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**Student-Faculty Research: Priming the Pump
for Additional Student-Faculty Contact**

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Abstract

Student-faculty interaction is widely believed to be positively related to undergraduate academic success, learning, and development. Undergraduate research experiences are also thought to promote substantive student-faculty contact. This study examined whether undergraduate research participants interacted more frequently than their peers who did not have such experiences. Data from more than 128,000 seniors indicated that across all institutional types and sizes as well as various major fields, undergraduate research participants had significantly more contact with faculty. Some institutional characteristics were related to the degree to which undergraduate research participants interacted more frequently with faculty.

Student-Faculty Research: Priming the Pump for Additional Student-Faculty Contact

Student-faculty interaction is linked with a range of positive benefits (Pascarella & Terenzini, 2005). Interacting with faculty is thought to foster academic integration, helping students see meaning in their studies which, in turn, has positive effects on their academic success and persistence (Amelink, 2005; Graunke & Woosley, 2005; Juillerat, 2000; Reason, Terenzini, & Domingo, 2005; Tinto, 1993). Out-of-class faculty interactions have been linked to degree completion (Pascarella, Smart, & Ethington, 1986; Stoecker, Pascarella, & Wolfe, 1988) and academic achievement (Volkwein, King, & Terenzini, 1986). When faculty-student contacts outside of class are positive, students feel validated and thereby establish a stronger institutional connection (Kuh, Kinzie, Buckley, Bridges, & Hayek, 2007; Kuh, Douglas, Lund, & Ramin-Gyurnek, 1994), which may reinforce academic goals and commitments to graduate (Pascarella & Terenzini, 2005).

Student-faculty interactions focused on intellectual matters are positively related to significant gains in student learning and development. For example, gains in reflective thinking have been positively associated with out-of-class faculty interactions about academic issues, career choice, and personal development, as well as working with faculty on research projects (Kitchener, Wood, & Jensen, 1999). Other studies show that engaging in a research project with a faculty member, talking with instructors outside of class, and serving on committees with faculty were positively correlated with student learning and development (Astin, 1993; Kuh, 2003; Kuh & Hu, 2001). On college campuses where faculty frequently interacted with students around coursework, first-year students and seniors reported more gains in personal and social development, general education knowledge, as well as practical competencies (Umbach &

Wawrzynski, 2005). Research also suggests that student-faculty interaction has conditional effects as academically prepared students who spent more time preparing for class reported higher rates of academically-related and informal faculty contact (Kuh & Hu). These researchers note that the direction of these effects is indeterminate as better academically prepared students may seek out faculty; likewise, faculty may more frequently invite conversations with students who display high academic ability and effort.

Mentored research is often mentioned as an effective means of promoting student-faculty interaction (Boyer Commission on Educating Undergraduates in Research Universities [Boyer Commission], 1998; Fricke, 1981; Hakim, 1998; Kuh, Kinzie, Schuh, & Whitt, 2005; Nikolova Eddins & Williams, 1997; Nikolova Eddins, Williams, Bushek, Porter, & Kineke, 1997). Some institutional undergraduate research programs were developed to specifically encourage regular student-faculty interactions (Baenninger & Hakim, 1999; Jonides, von Hippel, Lerner, & Nagda, 1992; Wilson, Cramer, & Smith, 2003). Kuh et al. (2005) contend that “when larger numbers of students on a campus work with faculty members on research, student-faculty interaction is likely to increase” (p. 174). Others have found that students who participated in undergraduate research felt more confident about approaching faculty and discussing research topics (Alexander et al., 1998) and about interacting more often with faculty in general (Foertsch, Alexander, & Penberthy, 1997). In addition, alumni who participated in mentored research as undergraduates were also significantly more likely to maintain contact with faculty after college and to ask faculty for job recommendations as compared to alumni with no research experiences (Hathaway, Nagda, & Gregerman, 2002).

