WIP: Factors Affecting Graduate STEM Student Attrition Rates

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***Abstract*—This Research Work-in-Progress paper presents a systematic literature review of existing work within graduate STEM education. Recently, engineering education researchers have begun to join the conversation of STEM education through studies exploring student attitudes and minority student experiences, among others. However, there is no centralized publication source for graduate STEM education leading to an undersaturated picture of existing research that causes researchers interested in graduate education to scour disparate sources to gain the necessary background to undertake their research. By conducting a systematic review of the existing literature, this work aims to give future researchers in graduate education a stepping off point for exploration understudied areas in graduate education. We conducted a search of the Journal of Higher Education and Frontiers in Education (FIE) proceedings from 2008-2018. Six articles were found that explored three factors that influence graduate student experiences. The factors are as follows: internal (e.g. advisor), programmatic (e.g. teaching assistantship) and external (e.g. family and future career). We have documented the initial conversations that have occurred in two sources. These results show graduate education as a relatively understudied area, but those seeking to do work in this area, can now more clearly understand the conversations that have occurred.**

***Index Terms*—Graduate Education, STEM, Attrition, Literature Review**

I. Introduction

Understanding why students persist and how they navigate through engineering is the focus of many studies, with researchers examining the student experience to give insight [1,2]. While much has been learned on the undergraduate level, there is little information about graduate students. The focus on graduate student experience of this paper is based on previous work [1,2] which demonstrated that the quality of student experiences can affect student outcomes such as retention and degree attainment. Examples of this type of research on the undergraduate level within engineering can be found in the works of Ohland and Lord [1,2], among others. Despite a wide disparity in degree completion between undergraduate and graduate students (67% and 43% respectively) [3,4], there is a small disparate pool of literature examining graduate students [5-20]. Additionally, in science and engineering, full time graduate student enrollment increased from 449,613 to 508,773 between 2008 and 2016 [3]. With a lower completion rate [4] and steady increases in enrollment [3], these numbers often leave those seeking to change graduate education wondering what work they can draw from. To meet this need, we propose a systematic literature review of graduate STEM education literature based on an article by Borrego and colleagues on how to conduct a systematic literature review [21]. The strengths of a systematic literature review lie in its ability to cross examine existing research, take stock of the different projects and research directions as well as identify the gaps in our understanding of the graduate student experience. Thus, this works strives to understand how existing research in STEM (science, technology, engineering, and mathematics) education communities has documented the experiences of graduate students. Specifically, this review aims to answer the question; what are the experiences of graduate students during their time enrolled in graduate school, and how do these factors influence their intentions to persist?

The authors gratefully acknowledge the NSF for supporting this project Grant Numbers (EHR-1535453 and 1535254).

II. Methods

Our systematic literature review consists of five steps ranging from developing the research question to the synthesizing the findings in a presentable manner [21]. The motivation to begin this project started with a search for articles on graduate student education that indicated no centralized publication source for data and studies on graduate education. This paper outlines the protocol used to understand what we currently know about graduate student experiences. Through the completion of an expanded systematic literature review in future work, we hope to highlight the holes in the literature that can be addressed by the broader engineering and STEM education communities.

A. Scoping and Developing Research Questions

The development of our research question stemmed from seeing multiple graduate students struggle through their degree programs and conversations with faculty indicating they were unsure how to help these students. From these observations and conversations, a search for literature pertaining to graduate student experiences began. Throughout this search little to no research on graduate students was found across multiple publication sources, highlighting the need for a systematic literature review to connect the few resources that do exist.

The scope of this paper focused specifically on graduate STEM education, chosen to better understand the conversations and factors around the graduate student experience. Since graduate education research is an emerging area of research, a 10-year timeframe was chosen. Additionally, to

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not exclude articles prematurely, the search term of graduate STEM education was used to obtain a broad list of the available publications and articles.

B. Finding and Cataloging Resources

Following the development of the research question and scoping of the review, the next goal was deciding which journals or conference proceedings would be focused on, which was accomplished by first reaching out to those who were currently funded or are conducting work in graduate engineering education research (n = 3). This sampling was a sample of convenience and was not exhaustive of all researchers or resources available. Despite the limitations of this sampling approach, it allowed for identification of commonly cited journals used by researchers in the field for systematic review of literature. Due to the work in progress nature of this article, two sources were selected for review: The Journal of Higher Education and the Frontiers in Education (FIE) Proceedings from 2008 to 2018. We then worked to exclude articles whose data was not focused on the desired population, such as tenure track professors, those working in industry as well as undergraduate and postdoctoral students.

