate research ($p < .001$). While the percentage of variance explained by the interaction terms may not be substantial (as shown in table 2), the fact that it was statistically significant is enough to suggest digging deeper into the gender and discipline interaction.

-- Insert Table 2 About Here --

Looking at faculty as a whole and not separating those in STEM from those in non-STEM fields, female faculty members tend to spend about the same amount of time working with undergraduates on research. As seen in Figure 1, the same trend is seen in the non-STEM fields, male and female faculty members spend approximately the same amount of time working with undergraduate students on research (on average 2.05 hours per week and 2.14 hours respectively). In contrast, among those faculty in STEM fields, males spend 3.26 hours a week while females only allocate 2.37 hours.

-- Insert Figure 1 About Here –

While controlling for time spent working on their own research (11.79 hours per week for males and 7.48 hours for females) and the other faculty and institutional characteristics in the model, males in STEM fields still spend more time working with undergraduates on research. As

Figure 2 shows these other factors do close the gap considerably. There does seem to be an interaction between gender and STEM discipline, because the gap is statistically significant with female faculty members devoting more time to undergraduate research in non-STEM fields while in contrast male faculty members in STEM fields spend more time on undergraduate research, even after controlling for all these faculty and institutional characteristics. However, female faculty in the STEM fields tend to devote nearly the same amount of time to undergraduate research even after controlling for other faculty characteristics and institutional characteristics.

-- Insert Figure 2 About Here –

Since controlling for faculty characteristics had such a profound effect on the gap between male and female faculty in both the STEM and non-STEM fields, exploring these effects more closely seems worthwhile. Table 3 displays the unstandardized coefficients for how the faculty characteristics predict the amount of time faculty members dedicate to undergraduate research. Course load and research activity are positive and statistically significant predictors of time spent on undergraduate research in both STEM and non-STEM fields. Number of years teaching is a negative and statistically significant predictor for STEM faculty while it is not for non-STEM faculty. While gender does seem to play a substantial role in predicting faculty involvement in undergraduate research, some of these other faculty characteristics also make a difference.

-- Insert Table 3 About Here --

Implications

These results suggest interesting implications for faculty members in STEM fields. One explanation for female STEM faculty spending less time researching with undergraduates could be that female faculty members in STEM fields have to spend this time doing something else. Nelson Laird, Garver, and Niskodé (2007) found that female faculty members spend a larger percentage of class time using active classroom practices than their male counterparts. It is possible then, that female faculty members in STEM fields spend more time planning and preparing for their classes. It is also possible that female faculty in STEM fields are spending more time doing such things as advising, service activities, or are having different types of interactions with students outside the classroom (Johnson et al., 2005; Kuykendall, Johnson, Nelson Laird, Ingram, & Niskodé, 2006). Female faculty members in STEM fields might also have fewer opportunities for working with undergraduates on research due to the level of student they teach or the type of courses they teach. Having such organizational barriers or a smaller percentage of time available for female faculty in STEM fields to work on research with undergraduates may lead to fewer female role models for future students in STEM fields. It is clear from our results faculty and institutional characteristic does little to explain why female faculty in the STEM fields engage, or rather do not engage, their students in research. More needs to be done to better understand what motivates or hinders female faculty in these fields and how such factors differ from their male counterparts in the STEM fields.

In addition, there might be policies and activities that programs and departments can introduce that would help faculty be more engaged in undergraduate research. Faculty who have been teaching in the STEM fields seem to spend less time on average working with undergraduate students on research. Senior faculty may benefit from extra support or incentives given by the program and department. This is the same group of faculty that students would most likely benefit from doing research with because of their knowledge in the field, so underscoring the benefits to students might get these faculty more involved.

The STEM fields should not be the only focus of this discussion, non-STEM fields could also use the information suggested by this study to improve faculty involvement in undergraduate education. In contrast to the STEM fields, non-STEM associate and full faculty did not spend any more time on undergraduate research than faculty with instructors rank. Making sure participation in undergraduate research is part of promotion and tenure would encourage faculty along all spectrum of faculty rank participate in undergraduate research.

