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Exploring Graduate Funding: Variation Across Engineering Disciplines and Relationships to Student Engagement and Satisfaction

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Graduate Funding and the Graduate Experience: An Exploratory Analysis at a College of Engineering

Abstract

The primary focus of this study is the relationship between graduate student funding types and various measures of student satisfaction. Graduate-level enrollments and degrees are continuing to grow. Given the significant numbers of STEM graduate students participating in assistantships and fellowships and the substantial investments to support those positions, minimal extant literature examines their relationships to the graduate student experience. This paper provides results from an exploratory study that addresses this topic through a college-wide survey of engineering graduate students. A one-way ANOVA identified three items with statistically significant differences between groups with different funding types. Items related to choosing research interests and allocation of graduate teaching assistantship positions. A follow-up study has been devised to examine these research questions further, in addition to other questions surrounding the graduate student experience, in a more systematic fashion.

Introduction

There is an established need to increase the number of STEM professionals in the United States to maintain a competitive edge globally in science and technology.[1] Although undergraduate education is invaluable to the creation and support of a stable economy, graduate education develops the critical thinking skills and tools for innovation that will help ensure the nation's prosperity.[2] This increased emphasis on postgraduate work has been marked by a growth in both graduate-level enrollments and degrees.

Graduate school applications and first-time enrollments were at an all-time high in 2014. Specifically in engineering, first-time graduate enrollment increased by 10.7% from Fall 2013 to Fall 2014.[3] From 2004 to 2014, the number of master's degrees awarded increased by 2.9%, and doctoral degrees awarded increased by 6.1%. In 2013, science and engineering doctorates accounted for 74% of all doctorates conferred.[4] As graduate student participation continues to increase, administrators, faculty members, and policymakers face the challenge of providing competitive funding for these students.

Significant investments are made annually toward graduate education. For example, last year, the National Science Foundation (NSF) spent over $333 million on the Graduate Research Fellowship Program.[5] These fellows represent only a fraction of the 450,000 full-time graduate students in the STEM fields enrolled in U.S. institutions.[6] In the STEM fields, those not receiving fellowships or grants similar to the GRFP are likely to fund their graduate educations through either research assistantships or teaching assistantships. Over 90% of 2013 doctoral degree earners in science and engineering reported having either an assistantship or fellowship as their primary source of financial support.[4]

Given the significant numbers of STEM graduate students participating in assistantships and fellowships and the substantial financial investments to support those positions, minimal extant

literature examines their relationships to the graduate student experience. The dearth of literature is particularly resonant for engineering graduate students. This paper provides results from exploratory research in addressing this topic through a college-wide survey of engineering graduate students. We present findings from preliminary exploratory work that will inform future data collection within this institution. This study also provides a lead-in to a more systematic, national-scale study of doctoral student funding in STEM education that was recently funded by the National Science Foundation. This study will discussed in the later sections of this paper.

The primary focus of this study is the relationship between graduate student funding types and various measures of student satisfaction. Specifically, this study addresses the following research questions:

1. What is the relationship between graduate student funding and graduate student relationships with faculty and peers?
2. What is the relationship between graduate student funding and the research and learning environment for graduate students?

Literature Review

Graduate funding mechanisms are more than just a means to fund graduate education. The structure of a teaching assistantship, research assistantship, or fellowship is highly connected to the graduate student experience. Much of the extant literature on assistantships and fellowships focuses on their connection to the building of relationships with faculty members and fellow students and the development of knowledge and skills. As this study aims to investigate how graduate student funding can relate to graduate student relationships and the research and learning experience, a review on the current literature on those topics will first be discussed.

Graduate Funding and Relationships with the Disciplinary Community

Much of the existing literature on the graduate student experience focuses primarily on the relationship of the graduate student to the larger community. Research specifically directed toward assistantships and fellowships examines the nature of the faculty-student relationship and how graduate departments aim to integrate each student into norms of their respective disciplines. As described in this section, the nature of the assistantship or fellowship can result in contrasting relationships for the student.

