Do Faculty-Student Collaborations Affect Achievement in Engineering and Technical Fields? A Large-Scale Analysis

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Abstract – **Analyzing survey data from a national sample of 3,118 undergraduates majoring in STEM, this study examined the extent to which faculty-student collaborations affect academic achievement as measured by college grades. Results suggest a statistically significant association between faculty-student relations and grades, even after controlling for confounding influences. Also, time spent studying was positively associated with college grades. Implications for future research and practice will be discussed.**

Index Terms – academic achievement, faculty, mentoring, STEM.

INTRODUCTION

Recent reports from the National Academy of Engineering indicate that future engineers must possess a comprehensive set of skills including, but not limited to, design and problem-solving skills, contextual competence, and interdisciplinary competence. And while the skills and abilities of the *Engineer of 2020* are well known, far less is known about how colleges and universities can effectively prepare undergraduates, especially those in engineering and technical (E&T) fields, for work in a changing global economy.

The weight of empirical evidence provides support for the important role that faculty-student collaborations (FSCs) play in undergraduates' success in general. For instance, research shows that substantive interactions with faculty (e.g., seeking advice, working on research project), affect student learning outcomes [1], especially for seniors [2], while Astin found that students gain more developmentally from being involved in educationally meaningful activities such as FSCs than more passive behaviors [3]. Consequently, Pascarella and Terenzini concluded that FSCs affect "student degree attainment and…overall academic development" [4]. Very few studies, to date, examine the influence of faculty-student collaborations on academic achievement among E&T undergraduates, using the goals of *Engineer of 2020* as a guide. This is the contribution made by the present study.

PURPOSE

The purpose of this study was to measure the extent to which faculty-student (F-S) collaborations affect academic achievement, as measured by college grades, among E&T undergraduates. Two research questions (RQs) guided the analyses: (a) What is the relationship between FSCs and college grades? (b) What is the relationship between FSCs and college grades, controlling for differences in background traits and institutional characteristics?

METHOD

As part of a larger study funded by the NSF that consists of both quantitative and qualitative components, this analysis presents survey findings from Phase 1 of this multi-year project only.

Sample

The nationally representative sample consisted of 3,118 undergraduates who responded to the *College Student Experiences Questionnaire* (CSEQ), administered by the Postsecondary Research Program at Indiana University. The sample consisted of undergraduates majoring in science, technology, engineering, and math (STEM) fields only (excluding health and allied fields), as defined by the National Science Foundation. Women comprised a slight majority of the sample (56%); 13% were transfer students, 41% were first-year freshmen, and 5% attended historically Black colleges/universities (HBCUs). Additional information describing the sample is shown in Table 1.

Data Collection and Analysis

Data were obtained from the national sample and provided to the researcher by the CSEQ Research Program. The CSEQ consists of 191 items designed to elicit information about the quality and quantity of students' experiences in college. The instrument was developed on the notion that "the more effort students expend in using the resources and opportunities an institution provides for their learning and development, the more they benefit" [5].

Items from several subscales were used in the present study. For instance, one scale measures students' experiences (e.g., time spent studying). One other subscale

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measured the frequency with which students engaged faculty members (7 items, *alpha* = 0.86), using a rating scale of 1 ("not often") to 4 ("very often"), while a single item indicated whether students had "worked with faculty on research project" (0 = no; 1 = yes). A single item measured students' college grades ranging from 1 ("C- or less") to 5 ("A"). To isolate the net effect of FSCs on academic achievement, several statistical controls were introduced: age, race, sex, first-generation status, marital status, year in school, HBCU, and institutional selectivity as measured by *Barron's College Guide*.

Data analysis proceeded in three stages. First, data were prepared for analysis using a combination of data reduction techniques (e.g., factor analysis) and reliability analysis. Second, correlations were calculated to measure the association between FSCs and college grades. Next, the clustering effects of individual students nested within institutions were considered using a combination of chi-square tests and intraclass correlations. It was determined that hierarchical linear regression techniques were appropriate for the study and would likely provide accurate and stable estimates of standard error. Thus, hierarchical linear regression tests were conducted to measure the relationship between FSCs and academic achievement among STEM majors, controlling for differences across an extensive set of control variables.

TABLE 1
DESCRIPTION OF SAMPLE (N = 3,118)

Variables	%
Academic	
Transfer student?	
Yes	13
No	87
Classification	
First-year	41
Sophomore	19
Junior	17
Senior	23
Attending HBCU?	
Yes	5
No	95
Worked with faculty on research?	
Yes	31
No	69
Demographic	
Age (in years)	
19 or younger	49
20-23	44
24 and above	7
Sex	
Male	44
Female	56
Marital status	
Single	95
Married/divorced/widowed	5
Race/ethnicity	
White	70
African-American	7
Latino	11
Asian Pacific Islander	11
American Indian	1

Note. HBCU = historically Black college/university.