In addition to fostering greater levels of student-faculty interaction, undergraduate research is associated with a range of positive benefits for students. Undergraduate research

participants were more likely to earn a baccalaureate degree (Nagda, Gregerman, Jonides, von Hippel, & Lerner, 1998), took more honors and advanced level courses (Bauer & Bennett, 2003; Jonides et al. 1992), and more frequently pursued educationally purposeful activities (Bauer & Bennett; Hathaway et al., 2002). They demonstrated higher levels of abilities in communication and interpersonal interaction, science, mathematics, and reasoning, and language mastery (Bauer & Bennett; Lopatto, 2004, 2006; Mabrouk & Peters, 2000; Seymour, Hunter, Laursen, & Deantoni, 2004; Ward, Bennett, & Bauer, 2002). Undergraduate research also has been shown to strengthen inquiry skills (Bauer & Bennett; DeAngelo & Levis-Fitzgerald, 2007; Gafney, 2001; Hathaway et al.; Kardash, 2000; Joyce, 2003; Lopatto, 2004; Mabrouk & Peters; NSSE, 2007; Seymour et al.; Ward et al.) and increased disciplinary knowledge (Ishiyama, 2002; Webster et al., 2006), critical thinking, reflective judgment (Bauer, 2001), and epistemological development (Baxter Magolda, Boes, Hollis, & Jaramillo, 1998; Ryder, Leach, & Driver, 1999). Engaging in research has been linked to building confidence in conducting research and making formal presentations (Alexander, Foertsch, Daffinrud, & Tapia, 2000; Jonides et al.; Joyce). Seymour et al. contends that undergraduate research participants may develop more confidence from taking risks with new responsibilities, behaviors, and relationships. Lastly, undergraduate research was positively related to having clearer career goals (Bauer & Bennett; Campbell & Skoog, 2004; Gafney; Kremer & Bringle, 1990), showing more interest in graduate school, and pursuing advanced education at significantly high rates (Alexander et al.; Bauer & Bennett; Foertsch et al., 1997; Hathaway et al.; Ishiyama; Jonides et al.; Lopatto, 2003a, 2003b, 2004; Mabrouk & Peters; Schowen, 1998; Seymour et al.; Ward et al.; Werner & Sorum, 2003).

Undergraduate research experiences seem to provide a structure and support for meaningful student-faculty interactions to occur. In fact, on-going, substantial faculty contact

during a mentored research experience proved to be the best predictor of student gains in intellectual skills, career and collaboration skills, and research skills (Buckley, Korkmaz, & Kuh, 2008). This finding is instructive, given that undergraduate research programs vary widely in their structure and activities (Hu, Scheuch, Schwartz, Gayles, & Li, 2008); but frequent faculty-student interactions throughout the research experience were significant predictors of student gains.

The benefits associated with undergraduate research likely contribute to the popularity of these initiatives (Hu, Kuh, & Gayles, 2007). In recent years, about one in five seniors in research universities and master's institutions did a research project with a faculty member outside of course or program requirements during their undergraduate studies (Kuh, Chen, Nelson Laird, & Gonyea, 2007; National Survey of Student Engagement [NSSE], 2007). Seniors at baccalaureate colleges reported even higher participation rates (24%) (NSSE, 2003, 2004, 2005, 2007; Hu et al.; Hu et al., 2008). Mentored research may be more prevalent at baccalaureate colleges because undergraduates are the potential pool of research assistants at these institutions; also, faculty members at these types of schools may be more inclined to work with undergraduates in these ways (American Council of Learned Societies [ACLS], 2007). In fact, one national study of 27,000 faculty found that more baccalaureate faculty spent a greater proportion of their research time with undergraduates than did faculty at master's or doctoral institutions (Kuh et al.). Many research universities also have difficulties creating sufficient numbers of research opportunities to accommodate the diverse interests and backgrounds of their large and heterogeneous undergraduate populations (Boyer Commission, 2002; Merkel, 2001). Whatever the reasons, most undergraduate research initiatives at research universities involve the most accomplished students (Boyer Commission, 2002; Geiger, 2004; Katkin, 2003).

Purpose

While about the effects of participating in undergraduate research are generally positive, little is known about the features of the research experience that contribute to these outcomes. In addition, it is not clear how participating in undergraduate research at different types of institutions affects other forms of student-faculty interaction. For example, some undergraduate research programs were also designed to promote the enrollment and retention of first-generation students, under-represented minorities, and women (Alexander et al., 1998; Foertsch et al., 1997; Hathaway et al., 2002; Jonides et al., 1992; Campbell & Skoog, 2004).

This study compares student-faculty interaction of undergraduates who participated in a faculty-mentored research experience with their counterparts who did not have such an experience. Three research questions guided this study:

- 1) First, how did the student-faculty interactions of undergraduate research participants compare with those of non-participants?
- 2) Second, what effect did participating in undergraduate research have on student-faculty interactions as compared with other student characteristics, such as major field of study, gender, and minority or first-generation status?
- 3) Lastly, how did participating in undergraduate research in different types of institutions relate to other forms of faculty contact?

