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Reasons for Their Departure: A Look at Undergraduate Women who Abandon STEM Majors

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Abstract

Despite surpassing undergraduate men in degree completion, undergraduate women are still underrepresented in certain STEM majors and depart from these fields at higher rates. Much of the existing research on this topic, however, is quantitative in nature and conducted at large research institutions. This study sought to gain a better understanding of the reasons why undergraduate women switched from STEM to non-STEM majors at a large, Midwest liberal arts institution. A qualitative, phenomenological design was used to identify the reasons students identify as important in their decision to switch majors, the ways in which gender might have been tied to this decision and the changes institutions might implement to encourage the persistence of future undergraduate women in STEM fields. Data were collected through semi-structured interviews and Astin's (1993) input-environment-outcomes model and Tinto's (1993) theory of student departure served as a theoretical framework. Findings provide insight on the lived experiences of undergraduate women who departed from STEM majors and the factors that contributed to their departure.

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Chapter One: Introduction

Problem Statement

Despite the fact that undergraduate women have surpassed their male counterparts in overall degree completion, they are still underrepresented in certain STEM majors (National Science Board [NSB], 2016; National Science Foundation [NSF], 2015) and depart from these fields at higher rates (Chen & Soldner, 2013; President's Council of Advisors on Science and Technology [PCAST], 2012). This gap in persistence is particularly problematic in areas including engineering, computer science, mathematics, and physics. High rates of departure are also common amongst those who have shown they are capable of succeeding in these fields (Chen & Soldner, 2013; PCAST, 2012).

Factors believed to contribute to this gap in persistence amongst genders include: levels of academic preparation, methods of instruction, bias and stereotypes, and levels of support (National Research Center [NRC], 2006; PCAST, 2012). Yet, many of the studies, which address the departure of undergraduate women from STEM majors, utilize quantitative data from large research universities that may not tell the entire story, nor extend to other institutional types (e.g., see Beasley & Fischer, 2012; Espinosa, 2011; Gayles & Ampaw, 2014; George-Jackson, 2011; George-Jackson, 2014; Griffith, 2010; Kokkelenberg & Sinha, 2010; Rosenthal, London, Levy, & Lobel, 2011; Szelenyi, Denson, & Inkelas, 2013; Su & Rounds, 2015). Because of this, it seems beneficial to investigate this issue further within the context of a large liberal arts institution, using a qualitative approach to better understand the reasons undergraduate women switch from STEM to non-STEM majors, so that these institutions might become better equipped to encourage persistence in the future.

Rationale for the Study

The departure of undergraduate students from STEM majors is particularly alarming, as it is projected that the United States will have to drastically increase the number of STEM degrees earned in order to maintain its status as a global leader in the fields of science and technology and fulfill the need for STEM professionals within the current economy (PCAST, 2012). In fact, it has been estimated that by 2018, there will be approximately 2.4 million job openings in STEM fields (Office of Science and Technology Policy [OSTP], 2016). This is concerning since these are the fields responsible for creating new products, advancing technology, improving health care, protecting the environment and expanding national security (Committee on STEM Education [CoSTEM] of the National Science and Technology Council, 2013). Thus, it seems logical to prioritize the retention of students who have already expressed interest in these majors, especially given the high rates of departure reported amongst those who have shown they have the capacity to succeed (Chen & Soldner, 2013; PCAST, 2012).

Furthermore, because women tend to leave these majors at higher rates than men, this not only represents a potential issue of inequity, but signifies an alarming loss of talent and ability, as many of these women have the potential to make invaluable contributions to their field (Blickenstaff, 2005; OSTP, 2016; Su & Rounds, 2015). It also symbolizes the loss of diverse perspectives, which might otherwise lead to more complete answers and descriptions, more accurate explanations, and more universal designs within STEM fields (Blickenstaff, 2005). Thus, it seems pertinent to investigate the reasons why undergraduate women switch from STEM to non-STEM majors, so that universities are better equipped to address the factors, which may lead to their departure.