Maher et al.[7] found that interactions between research supervisors and research assistants facilitated through graduate research assistantships (GRAs) are highly influential of students' research capacity in science and engineering. However, the influence was strongest only when both parties were fully committed. Bowen and Rudenstine[8] found that graduate teaching assistantships (GTAs) facilitate structured engagement with colleagues, which are positively related to graduate completion. Similarly, when GTAs have meaningful conversations about their teaching with faculty members or peers, they are likely to teach more effectively[9] and sustain motivation and interest in teaching[10].

While assistantships and fellowships have a large influence on graduate student interactions with faculty members, they also have a relationship to the graduate students' exchanges with the larger academic community. Graduate research and teaching assistantships provide opportunities for graduate students to learn the values and norms of their programs by increasing formal and informal interactions with faculty and peers.[11] Fellowships, on the other hand, have demonstrated an increased likelihood of isolation for graduate students[12]; however, this has also been refuted in the sciences.[8]

Taken collectively, prior research illuminates how GRAs, GTAs, and fellowships can facilitate or hinder graduate student relationships to faculty and the greater disciplinary community. This study seeks to extend that work by investigating the relationship between the type of funding mechanism and satisfaction with relationships and support offered by faculty and peers within a College of Engineering.

Graduate Funding and the Research and Learning Environment

Extant research shows that research and teaching assistantships provide opportunities for students to develop the skills necessary for the relevant work through direct experiences as well as faculty and peer guidance. These experiences also facilitate an increased self-confidence and greater identity alignment with those particular work responsibilities. The nature of learning experiences that are afforded through assistantship experiences can be connected to the graduate student experience as a whole.

Assistantships play a role in knowledge acquisition for graduate students. Grundy[13] found that graduate research assistants enhanced their research knowledge and skills through working alongside experienced researchers. Niemczyk[14] identified specific skills developed through a research assistantships including conducting literature reviews, interviewing, and analyzing data. Graduate teaching assistants, similarly, accumulate the skills needed to lead courses, although numerous studies have addressed concerns of limited training (e.g. [15]).

Skill development has also been examined inside the context of the learning community. Grundy[13] found that graduate research assistants increased their self-confidence toward research by working alongside fellow researchers. Similarly, research assistantships have been found to contribute to the development of graduate students' identities as researchers.[16] Such beliefs also have been connected to research interests and performance attainments in graduate students. Studies on faculty mentoring of graduate teaching assistants have positively related to self-efficacy for instruction.[17] In addition, Connolly and Lee[18] found significant relationships between doctoral student participation in teacher development training and college-teaching self-efficacy.

Teaching and research assistantships have been found to afford numerous learning opportunities for graduate students. While extant literature has documented cognitive and affective outcomes facilitated through assistantships, this study seeks to address specifically what relationship graduate funding types have to satisfaction within the research and learning environment.

Methodology

To gain a better understanding of graduate student funding in the College of Engineering and whether funding type relates to students' graduate school experiences, the College developed and administered a survey to the entire engineering graduate student population at a single research institution. This survey was administered prior to our full team's involvement in the research, and thus the research for the current paper can be characterized as archival, secondary data analysis. Items on the survey gathered demographic data including gender, degree program, current funding type (e.g., graduate teaching assistantship, graduate research assistantship), degree type (i.e., Master's, Doctoral), current year in school, location of classes (i.e., main campus or off campus location), and residency status (i.e., US citizen, international student). Items on the survey examined the graduate student experience in three main areas: 1) satisfaction with relationships to and support offered by faculty and peers, 2) satisfaction with the research and learning environment, and 3) understanding of how funding was allocated in their department. Survey items analyzed for this paper can be found in Appendix A.

Relationships and support offered by faculty and peers were measured with items asking students to rate their satisfaction with the sense of community in their lab, ability to find an advisor, advising/mentoring received from their advisor, and amount of contact with faculty. Response options ranged from 'very dissatisfied' to 'very satisfied' on a five-point Likert scale. Relationships were also measured by items that asked respondents to rate their agreement with the amount of collaboration with faculty and peers. Response options ranged from 'strongly disagree' to 'strongly agree' on a five-point Likert scale. Two additional items measured graduate students' relationships with peer students and faculty measured on an 11-point scale (0 to 10).