In the end, because of the benefits for students, institutional administrators, program chairs, and faculty should find ways to use the information about the characteristics that make faculty more likely to engage in research with undergraduates. Understanding the gender and discipline differences and their implications could make a difference in practices and policies. In addition, future research could identify other additional factors not explored in this study.

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Table 1. *Variables used in regression analyses.*

Dependent Variable

Faculty time on undergraduate research: The faculty member's individual score on an 8-item scale asked faculty how many hours per 7-day week they spent working with undergraduates on research with the ranges: 0, 1-4, 5-8, 9-12, 13-16, 17-20, 21-30, More than 30) recoded to the midpoints of these ranges.

Independent Variables

1. Faculty Characteristics

Gender: 0 = male, 1 = female

Race/Ethnicity: Black or African American; Mexican, Mexican American, Puerto Rican, other Hispanic or Latino; Asian, Asian American, or Pacific Islander; American Indian or other Native American; multiracial; other, each coded as a dummy variable (1 or 0) with White used as the comparison group

Faculty rank: Lecturer or instructor; Assistant professor; Associate professor; Full professor, each coded as a dummy variable (1 or 0) with Lecturer or instructor as the comparison group

Courses taught: The number of undergraduate and graduate courses have taught/will teach this academic year with a range from zero to 9 or more (0, 1, 2, 3, 4, 5, 6, 7, 8, 9 or more).

Years taught: The number of actual years a faculty member has been teaching at any college/university

Employment status: 0 = part-time, 1 = full-time

Research activity: The faculty member's individual score on an 8-item scale that asked faculty how many hours per 7-day week they spent on research and scholarly activities with the ranges: 0, 1-4, 5-8, 9-12, 13-16, 17-20, 21-30, More than 30) recoded to the midpoints of these ranges.

STEM field membership: 0 = a faculty member with an appointment not in a Science, Technology, Engineering, or Math (STEM) field, 1 = a faculty member with an appointment in a STEM field

2. Institutional Characteristics

Type of control: 0 = public, 1 = private

Carnegie classification: Carnegie Research Extensive, Carnegie Research Intensive, and Carnegie Masters – each coded into dummy variables (1 or 0) with Carnegie Baccalaureate Colleges-Arts & Sciences as the comparison group

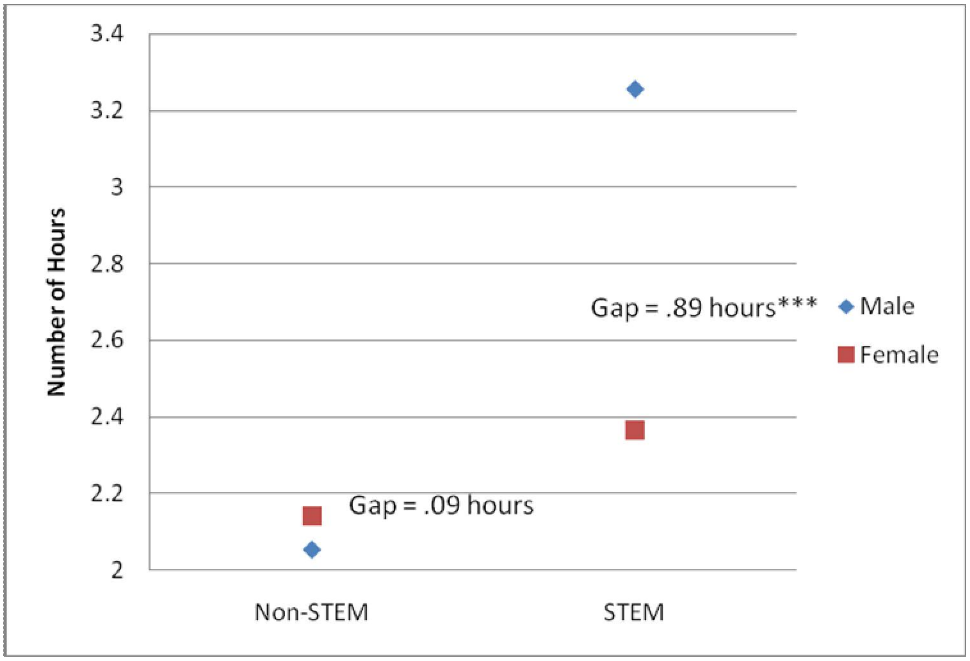
3. Interaction Terms

STEM membership by gender: cross product of the dummy coded variable representing STEM field membership and a dummy-coded variable representing gender.