Background of the Problem

In American society, there has long since been a history of inequality for women. This is especially true within the realm of education and higher education in particular. Dating back to the colonial period, attendance at a college or university was largely restricted to White men from Christian backgrounds and prestigious families (Thelin & Gasman, 2010). In fact, it was not until the mid-nineteenth century that women were able to participate in postsecondary education through the establishment of female[1] *academies* or *seminaries*, which taught home economics and proper etiquette alongside the more traditional curriculum of science, mathematics, language, and composition (Horowitz, 1984). Many of these institutions eventually became degree-granting colleges, but it was not until the late nineteenth century that coeducation was pioneered by institutions such as Oberlin and Cornell (Thelin & Gasman, 2010).

Yet, even as coeducation became the norm across the country, women still experienced discrimination both within academics and co-curricular activities (Gordon, 1990; Nerad, 1999). It was also suspected that the standardized testing and selective admissions practices adopted in the 1920s might discriminate against students on the basis of race, ethnicity, and gender (Thelin & Gasman, 2010). Title IX of the Education Amendments Act of 1972 attempted to address these issues of gender inequality, prohibiting discrimination based on sex in all educational programs that receive government funding (National Women's History Project, n.d.). As a result, women gained slightly more access to formerly male-dominated fields including business, law, and medicine, along with various doctor of philosophy (Ph.D.) programs (Thelin & Gasman, 2010). The Women's Educational Equity Act of 1974 then designated funds to help develop non-sexist materials for the classroom and programs to increase women's participation in education, and the Gender Equity in Education Act of 1994 provided teachers with training on gender equity and sexual harassment prevention (The National Women's History Project, n.d.).

By the start of the 21st century, women accounted for the majority of students enrolled at many public institutions (Thelin & Gasman, 2010). Yet, even though women earn 57% of all degrees awarded today, there are still disparities reported in terms of resources and opportunities (NSF, 2015). This is especially true within STEM fields, although women's participation in these fields has risen since the late 1990s. There still appears to be a "leaky pipeline," defined as carrying "students from secondary school through university and on to a job in STEM" and appears to "leak more women than men" (Blickenstaff, 2005, p. 369). Thus, while few women pursue STEM majors in the first place, even fewer demonstrate persistence, and many seek employment in other fields after graduation (Blickenstaff, 2005). In fact, it has been reported that women hold only 25% of STEM jobs available (CoSTEM of the National Science and Technology Council, 2013).

As a result, the underrepresentation of women in STEM fields has become a priority. Indicative of this is the five-year strategic plan for STEM education created in response to the reauthorization of the America Creating Opportunities to Meaningfully Promote Excellence in Technology, Education, and Science (COMPETES) Act in 2010 (CoSTEM of the National Science and Technology Council, 2013). Part of this initiative is to address the underrepresentation of women and minority populations in STEM and encourage their increased participation in these fields. Still, it seems that the body of literature devoted to the study of this issue is inadequate, especially when examining the departure of women from STEM fields at the undergraduate level.

This is primarily because existing research utilizes quantitative data from national surveys and datasets derived from large research universities (e.g., see Beasley & Fischer, 2012; Espinosa, 2011; Gayles & Ampaw, 2014; George-Jackson, 2011; George-Jackson, 2014; Griffith, 2010; Kokkelenberg & Sinha, 2010; Rosenthal, London, Levy, & Lobel, 2011; Szelenyi, Denson, & Inkelas, 2013; Su & Rounds, 2015). In addition, many studies focus on the predictive power of individual factors and institutional characteristics (e.g., see Espinosa, 2011; Gayles & Ampaw, 2014; George-Jackson, 2011; George-Jackson, 2014; Griffith, 2010; Kokkelenberg & Sinha, 2010; Su & Rounds, 2015; Szelenyi & Inkelas, 2010), or the effectiveness of proposed interventions (e.g., see Dawson, Berstein, & Bekki, 2015; Morganson, Major, Streets, Litano, & Myers, 2015; Rosenthal, London, Levy, & Lobel, 2011; Szelenyi, Denson, & Inkelas, 2013; Tsui, 2007; Vieyra, Gilmore, & Timmerman, 2011).