C. Defining Inclusion Criteria

The next step was generating inclusion criteria to keep the content specific and focused on the research question proposed. Searching "Graduate STEM Education" yielded over 500 results through the two publication sources. By reading the titles and keywords, this list was able to be narrowed to 167. Keywords of interest were as follows: graduate education, masters, doctorate, attrition, experience. To further refine this list, abstracts were read to determine if an article focused on experiences and leveraged data from graduate students specifically. By this point there were only 19 articles that focused on graduate student experiences. These nineteen articles were then reviewed in-depth, and articles whose direct focus was not on graduate students were excluded.

D. Critique and Appraisal

With 19 articles representing the current research on graduate STEM education, the critique and appraisal stage in which the researcher focused on two criteria. First was the quality of the data being reported on, led by whether the data was drawn from graduate students or focused solely on policy, funding, or undergraduate student perception. Secondly, the paper was examined for how well the authors presented not only their findings but also their limitations within the paper. The goal at this stage was to remove any unnecessarily biased, statistically insignificant, or otherwise inconsequential articles. This further refinement resulted in 6 articles whose distribution is outlined in Table I. These articles are to be synthesized and cross examined for influential factors contributing to graduate student experiences. Future work will revisit articles with more in-depth quality considerations (e.g., Walther 2013 [6]) as this represents a preliminary survey and critique of the existing literature.

TABLE I
NUMBERS OF ARTICLES MEETING THE SEARCH CRITERIA AND REMAINING AFTER EXCLUSION

Publication Sources (2008-2018)	***Met Search Criteria***	***Had Keywords***	***Met Inclusion Criteria***
Journal of Higher Education	76	8	3
FIE Proceedings	91	11	3

E. Synthesis

The final stage in this systematic literature review was to synthesize and cross examine the findings from each article into factors that could serve as a starting point for researchers and educators interested in learning about graduate STEM education and the students experiences. Shown in Table 2., our synthesis resulted in three factors which will be expanded upon in the discussion section: individual, programmatic and external influences.

TABLE II
FACTORS INFLUENCING GRADUATE STUDENT EXPERIENCES

Factor	***Citation***
Individual	Noy, S., and Ray, R. (2012).Graduate students perceptions of their advisors:Is there systematic disadvantage in mentorship?*The Journal of Higher Education*, 83(6), 876914. https://doi.org/10.1353/jhe.2012.0036 Dykes, L. (2009). Academic aspirations: An analysis of the influence of doctoral advisors and Marylands alliance for graduate education and the professoriate (AGEP) on graduate students attitudes regarding careers in academia. *Proceedings - Frontiers in Education Conference*, FIE, 15. https://doi.org/10.1109/FIE.2009.5350556
Programmatic	Mena, I. B., Diefes-Dux, H. A., Capobianco, B. M. (2013). Socialization Experiences Resulting from Doctoral Engineering Teaching Assistantships. *The Journal of Higher Education*, 84(2), 189212. https://doi.org/10.1353/jhe.2013.0013 Holley, K. A. (2017). The Longitudinal Career Experiences of Interdisciplinary Neuroscience PhD Recipients. *The Journal of Higher Education*, 89(1), 122. https://doi.org/10.1080/00221546.2017.1341755
External	Cintron, L. G., and Cohoon, J. M. G. (2015). Work/family attitudes of computing graduate students. *Proceedings - Frontiers in Education Conference*, FIE, 2014. https://doi.org/10.1109/FIE.2015.7344176

III. DISCUSSION

Comparing the number of publications that met the inclusion criteria (6) to the number of articles that met the search criteria (167) shows the need for more focus in graduate education. With only 3.6 percent of articles about graduate students containing data from the students themselves, an argument can be made that the conversation within graduate education is not focused on the students narrative, but on policies and funding. Examples of the articles that were excluded in the last pass of the review are the works of Strayhorn, Kennedy

et al., and Gilmore et al. [23]-[25], which were removed due to the population of interest and timeframes whose focus was outside the scope of this review. The articles that did focus on the graduate students experiences they were divided into 3 factors that influenced those pursuing advanced degrees (Table 2).