RESULTS

The first research question focused on the magnitude and direction of the association between FSCs and college grades among the sample. There was a statistically significant correlation between college grades and F-S interactions (r=0.08, p<0.01), as well as college grades and F-S research collaborations (r=0.05, p<0.01). It's also interesting to note that the two F-S interaction variables were associated statistically (r=0.38, p<0.01). Findings suggest that STEM majors who interacted or collaborated with faculty members also tended to have higher grades.

To estimate the net effect of F-S collaborations on STEM majors' grades, controlling for potentially confounding differences, hierarchical linear regression analysis was conducted using a three stage model where stage 1 (i.e., demographic variables), stage 2 (i.e., institutional variables), and stage 3 (i.e., F-S variables) were force-entered by the researcher. Hierarchical regression results suggest that the first model was significant, F(9,2946)=22.13, p <0.01. The sample multiple correlation coefficient was 0.25, indicating that approximately 6% of the variance in college grades among the STEM sample can be accounted for by demographic factors. Significant predictors included: sex (B=0.12), marital status (B=0.19, p=0.07), first-generation (B=-0.25), and hours spent studying (B=0.12).

Hierarchical regression results suggest that the second model was significant, F(11,2944)=19.26, p<0.01. The sample multiple correlation was 0.26, indicating that approximately 7% of the variance in college grades among the STEM sample can be accounted for by demographic and institutional factors with institutional factors adding incrementally (1%) to the explained variance. Significant predictors included: sex (B=0.12), marital status (B=0.21), first-generation (B=-0.22), hours spent studying (B=0.11), and institutional selectivity (B=0.05).

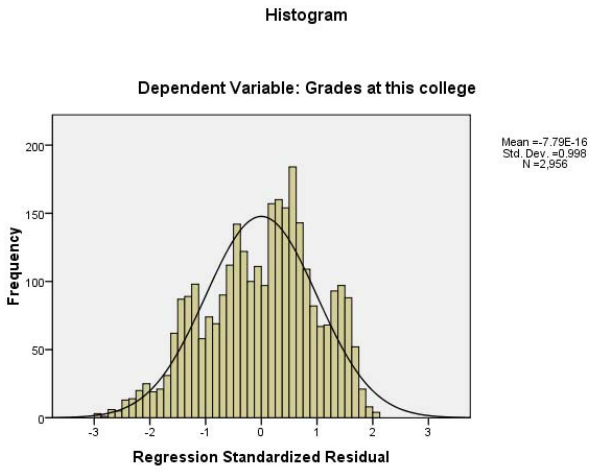
Finally, hierarchical regression results suggest that the last and final model was significant, F(13,2942)=17.46, p<0.01. The sample multiple correlation coefficient was 0.27, indicating that approximately 7% of the variance in college grades among the STEM sample can be accounted for by demographic, institutional, and F-S factors. Significant predictors included: sex (B=0.12), marital status (B=0.20), first-generation (B=-0.22), hours spent studying (B=0.11), institutional selectivity (B=0.05), and faculty-student interactions (B=0.01). The regression standardized residual is shown in Figure 1.

CONCLUSION

Survey results from the national sample indicate that F-S interactions and research collaborations are associated with STEM majors' grades. Asking faculty members about class assignments, discussing ideas about term papers or career plans, even socializing with faculty members outside of class affects college grades, controlling for differences in background traits and institutional characteristics.

Additionally, STEM majors grades seem to be noticeably influenced by the amount of time they devote to studying and completing assignments outside of class. E&T faculty members might consider these findings when making decisions about course activities; the present study lends empirical support to the importance of homework and out-of-class assignments. Results also provide clues to strategies that hold promise for raising STEM students' academic achievement, especially those who might face unique challenges in technical fields such as women and first-generation students. For instance, the results of this study suggest that women and first-generation students majoring in STEM are at a disadvantage academically when compared to men and non-first generation STEM majors. Engaging women and first-generation STEM majors in F-S research collaborations is likely to raise their academic performance, perhaps by increasing students' academic self-efficacy and the amount of effort they expend on academic tasks. Thus, deans, department heads, and policymakers would be well served to consider structured undergraduate research experiences as an educationally effective practice for improving academic achievement. Although more research is needed, this study provides an initial foray into the role that FSCs play in STEM students' success and how that information can be used by college student educators.

FIGURE 1
HISTOGRAM OF REGRESSION



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