Experiences with the research and learning environment were measured by items that asked respondents to rate their agreement with the extent to which they saw their research activities contributing to overall research goals in their lab, whether their selection of courses was diverse, and current issues in their discipline. Response options ranged from 'strongly disagree' to 'strongly agree.' Understanding about how funding was allocated was measured by two items that asked respondents to indicate their agreement on whether they understood how GTA positions were assigned in their department. Response options ranged from 'strongly disagree' to 'strongly agree' on a five-point Likert scale for these items.

The survey was sent to all currently enrolled graduate students in the College of Engineering at the end of the Spring 2015 semester. Students were emailed directly and asked to click on a link that would take them to the online survey. One reminder was sent to the students via email asking them to complete the survey. In addition to direct emails, several graduate student groups made references to the survey and reminded students to complete it via public announcements at their group meetings. Groups included college-specific and university-wide organizations such as graduate student government and the College of Engineering Graduate Student Representatives Forum. In total, 447 engineering graduate students, including 170 Master's level and 262 Doctoral level students, completed the survey, representing a 21.9% response rate.

To address the research questions associated with this exploratory study, we conducted a one-way analysis of variance (ANOVA). Our independent variable was graduate funding type, which included 3 factor-levels: graduate teaching assistantship (GTA), graduate research assistantship (GRA), and other (includes fellowship, self-funded, industry sponsorship, other). Dependent variables included all survey items described previously (found in Appendix A). Bonferroni post-hoc analysis was used to compare factor-level means.

Limitations

As the method of data collection was a cross-sectional survey, certain limitations should be acknowledged. First, the cross-sectional nature of data collection limits all results to associations between variables; no causal claims can be made on these relationships. For example, because of this design, we are unable to determine whether students seeking certain kinds of graduate experiences were drawn to different types of funding or whether the funding led to the different experiences. Second, the response rate of 22% represents a lower than average overall response rate typical of online surveys.[19] The size of survey respondents limited the number of additional factors, such as degree program, from inclusion in the analysis.

The Council of Graduate Schools has written on the high variation in program characteristics for STEM Master's Programs.[20] To prevent any confounding variables and to allow for a more direct comparison, analyses were completed exclusively on doctoral students. This decision also afforded a closer connection to extant literature, as the literature has largely ignored Master's degrees. However, this decision further decreased the sample size.

Results and Discussion

Of the 262 doctoral student responses, the highest response rate came from graduate research assistants, which represented 63% (165) of respondents (see Table 1). Graduate teaching assistants comprised 19.8% (52) of respondents. The Other factor-level, which combined fellowship, self-funded, industry sponsorship, and other categories, totaled 38 responses. Electrical engineering doctoral students responded in the highest numbers within different degree programs at 51 (19.5%), followed by computer science students (17.9%) and civil engineering students (10.7%) (see Table 2). Table 3 reports the gender distribution of doctoral degree respondents. 177 males and 70 females responded, constituting percentages of 67.6% and 26.7% respectively. This represents a slightly higher percentage of females in the sample than enrolled in the College of Engineering, which was comprised of 22.3% females.

Table 1: Frequencies of Funding Type

	n	%
GTA	52	19.8
GRA	165	63.0
GA	7	2.7
Fellowship	19	7.3
Self-funded	10	3.8
Industry Sponsorship	3	1.1
Other	6	2.3
Total	262	100.0

Table 2: Frequencies of Degree Program		
	n	%
Aerospace	9	3.4
Biological Systems	14	5.3
Biomedical	9	3.4
Chemical	6	2.3
Civil	28	10.7
Computer Eng	15	5.7
Computer Science	47	17.9
Electrical	51	19.5
Engineering Education	17	6.5
Engineering Mechanics	15	5.7
Environmental	4	1.5
Environmental Science	3	1.1
Industrial & Systems	11	4.2
Materials Science	5	1.9
Mechanical	23	8.8
Mining	5	1.9
Total	262	100.0

Table 3: Frequencies of Gender		
	n	%
Male	177	67.6
Female	70	26.7
Prefer Not Answer	15	5.7
Total	262	100.0

Means and standard deviations for each survey item are reported in Appendix A. Means for survey items on a 1 to 5 Likert scale ranged from 3.11 (I understand the system by which GTA positions are assigned in my department) to 4.04 (I am currently part of a lab group that meets regularly. Items on the 0 to 10 scale exhibited means of 7.36 and 7.26 respectively.