Answering these questions would help us determine whether there were conditional effects of student and institutional characteristics on student-faculty interaction. For example, students in some fields are more likely to participate in mentored research, such as the laboratory sciences and engineering as compared to pre-professional fields (business, education), some social sciences (economic, political science), humanities, and the arts (Boyer Commission, 2002, Kuh

et al., 2007; Russell, Hancock, & McCulough, 2007). Examining the conditional effects on students would reveal whether there were significant differences in student-faculty interaction according to students' major field, gender, and under-represented or first-generation status.

Data Source and Methods

To explore the relationship between undergraduate research and student-faculty interaction, we used the National Survey of Student Engagement (NSSE) 2008 dataset. NSSE is an annual survey that measures the degree to which undergraduates participate in educational practices that prior research has found to be linked to valued collegiate outcomes (Chickering & Gamson, 1987; Kuh, 2001, 2003). The NSSE instrument is administered each year to a random selection of first-year and senior students at hundreds of colleges and universities. We used this instrument because it included items about participating in undergraduate research as well as separate items about student-faculty interaction.

Sample

The sample consisted of 128,377 randomly selected seniors attending 711 different US colleges and universities who completed the NSSE survey in 2008. The institutional sample size ranged from 450 to 4,000 students, and was based on undergraduate enrollment (NSSE, 2008b). During this particular year, the institutional-level response rate was approximately 40% for the both Web-based and paper administration modes for seniors (NSSE, 2008a). We included only full-time seniors in this study because part-time students made up around 15% of the senior respondents and engaging in undergraduate research was relatively rare among part-time students (11%). Sixty-four percent of the respondents were female, 41% were first-generation college students (with neither parent having a baccalaureate degree), 13% were adult (28 and older), and 13% were under-represented students of color (African American, Latino, or Native

American). The institutions varied in terms of size; 49% had a total enrollment of less than 2,500, 22% were between 2,500 and 5,000, 16% were between 5,000 and 10,000, and 13% were more than 10,000. Fifty-eight percent of the institutions were private. The Carnegie classifications for institutions were: 14% Doctoral Universities, 24% Master's Colleges and Universities (larger programs that awarded 200 degrees or more), 12% Master's Colleges and Universities (medium programs that awarded between 100 and 199 degrees), 7% Master's Colleges and Universities (small programs that awarded up to 99 degrees), 20% Baccalaureate Colleges-Arts & Sciences, 14% Baccalaureate Colleges-Diverse Fields, and 9% other types of institutions.

This data set was weighted for gender and institutional size in order to better represent these sampled populations. We used list-wise deletion to treat missing data in the analyses. No pattern of missing data was evident as we had sufficient cases to study the student and institutional characteristics.

Measures

The student-faculty interaction scale included five items about faculty contact:

- discussed grades or assignments with an instructor,
- talked about career plans with a faculty member or advisor,
- discussed ideas from your readings or classes with faculty members outside of class,
- received prompt written or oral feedback from faculty on your academic performance, and,
- worked with faculty members on activities other than coursework (committees, orientation, student life activities, etc.).

The response options included very often, often, sometimes, and never. The reliability coefficient for this scale (Cronbach's Alpha) was .77. 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. Undergraduate research participants indicated that they had done this and were coded as 1 and the rest were coded as 0. (Appendix A contains a list of items used in this analysis).

Data Analyses

The data were analyzed in three steps. First, we produced descriptive statistics for the undergraduate research participants. Next, we compared whether undergraduate research participants and non-participants differed regarding the frequency and nature of their contact with faculty, which provided a partial answer to the first research question. To compare student-faculty interaction by major field and institutional type, scores on the 100 point student-faculty interaction scale were standardized which made it possible for the results to be interpreted as effect sizes. An effect size is the proportion of a standard deviation change in the dependent variable as a result of a one-unit change in an independent variable. The larger the effect size, the more likely the difference between groups represents performance that warrants serious discussion and perhaps institutional action. As suggested by Rosenthal and Rosnow (1991), we consider an effect size of .10 or less to represent a trivial difference, between .10 and .30 small, between .30 and .50 moderate, and greater than .50 large. Because statistical significance is sensitive to sample size, effect sizes were particularly important in this study as the large number of cases used at both the student- and institution-level made it more likely that small differences would be statistically significant.