Table 2. *Partitioning of variance explained for the model.*

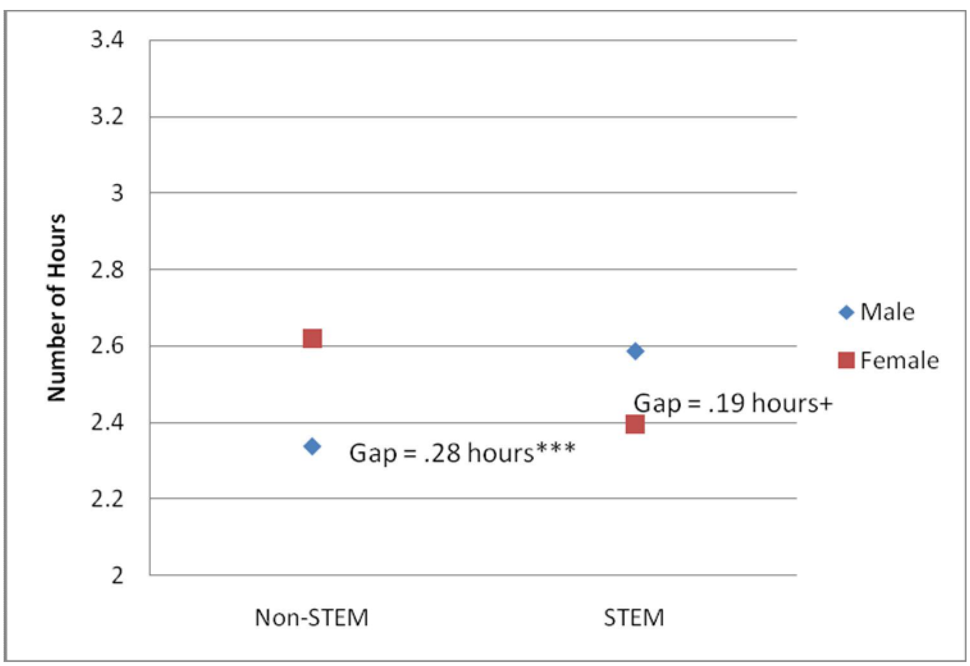
	Time on Undergraduate Research
Variance due to:	
Faculty Characteristics	.109***
Institutional Characteristics	.011***
Interaction Terms	.001***
Total Variance Explained	.121***
Adjusted R^2	.119***

***$p < .001$



***p < .001

Figure 1 Comparing time per week spend work with undergraduates on research by discipline and gender before controlling for any factors.



+p<.10, ***p < .001

Figure 2 Comparing time per week spend work with undergraduates on research by discipline and gender after controlling for other faculty and institutional characteristics.

Table 3. *Effects[a] of faculty characterics on the number of hours faculty spend on undergraduate research.*

	STEM	Non-STEM
Faculty Characteristics		
Gender	-.19+	.28***
Black or African American	.89**	.62***
Mexican, Mexican American, Puerto Rican, or other Hispanic or Latino	2.54**	.86+
Asian, Asian American, or Pacific Islander	.48+	.07
American Indian or other Native American	.84+	.00
Other Race	.49	1.13***
Multiracial	.34	.49
Course load	.06*	.06***
Number of years teaching	-.04***	.00
Assistant Professor rank	.89***	.26*
Associate Professor rank	1.51***	.24+
Full Professor rank	1.13***	.10
Fulltime	.02	.26**
Research activity	.14***	.10***
R^2	.172***	.082***

+ p < .10, * p < .05, ** p < .01, *** p < .001

[a] Adjusted for the Carnegie classification and control of the institutions at which that the faculty members teach.