One-Way ANOVA

Of the twenty survey items analyzed (see Appendix A), three items exhibited statistically significant differences between at least one of the factor-levels at a 95% confidence level (Table 4). Of those three items, one related to research interests and the other two related to assignment of GTA positions. All three of these items related to students' agency and fairness within certain aspects of the graduate experience, specifically, whether students were able to follow their own interests and the process by which teaching assignments were made. For each of these items, interpretations of the post-hoc analyses will be described.

Table 4: Statistically Significant (p<0.05) One-way ANOVA Results						
		Sum of Squares	df	Mean Square	F	Sig.
I have been able to follow my research interests rather than my advisor's for funding	Between Groups	7.605	2	3.802	3.044	.049
	Within Groups	313.576	251	1.249		
	Total	321.181	253			
I understand the system by which GTA positions are assigned in my department	Between Groups	10.654	2	5.327	3.826	.023
	Within Groups	348.042	250	1.392		
	Total	358.696	252			
I believe the system by which GTA positions are assigned is fair in my department	Between Groups	8.458	2	4.229	4.705	.010
	Within Groups	224.712	250	.899		
	Total	233.170	252			

Selecting Research Interests

Post-hoc analysis shows that doctoral students in the Other funding category reported averages higher than those of graduate research assistants (Table 5). Students who receive funding from sources that were not directly linked to a specific collaboration with a faculty member articulated more freedom over their research pursuits than their peers who were funded as GRAs. This finding has been cited as one of the primary benefits of fellowship programs for graduate students.[21] Unfortunately, a direct comparison between fellowships and assistantships is not fully possible because of the aggregate "Other" category in our analysis. Future work with a larger sample size would aim to untangle this category to determine if similar findings hold true for fellowship students, self-funded students, or those participating in industry-sponsored programs.

Although the academic freedom of a fellowship can certainly been seen as a positive motivator for many graduate students, following a unique, independently driven research path may promote an isolating environment from faculty and other graduate students. Some students who were funded via fellowships have reported such experience.[12] Further research should be conducted to examine the nuances of how fellowships, and other funding programs not directly linked to a faculty member, may promote or inhibit graduate student experiences.

Assignment of GTA Positions

Post-hoc analyses of the two items relating to the assignment of GTA positions show that graduate teaching assistants both understand the system better and believe it is fairer than their graduate research assistant counterparts (Table 5). The first item is an indication of the understanding of the funding system. It is logical to reason that GTAs would understand the allocation of GTAs more than GRAs because they are more directly involved in the system. Unfortunately with limitations of the survey items, this interpretation excludes the experiences of other graduate students. In future analyses, the item may be reworded to "the system by which assistantship positions are assigned" to encompass the experiences of more graduate students.

Table 5: Bonferroni Post-hoc Results for Statistically Significant ANOVA Items							
Dependent Variable	Factor-level		Mean Difference	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
I have been able to follow my research interests rather than my advisor's for funding	GTA	GRA	.090	.178	1.000	-.34	.52
		Other	-.407	.239	.268	-.98	.17
	GRA	GTA	-.090	.178	1.000	-.52	.34
		Other	-.496	.201	.043	-.98	-.01
	Other	GTA	.407	.239	.268	-.17	.98
		GRA	.496	.201	.043	.01	.98
I understand the system by which GTA positions are assigned in my department	GTA	GRA	.523	.189	.018	.07	.98
		Other	.398	.253	.351	-.21	1.01
	GRA	GTA	-.523	.189	.018	-.98	-.07
		Other	-.125	.212	1.000	-.64	.39
	Other	GTA	-.398	.253	.351	-1.01	.21
		GRA	.125	.212	1.000	-.39	.64
I believe the system by which GTA positions are assigned is fair in my department	GTA	GRA	.464	.152	.008	.10	.83
		Other	.305	.203	.404	-.18	.79
	GRA	GTA	-.464	.152	.008	-.83	-.10
		Other	-.159	.171	1.000	-.57	.25
	Other	GTA	-.305	.203	.404	-.79	.18
		GRA	.159	.171	1.000	-.25	.57