Yet, few adopt a qualitative approach (e.g., see Goldman, 2012; Morganson et al., 2015; Vieyra, Gilmore, & Timmerman, 2011) and many focus instead on persistence (e.g., see Dawson, Bernstein & Bekki, 2015; Espinosa, 2011; Gayles & Ampaw, 2014; George-Jackson, 2014; Griffith, 2010; Kokkelenberg & Sinha, 2010; Morganson et al., 2015; Smith, Douglas & Cox, 2009; Szelenyi, Denson & Inkelas, 2013; Szelenyi & Inkelas, 2011; Vieyra, Gilmore & Timmerman, 2011). Thus, further qualitative research that seeks to understand the reasons undergraduate women depart from STEM majors at liberal arts institutions seems warranted.

Statement of Purpose

This study sought to understand the reasons undergraduate women at a large, Midwest liberal arts institution switch from STEM to non-STEM majors, and the changes this institution might implement to encourage the persistence of women in STEM in the future. To accomplish this, current undergraduate women who switched from STEM to non-STEM majors were interviewed about the reasons contributing to their departure, their experience as a woman in a STEM field at this particular institution, and any recommendations that might allow the university to encourage women's persistence in the future.

While previous research has focused primarily on the departure of women at large research institutions, this study provided insight regarding the reasons women depart from STEM fields at a large, liberal arts institution in the Midwest. This information may be used to inform recommendations for encouraging the persistence of other undergraduate women in STEM majors at comparable institutions.

Research Questions

In order to better understand the experience of undergraduate women who switch from STEM to non-STEM majors at this liberal arts institution in the Midwest, three questions guided this study:

1. What reasons do these students identify as important in their decision to switch from STEM to non-STEM majors?
2. In what ways, if any, is gender tied to their decision to switch majors?
3. What changes, if any, could institutions implement to encourage the persistence of future undergraduate women in STEM?

Design, Data Collection, and Analysis

A qualitative phenomenological research design was utilized in this study. Participants were current undergraduate women at a large liberal arts institution in the Midwest who switched from STEM to non-STEM majors. In order to recruit these participants, the director of institutional analysis was asked to email students who fit this criterion. This email included a brief description of the study and my contact information for those interested in participating.

Eventually, eight participants were then interviewed using a semi-structured format and audio-recorded to ensure accuracy (Fraenkel, Wallen, & Hyun, 2012). Interview questions are included in Appendix D. However, the semi-structured format permitted the use of follow-up questions.

After the completion of each interview, a line-by-line transcription was completed and a qualitative analysis was conducted by coding for common themes or trends amongst participants (Fraenkel, Wallen, & Hyun, 2012).

Definition of Terms

Definitions of key terms used in this study have been included for clarification:

- **Departure**: comparable to STEM attrition, departure refers to the "enrollment choices that result in potential STEM graduates (i.e., those who declare a STEM major) leaving STEM fields" (Chen & Soldner, 2013, p. 2).
- **Persistence**: persistence is used to the describe the event that students with STEM majors, remain in STEM fields throughout college (Chen & Soldner, 2013, p. 6)
- **Retention**: retention is "the rate at which students persist in their educational program at an institution" (U.S. Department of Education, 2015, p. 27). More specifically, it is the "percentage of first-time bachelors (or equivalent) degree-seeking undergraduates from the previous fall who are again enrolled in the current fall" (U.S Department of Education, 2015, p. 27). In this case, retention will focus on the percentage of women who remain in STEM majors.
- **STEM fields**: mathematics, natural sciences (i.e., physical, biological, and agricultural sciences), engineering and engineering technologies, and computer and information sciences. This excludes social and behavioral sciences, such as

psychology, economics, sociology, and political science (U.S. Department of Education, 2009).

- **Stereotype threat**: stereotype threat is “the threat of being viewed through the lens of a negative stereotype, or the fear of doing something that would inadvertently confirm that stereotype” (Steele, 1999, p. 3).