Next, with student-faculty interaction as the dependent variable, MANOVA (multivariate analyses of variance) was used to determine if participating in undergraduate research was a significant predictor of other faculty interactions, after controlling for student characteristics such as gender, first-generation status, adult, under-represented minority, and major field. We examined the partial eta-squared scores to determine the relative effect of each variable compared with the undergraduate research experience. Partial eta-squared is the proportion of total variability attributable to a factor. We also examined interaction effects of various student characteristics to identify conditional effects.

After looking at the relationship of undergraduate research and student-faculty interaction at the student level, we considered whether this relationship differed at the institutional level. In other words, does participating in undergraduate research at different size institutions or different types of institutions according to the Carnegie classification have differential effects on student-faculty interaction? To answer this third research question, we used hierarchical linear modeling (HLM) (Raudenbush & Bryk, 2002) because this data was nested and we wanted to estimate the institutional effects on student-faculty interaction as well as undergraduate research participation. At the student level, we controlled for the same characteristics that we controlled in MANOVA: gender, first-generation status, adult, under-represented minority, and major field. At the institution level, we controlled for institution type using the Basic 2005 Carnegie classification (Carnegie Foundation for the Advancement of Teaching, 2005) as well as institutional size and control (public, private). We allowed the intercept to vary, thereby partitioning the variance that could be attributed to institution-level effects. We randomized the slope of the undergraduate research variable in order to partition the variance that may exist due to institutional differences in the undergraduate research dependent variable. Because the continuous measure of student-

faculty interaction was standardized, the unstandardized coefficients in all the tables represent the effect size.

Next, we estimated a model of student-faculty interaction and undergraduate research experiences. We used four steps to enter the independent variables. In the first step, we only included undergraduate research experience to determine this effect without student and institutional controls. In the second step, we included the student level controls. The third step included institutional controls for the intercept. The final step included the institutional controls for the undergraduate research slope. This approach made it possible to determine the variance explained by student characteristics, institutional characteristics, and the effects of institutional characteristics as well as the undergraduate research experience on student-faculty interaction. Finally, we displayed some case scenarios based on the final HLM table to allow readers to conceptualize the effects of undergraduate research experience in student-faculty interaction at different types of institutions.

Limitations

Although the institutions administering NSSE mirror all US colleges and universities in terms of institutional characteristics, the results and conclusions of this study are limited to only those schools that used NSSE in 2008. In addition, pre-college measures of predispositions for either participating in undergraduate research or interacting with faculty were not available. Consequently, it is possible that differences between students may be due to entering student characteristics (Pascarella, 2001). This study considered differences in student-faculty interaction rates for participants and non-participants in undergraduate research, which was defined as working on a research project with a faculty member outside of course or program requirements.

This study did not examine the experiences of students who complete independent research that was not necessarily supervised by a faculty member.

Results

Table 1 presents descriptive statistics for the student and institutional characteristics among participants. Twenty-two percent of respondents had worked on a research project with a faculty member outside of course or program requirements. Slightly more men than women (23% and 21% respectively) participated in undergraduate research. First-generation students (19%) were less likely to have such an experience compared to students with at least one parent with a college degree (24%). Similarly, older seniors (14%) were much less likely to have a research experience than younger students (14% and 23% respectively). Students majoring in biological and physical sciences (42%) had the highest rate of participation, followed by Engineering (30%), Social Sciences (27%), Arts and Humanities (19%), Education (14%), and Business and Professional Fields (14%). Participating in undergraduate research was most common in Baccalaureate Colleges-Arts and Sciences (31%), followed by Doctoral Universities (24%), Baccalaureate Colleges-Diverse Fields (22%), Masters Colleges and Universities – small programs (22%), medium programs (21%), and larger programs (17%), as well as other Carnegie institutions (16%). When comparing participation rates by institutional size, undergraduate research participation was most common in institutions that enrolled less than 2,500 undergraduates (27%) and next were institutions that enrolled from 2,500 to 5,000 undergraduates (23%). Larger institutions that enrolled between 5,001 and 10,000 and more than 10,000 had fewer undergraduate research participants (20% and 21% respectively).