The second item, on fairness of the GTA assignment process, presents a more nuanced discussion on the experiences of graduate students. Based on the wording of the survey item, no full interpretation can be made on the relationship between opinions on fairness of the system and the graduate student experience, or rather, how graduate students feel about their current position. Further investigation should seek to address why GRAs find the system of GTA assignment more unfair than GTAs. Such research could uncover underlying mechanisms for why GRAs find the process more unfair and how it affects the graduate experience for those students.

Future Work

As noted, this preliminary exploratory research contains several limitations. Following these analyses, our research team will be involved in helping devise more targeted survey items for future data collection as opposed to relying on secondary data. New survey items will seek to understand how students considered funding when selecting their graduate program of study and whether they actively seek different kinds of funding once they have been admitted. Survey items will also be better aligned with a theoretical framework in future administrations. We also hope to link survey responses to individual students so that their participation and responses might be tracked over time, thereby producing a longitudinal data set.

Beyond this specific project, our research team is in the process of launching a five-year, national-scale project funded by the National Science Foundation (NSF). The research design addresses many of the limitations identified about the current study—sample sizes are large, data extend backward for decades, and institutional and disciplinary comparisons can be made. The data set also links pre-doctorate and post-degree experiences to the graduate student experience, which will allow for much broader analyses than what was possible in the current paper. The study also includes an in-depth qualitative investigation, which will allow for much more in-depth understanding of the issues illuminated in this paper.

Briefly, the purpose of the upcoming NSF research study is to understand how to spend graduate student funding wisely to ensure a variety of student experiences and an optimal set of outcomes, including equal access for all students to the financial, academic, professional, and social resources that support success in graduate study. Differences in the types of funding offered to STEM graduate students from underrepresented backgrounds have potential implications for equity, access, and success. African American, Hispanic and female graduate students receive more fellowships and fewer research assistantships than students from other subpopulations, which could be isolating underrepresented students from important research mentoring experiences. For example, for women in STEM this translates into a statistically significantly lower rate of presenting conference papers and publishing articles while in graduate school. Those are the kinds of implications of policy decisions that our research will interrogate. Figure 1 illustrates the basic design of this upcoming research.

Several decades of national data from the Survey of Earned Doctorates (SED) will allow us to build regression models relating graduate students' incoming characteristics, the types of funding they receive during graduate study, and outcomes related to degree completion and employment. Interviews across eight STEM disciplines and seven NSF-funded centers at eight institutions will probe alternative explanations and assumptions about how graduate student funding decisions are made and impact student success. In summary, this upcoming project represents a much larger, more systematic approach that will build off of the single-institution, exploratory research described in the current paper.