The first factor was the influence that a students advisor has on their time in graduate school. Within this topic the articles discussed the implications of race and gender and how the amount of support a student perceives is correlated to their persistence. Laura Dykes reported [27] a negative correlation between pursuing a career in academia and having personal problems with their advisor. While the focus of Dykes article was on student pursuing academia, the results show that there is a correlation between advisor support and students persistence. The other article centered on advisor influence is a paper by Noy and Ray in the Journal of Higher Education [26]. They report that people of color in general perceived a lack of respect from their advisor when compared to their peers [25]. Secondly, that women perceived no lack of support from their advisors, unless they were of a minority groups [26]. This highlights the need for research understanding the implications at being at the intersection of race and gender. Taken in tandem there is evidence supporting the negative effect of a lack of advisor support for people of color.

The second factor that emerged was program specific experiences based on the program that students chose for their advanced degrees. The first finding is from Holley [28], where she reported that interdisciplinary neuroscience students felt isolated and had trouble finding careers [28]. This resulted in students being trapped in postdoctoral assignments unable to move into tenure track or industry positions [28]. The other article by Mena et al. [29] was in line with the topic of socialization, taken in the context of teaching assistantships. In addition to being a common way that graduate students support the financial obligations of graduate school, students had opportunities to socialize with professors, students and peers as well as developed professional skills (e.g. presentation, teaching and networking skills). Opportunities to socialize in this manner are more important in smaller programs, as feelings of isolation have been shown to negatively impact students persistence [28]. One possible conclusion that can be drawn from the mixed outcomes of teaching assistantships is based on programs, these opportunities will impact students differently, particularly as this is not always a preferred decision on the students part.

The final factor, beyond the degree influences, examined how influences external to the university context affected students. Specifically, this article examined how confident graduate students are in balancing work and family life, as well as if family or personal responsibility was a consideration in applying for graduate school. Cintron and Cohoon [30] reported that approximately two thirds of men and women reported that family was influential in pursuing their doctorate. Despite the strong considerations by student, this study did not delineate whether the influence of family was positive or negative. Taken holistically, the literature indicates three different levels that influence their experiences in graduate school, the individual (e.g., advisor relationships), the programmatic (e.g., teaching assistantships), and the external (e.g., family). The review of this small body of literature shows that researchers have multiple areas they can target in graduate education to address problems that include but are not limited to high attrition rates.

IV. Limitations

The limitations identified in this project arise from the use of only a single search term across a small selection of publication sources, resulting in a small sample of articles from one facet of and the graduate education community. Further development and refinement of factor titles and groupings is expected as the breadth of literature is expanded, and the search terms evolve. Additionally, this work has been scoped to focus on STEM education, and as such the relevance to engineering education requires further testing.

V. Future Work

Future work from this project aims to expand upon this literature review for a more comprehensive understanding of graduate education. Additional work is needed to determine how the factors found in this work interact with one another, and how these interactions serve to shape student attrition in graduate education

To broaden and build upon this literature review, future work will seek to analyze more publication sources and refine the search terms to be more varied in search of nuanced articles in the graduate education space. One example of another publication sources is the Studies in Graduate and Postdoctoral Education Journal. Finally, other search terms that this research intends to use in the future include but are not limited to, graduate student experience, factors affecting graduate student health, graduate attrition, and graduate student persistence. By instituting these changes in a future literature review, a more representative picture of the experiences of graduate students will hopefully be obtained, allowing for more focused institutional reform at the graduate student level.

VI. Conclusions

Through examination of the Journal of Higher education as well as the Proceedings of the Frontiers in Education (FIE) for the last 10 years (20018-2018) there were 167 journal articles that were found via searching graduate stem education of which, 6 journal articles met the inclusion criteria of focusing on graduate student experiences. Within these 6 articles, there were 3 factors that have been researched and found to be influential in graduate student experiences. Through cross examination and synthesis of the different articles grouped under each factor, a representative sample of existing research in two publication sources has been accomplished. Using this literature review as a tool it is the hope of the researcher that other areas of the graduate student experience can be explored and connected to the existing literature base outlined in this research.

ACKNOWLEDGMENT

The authors would like to thank Dr. Joyce Main, Dr. Catherine Bernadier and Marissa Tsugawa-Nieves for their input on publication sources for the future work of this project. Furthermore, thank you to the National Science foundation for funding support under grant numbers (EHR-1535453 and 1535254).

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