<Insert Table-1 about here>

Table 2 indicates that research participants reported significantly more faculty interaction across all major fields. The average student-faculty interaction score for research participants was 60 and for non-participants it was 45, with a mean difference of 15. The average effect size difference was large at .69, ranging from .63 (engineering) to .80 (business and professional fields) (Table 2).

<Insert Table-2 about here>

Table 3 shows the different rates of student-faculty interaction among undergraduate research participants and non-participants at different institutional types. Research participants reported significantly more faculty contact across all types of colleges and universities. Research participants in institutions except Doctoral Universities reported student-faculty interaction levels above 60, while those at Doctoral Universities reported an average student-faculty interaction level of 56. Student who did not participate in undergraduate research reported significantly less faculty engagement, Doctoral University (42), Masters Colleges and Universities – large programs (45), medium programs (47), and small programs (50), Baccalaureate Colleges – Arts and Sciences (50) and Diverse Fields (49), as well as other Carnegie types (42). The effect size differences ranged from .61 (Doctoral Universities) to .82 (Masters Colleges and Universities – large programs).

<Insert Table-3 about here>

The MANOVA produced an adjusted R square of .10. Four variables were significant: undergraduate research (F test=1744.12, $p < .001$), major field (F test=26.50, $p < .001$), under-represented minority (F test=55.06, $p < .001$), and female (F test=5.56, $p < .05$). Undergraduate research had the largest effect with a partial eta squared of .014, following by major field with .001. The effects for under-represented minority and gender were trivial. After controlling for

various student characteristics, research participants were significantly more likely to engage with faculty in other settings. Some of the interaction effects were statistically significant; however these effects were trivial due to the large sample size.

Table 4 presents the relationships between undergraduate research participation and student-faculty interactions after taking into account both student and institutional characteristics. The base (unconditional) model includes only the random intercept and error terms and no controls. From the base (unconditional) model, 6.6% of the variance in student-faculty interaction was explained by institutional characteristics and the remaining 93.4% was explained by student characteristics. Adding the undergraduate research experience slope in step 1, explained around 8.9% variance at the student level. The effect size of .70 was consistent with the descriptive statistics about undergraduate research participation as among different major fields undergraduate research participants had significantly higher student-faculty interaction rates than non-participants. In the second step, we included the remaining student level characteristics which accounted for only .9% more variance in the student level. The effect sizes were trivial for all these student level characteristics except for the major fields of arts and humanities (.21) and education (.27).

Although the variation at the institutional level was small, step 3 indicates that additional institutional characteristics for the intercept explained most of the variance (66.4%). Institutional control (private/public) did not matter, but institutional size and type were significant with small effect sizes. As institutions became larger, student-faculty interaction dropped by an effect size of .10. Masters Colleges and Universities with large programs and other Carnegie types of institutions were not statistically different than Doctoral Universities. Masters institutions with medium and small programs and Baccalaureate Colleges (Arts & Sciences and Diverse Fields)

had small effects as seniors in these institutions reported significantly more student-faculty interactions than seniors in Doctoral Universities.

In the final step, the same institutional characteristics were entered along with the undergraduate research experience slope. The overall variance explained at the individual level (9.8%) and institutional level (66.1%) did not change much from step 3. The effect of undergraduate research slope dropped from .71 to .43 indicating that the relationship between undergraduate research participation and student-faculty interaction varied by the institutional characteristics. The effects were mostly related to the Carnegie groups. As compared to seniors in Doctoral Universities, undergraduate research participants had significantly more student-faculty interaction at the following kinds of institutions: Masters Universities and Colleges with large programs (.19), medium programs (.16), and small programs (.11) in addition to Baccalaureate Colleges – Diverse Fields (.14) and other types of institutions (.17). Also, participants in undergraduate research at larger colleges or universities had higher rates of student-faculty interaction as compared to students at smaller size institutions. This was contrary to the intercept finding as students at larger institutions had lower average rates of student-faculty contact in general. When we combined the intercept and the undergraduate research slope at different size institutions, we found normally students attending larger size institutions were at a disadvantage in interacting with faculty, however when these students at larger institutions did undergraduate research they were not as disadvantaged in their interactions with faculty.