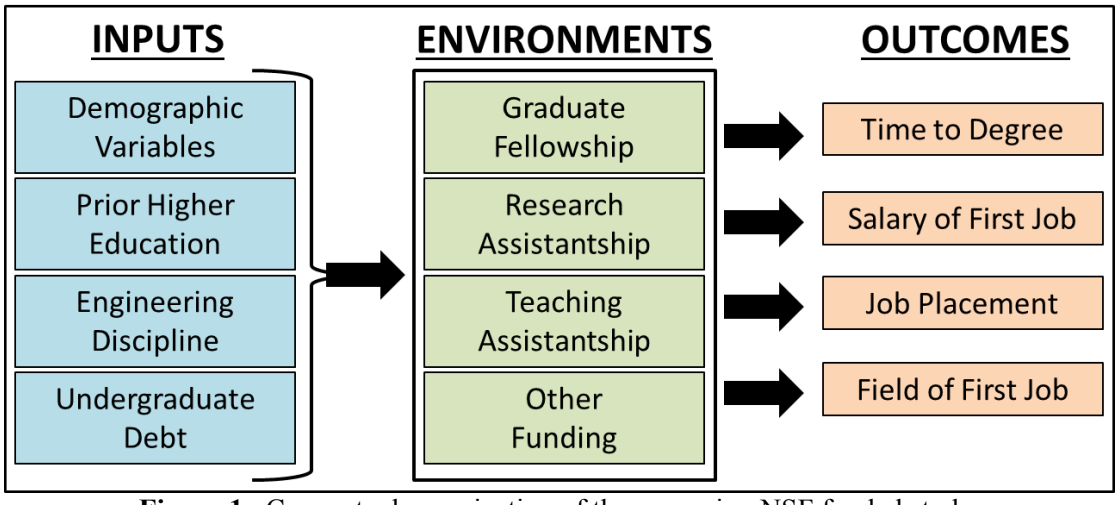

Figure 1. Conceptual organization of the upcoming NSF funded study.

Conclusion

In this study, we used a survey distributed to all graduate students in a College of Engineering to examine the relationship between the type of funding a graduate student holds and their relationships and experiences in the research and learning environment. Focusing exclusively on doctoral students, three items were found to have statistically significant differences between groups with different funding types, all relating to students' agency in the choosing of research interests and allocation of graduate teaching assistantship positions. However, limitations of the study (i.e. cross-sectional survey, low response rate) prevented a more robust analysis.

A follow-up study has been devised to examine these research questions, in addition to other questions surrounding the graduate student experience, in a more systematic fashion. The five-year project, sponsored by the National Science Foundation, will specifically examine how graduate student funding relates to a variety of student experiences and outcomes, seeking an understanding of ways to enable equal access for all students to the financial, academic, professional, and social resources that support graduate student success. The project will involve quantitative analyses of a national, longitudinal data set and an in-depth qualitative investigation to allow for much deeper understanding of findings.

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Appendix A: List of Survey Items Analyzed with Mean and Standard Deviation

	Mean	s.d.
Please indicate your agreement with the following statements (1 – Strongly Disagree; 5 – Strongly Agree):		
I am currently part of a lab group that meets regularly	4.04	1.082
I can see my research contributing to the aims and goals of the research group I am a part of	4.02	.988
I collaborate closely with the faculty members and/or primary investigator in my research area of interest	3.93	1.052
I collaborate closely with other graduate students that are in my lab group and/or research area of interest	3.52	1.187
I have a group of graduate students that provide each other with academic support	3.44	1.222
I have been adequately advised of the graduation requirements for my degree	3.59	1.120
I have been able to follow my research interests rather than my advisor's for funding	3.48	1.125
I understand the system by which GTA positions are assigned in my department	3.11	1.201
I believe the system by which GTA positions are assigned is fair in my department	3.30	.955
Rate your satisfaction on the following elements (1 – Very Dissatisfied; 5 – Very Satisfied):		
Overall quality of instruction by faculty	3.66	1.003
Sense of community in my department	3.45	1.131
Sense of community in my program/lab	3.78	1.069
Amount of contact with faculty	3.75	1.059
Ability to find a faculty advisor	3.91	1.076
Career advising/mentoring received	3.61	1.159
Availability of resources needed to complete degree (e.g. equipment)	3.95	.966
Diversity, modernness, usefulness of courses in research area	3.48	1.142
Representation in University Governance	3.25	.846
How would you describe relationships with students that are in your department? (0 – Cold, Discouraging, Sense of Alienation; 10 – Friendly, Supportive, Sense of Belonging)	7.36	2.097
How would you describe relationships with faculty that are in your department and/or committee? (0 – Remote, Discouraging; 10 – Approachable, Encouraging, Supportive)	7.26	2.270