<Insert Table-4 about here>

To illustrate the influence of undergraduate research participation on the overall student-faculty interaction scores with regard to institutional characteristics, we estimated three institutional cases based on the final step in the HLM model in Table 4. Since student-faculty

interaction scores were standardized, the mean is 0. Table 5 presents estimated student-faculty interaction scores for an undergraduate research participant and non-participant at three different types of institutions. A typical non-participating student at a small Baccalaureate-Arts & Sciences College might have a student-faculty interaction score of 0 (the mean) and .60 if a research participant. The typical student range at a large Master's institution with large programs might range between -.34 to .46, while the range changes from -.43 to .27 at a very large Doctoral University. The difference between an undergraduate research participant and non-participant ranged from .60 to .80, a large effect. These variations were consistent with Table-2 findings.

<Insert Table-5 about here>

Discussion and Conclusion

Involving undergraduates in faculty mentored research has been promoted as a means to enhance the quality of undergraduate education (American Association of Colleges & Universities [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; Kuh, 2008) and to encourage student-faculty interaction (Boyer Commission, 1998; Fricke, 1981; Hakim, 1998; Kuh et al., 2005; Nikolova Eddins & Williams, 1997; Nikolova Eddins et al., 1997). The findings from this study substantiated these outcomes and also indicate that participating in undergraduate research has conditional effects and point to three conclusions.

First, participating in undergraduate research is positively associated with student-faculty interaction across all major fields. This finding supported other studies that show that undergraduate research experiences will foster student-faculty contact (Alexander et al, 1998;

Foertsch et al., 1997; Hathaway et al., 2002; Kuh et al., 2005). However, the direction of these findings is unknown as undergraduate research participants may have already frequently interacted with faculty or engaging in undergraduate research may have increased their faculty interactions in other contexts. Knowing more about the direction of these findings is a worthwhile research question for future studies to address.

Second, participating in undergraduate research had a stronger effect on rates of student-faculty interaction than other student characteristics (gender, under-represented ethnic or minority identity, first-generation status, adult, and major field). Most effect size differences for student characteristics were trivial with the exception of the major field of arts and humanities and education, which had small effects. Thus, undergraduates majoring in those fields had significantly higher student-faculty interaction rates than biological and physical science majors, which is another finding to further investigate. This result is consistent with other national studies that found students majority in humanities (Kuh & Hu, 2001) as well as applied disciplines (Kuh, Hu, & Vesper, 2000) reported significantly higher rates of student-faculty interaction.

Third, the effect of participating in undergraduate research on student-faculty interaction varied by institutional size and mission. Undergraduate research participants who attended Masters Colleges and Universities with large, medium, and small programs and Baccalaureate Colleges with Diverse Fields as well as other Carnegie type institutions reported significantly more student-faculty interaction than did seniors at Research Universities. Students who participated in undergraduate research at larger institutions had higher rates of student-faculty interaction as well. This latter finding is important because undergraduates at larger institutions generally have lower rates of student-faculty interaction; participating in undergraduate research

significantly increased these student-faculty interactions. The undergraduate research experience at Baccalaureate Colleges-Arts and Sciences and Research Universities had no effect on student-faculty interaction.

Implications

This study shows that undergraduate research participants interact more frequently with faculty than their counterparts without mentored research experiences. However, some students are less likely than others to have this experience and reap its multiple benefits. That is, similar to what Kuh (2008) reported, proportionately fewer first-generation students, under-represented minorities, and women engaged in undergraduate research as compared to their counterparts. More must be done to insure that all students have equal opportunities to engage in this high-impact educational practice.

It is easier to involve students who already have the necessary skills to work independently and who can make research contributions in a timely manner as they require less training and supervision (Gates, Teller, Bernat, Delgado, & Della-Piana, 1998). Time limitations may prevent many from participating in undergraduate research because of other academic and work commitments (Hakim, 2000; Katkin, 2003; Merkel, 2001, 2003; Merkel & Baker, 2002). Yet, only involving those skilled and available undergraduates does not expand the pool of research participants or support a wider range of students advancing onto graduate school.

Undergraduate research participation had the greatest impact on higher levels of student-faculty contact in larger institutions as well as in Masters Colleges and Universities with large, medium, and small programs, Baccalaureate Colleges – Diverse Fields, and other types of Carnegie institutions. This was not the case at Baccalaureate Colleges-Arts & Sciences, perhaps because these institutions already offer favorable faculty-student ratios and more small classes,

making it easier for faculty to know more students by name and for students to participate actively in classes (Kuh et al., 2007). Participating in undergraduate research appears to have greater effects on improving student-faculty contact in institutions with moderate or larger classes, higher faculty-student ratios, and fewer opportunities to personally connect with faculty. Why this is not so at Research Universities is not known. Perhaps the priorities and reward systems at such institutions discourage faculty from spending as much time with students who work on faculty projects. Kuh et al. (2007) found that, on average, faculty spent two and a half hours a week working with undergraduates on research. While Research University faculty devoted about twice as much time to research as their counterparts at baccalaureate and master's institutions, this increased time spent on research did not translate into additional time spent working with undergraduates (Kuh et al., 2007). In part, this may be because Research University faculty may work more often with graduate students on research which is consistent with the institutional mission. Merkel (2003) also found that public Research Universities, in particular, faced significant challenges in developing a culture of undergraduate research because they were large and complex organizations, where undergraduate research may flourish in some departments but not in others or where such experiences may be targeted at the most talented students (Boyer Commission, 2002; Geiger, 2004; Katkin, 2003). Also, undergraduate research programs in research universities tend to be geared toward high ability students as opportunities to enrich their learning. These same students may also interact more frequently with faculty than their peers which reduces the impact of the research experience per se on faculty contact.

While this study established a positive link between undergraduate research and increased student-faculty interactions, the obvious disparities for faculty involved in undergraduate research makes it difficult to promote this as an educational reform effort (Hu et

al., 2008). Unlike graduate students who work relatively independently, undergraduate research is a teaching-intensive endeavor that requires more faculty interaction, instruction, and guidance (Baenninger & Hakim, 1999). Belliveau and O'Leary (1983) consider that 50 to 70 percent of an undergraduate's research effort will be spent learning and only 30 to 50 percent will be producing results. It has estimated that properly supervising one or two undergraduate research experiences can occupy as much time as teaching one course (Coker & Davies, 2002; Stevens & Reingold, 2000), as it takes time to communicate frequently and clearly about the research and expected outcomes as well as to teach skills and techniques that students need to carry out projects (Merkel & Baker, 2002; Ravert, Boyer, Harmon, & Scoffield, 2004; Schultz, 2001). For faculty who are already busy with research, teaching, advising graduate students, and writing grant proposals, mentoring undergraduates adds another responsibility and activity (Luyben, 2005; Merkel, 2001; Mervis, 2001). Clearly institutional and disciplinary support is needed for faculty who mentor undergraduate research participants.

Conclusion

This study showed that students who have an undergraduate research experience interact more frequently with faculty members during their senior year of college. These effects were conditional, in that student-faculty interaction varied according to such institutional features as size and mission. More information is needed about the causal relationships between undergraduate research experiences and student-faculty contact.

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Table 1. The participation rates in undergraduate research experiences

Characteristics	% Participated in Undergraduate Research
Students	
Women	21%
Men	23%
Under-represented ethnic or minority	21%
White	22%
First-generation college	19%
Student with one parent with a college degree	24%
Traditional age	23%
Non-traditional age	14%
Biological & Physical Sciences	42%
Engineering	30%
Social Sciences	27%
Arts & Humanities	19%
Education	14%
Business & Professional Fields	14%
Institutional	
Doctoral Universities	24%
Masters-Large Programs	17%
Masters-Medium Programs	21%
Masters-Small Programs	22%
Baccalaureate Colleges-Arts & Sciences	31%
Baccalaureate Colleges-Diverse Fields	22%
Other Carnegie classifications	16%
Undergraduate enrollment less than 2500	27%

Undergraduate enrollment 2500 to 5000	23%
Undergraduate enrollment 5001 to 10,000	20%
Undergraduate enrollment over 10,000	21%

Table 2. The standardized and unstandardized difference in student-faculty interaction by major fields

		Arts and Humanities	Biological & Physical Sciences	Business & Professional	Education	Engineering	Social Science	Other	All
Standardized SFI	Non-participant	-.12	-.30	-.26	-.03	-.48	-.23	-.26	-.23
	Participant	.65	.33	.54	.71	.15	.47	.46	.46
Unstandardized SFI	Non-participant	47	43	44	49	39	45	44	45
	Participant	64	57	62	65	53	60	60	60
Effect-size difference		.77	.63	.80	.74	.63	.70	.72	.69

Table 3. The standardized and unstandardized difference in student-faculty interaction by Carnegie classification and undergraduate research participation

		Doctoral	Masters Large	Masters Medium	Masters Small	BA - AS	BA -Div	Other
Standardized SFI	Non-participant	-.34	-.23	-.10	.01	.02	-.01	-.21
	Participant	.27	.59	.64	.68	.64	.71	.55
Unstandardized SFI	Non-participant	42	45	47	50	50	49	45
	Participant	56	63	64	65	64	65	62
Effect-size difference		.61	.82	.74	.68	.62	.72	.77

Table 4. The effect size and significance level for student and institutional characteristics and the variance explained for each step in HLM Model

Independent Variables	Base Model	Step 1	Step 2	Step 3	Step 4
Intercept					
<i>Intercept2</i>	.00	-.15 **	-.25 **	-.06	-.02
		*	*	**	**
<i>Size</i>				-.10 *	-.11 *
<i>Private</i>				.03	.02
<i>Masters Large</i>				.04	.01
<i>Carnegie Masters Medium</i>				.11 **	.08 **
<i>Type:</i>				**	
<i>Doctoral Masters Small</i>				.13 *	.11 **
<i>Univ as Baccalaureate - AS</i>				.11 **	.11 **
<i>reference Baccalaureate -Div</i>				.10 **	.08 *
<i>Other</i>				-.07	-.09
		**	**	**	**
Undergraduate Research slope		.70 *	.71 *	.71 *	.43 *
					**
<i>Size</i>					.06 *
<i>Private</i>					.03
					**
<i>Masters Large</i>					.19 *
<i>Carnegie</i>					**
<i>Type: Masters Medium</i>					.16 *
<i>Doctoral Masters Small</i>					.11 *
<i>Univs as Baccalaureate - AS</i>					.07
<i>reference Baccalaureate -Div</i>					.14 **
					**
<i>Other</i>					.17 *
First-generation			-.03 **	-.03 **	-.03 **
			**	**	**
Minority			.08 *	.09 *	.09 *
			**	**	**
Adult Female			-.05 *	-.05 *	-.05 *
			.00	.00	.00
			**	**	**
<i>Major: Arts & Humanity</i>			.21 *	.20 *	.20 *
<i>Biological and Physical Sciences as reference</i>			**	**	**
<i>Business & Professional</i>			.07 *	.07 *	.07 *
			**	**	**
<i>Education</i>			.27 *	.27 *	.27 *
			**	**	**
<i>Engineering</i>			-.08 *	-.08 *	-.08 *
			**	**	**
<i>Social Sciences</i>			.09 *	.09 *	.09 *
			**	**	**
<i>Other</i>			.07 *	.08 *	.07 *

Variance Components

Total variance	1.02		.93		.91		.88		.88
Variance within institutions		**		**		**		**	**
Variance research slope	.95	*	.87	*	.86	*	.86	*	.86
Variance between institutions				**		**		**	**
Proportion between institutions	.07		.02	*	.01	*	.01	*	.01
Variance between explained									
Variance within explained	6.6%		6.1%		5.4%		2.6%		2.6%
			16.3%		27.0%		66.4%		66.1%
			8.9%		9.8%		9.8%		9.8%

Table 5. Case scenario estimates of student-faculty interaction for various student and institutional characteristics

Cases	Inst. Size	Private	Carnegie Type	Estimation		
				Research participant	Not Participant	Difference
Case-1	Small	yes	Bac-AS	.60	.00	.60
Case-2	Large	yes	MA-L	.46	-.34	.80
Case-3	Very large	no	Doc	.27	-.43	.70

Appendix A – NSSE survey items about undergraduate research and student faculty interaction

Which of the following have you done or do you plan to do before you graduate from your institution?

1. Work on a research project with a faculty member outside of course or program requirement.

1=Done, 0= Plan to do, Do not plan to do, Have not decided

In your experience at your institution during the current school year, about how often have you done each of the following?

2. Discussed grades or assignments with an instructor

1=Very little, 2=Some, 3=Quite a bit, 4=Very much

3. Talked about career plans with a faculty member or advisor

1=Very little, 2=Some, 3=Quite a bit, 4=Very much

4. Discussed ideas from your readings or classes with faculty members outside of class
1=Very little, 2=Some, 3=Quite a bit, 4=Very much

5. Received prompt written or oral feedback from faculty on your academic performance
1=Very little, 2=Some, 3=Quite a bit, 4=Very much

6. Worked with faculty members on activities other than coursework (committees, orientation, student life activities, etc.)
1=Very little, 2=Some, 3=Quite a bit, 4=Very much