Delimitations of the Study

Delimitations of this study include only interviewing undergraduate women who departed from STEM majors at one institution, and not those who persisted; and, only interviewing students who were currently in attendance at this institution.

Limitations of the Study

A limitation of this study is that students from one large liberal arts institution were interviewed and findings may not be representative of comparable institutions. Another limitation is that the students who volunteered to participate in this study may have had different characteristics than those who did not, meaning that while the results may be representative of the sample they may not extend to the larger population. For example, those that came forward may have been more motivated, or more likely to participate in activities outside of the classroom. They may also have felt they had more to share.

Organization of Thesis

While this first chapter provided an introduction for this study, the next explains the theoretical framework that guided its inquiry, and examines the existing literature on this topic. Chapter 3 explains the research design, data collection, and procedure for data analysis. Chapter 4 provides a detailed report of the findings and Chapter 5 explores the implications of these findings and provides emerging recommendations. Opportunities for future research regarding the departure of undergraduate women from STEM majors are also addressed in Chapter 5.

Chapter Two: Literature Review

Introduction

In comparison to quantitative studies conducted at large research institutions, studies that address the departure of women from STEM fields at liberal arts institutions are limited. The data gathered from previous studies, however, is helpful in understanding potential reasons why undergraduate women depart from STEM fields. This information was used to inform this study and interpret the data. The literature review that follows provides the theoretical basis for this study. It then explores potential barriers for undergraduate women in STEM, which have been identified previously, including: levels of academic preparation, methods of instruction, bias and stereotypes, and levels of support. Intervention strategies, which have been previously proposed, are discussed as well.

Theoretical Framework

Following the assertion that a student's persistence does not solely hinge on levels of preparation, ability, and motivation, several theories have been proposed to explain undergraduate retention. Two of the most applicable to this study are Astin's (1993) input-environment-outcomes (IEO) model and Tinto's (1993) theory of student departure. A basic assumption of both is that student success is not only dependent on pre-college experiences, but also on those, which occur after they enroll. In his model, Astin suggests that students enter college with a certain set of pre-determined characteristics (or inputs) that influence their persistence. The three most relevant examples in this study are gender, academic preparation, and interest in pursuing a STEM major. Still, there is also the impact of the environment including the characteristics of the institution, faculty, methods of instruction, students' peer group, place of residence, and level of involvement (Astin, 1993). The effect of these experiences is then described in terms of outcomes (i.e., the final component of the model) – the most relevant examples in this study being a student's satisfaction with their major, academic achievement, and retention in STEM.

In comparison, Tinto (1993) addresses the importance of a student's integration in the academic and social communities of the institution. Applying this to STEM specifically, this suggests that in order for students to remain in STEM majors, they must also be integrated in the field. This arguably places greater responsibility on the institution, as it is at least somewhat in their control. Tinto also argues that most student departures are due to perceptions of insoluble problems – the most common being that they do not belong or are unable to succeed academically. Additionally, like Astin (1993), Tinto recognizes the influence of pre-college characteristics on a student's commitment to their educational goals, yet goes on to suggest that this commitment is either increased or decreased depending on the student's subsequent experiences. If, for instance, their experience is mostly positive, a student will become more integrated, but if it is negative, a student will become removed instead (Tinto, 1993). Tinto clarifies, however, that retention is not only about keeping students physically present, but furthering their education – an important distinction as it relates to STEM as well, since the goal should be for student success, not just persistence in their major.

Several studies have drawn from Astin (1993) and Tinto's (1993) work while examining factors related to undergraduate students' persistence in STEM fields (e.g., see Gasiewski, Eagan, Garcia, Hurtado, Chang, 2011; Gayles & Ampaw, 2011; Kokkelenberg & Sinha, 2010; Maltese & Tai, 2011; Smith, Douglas & Clark, 2009; Szelenyi & Inkles, 2011; Wilson et al., 2015). Yet, few have utilized this framework to specifically address the experience of undergraduate women and the factors, which contribute to the abandonment of STEM majors.

Thus, it is this theoretical framework provided by Astin (1993) and Tinto (1993) on retention, which will be adopted as the research is evaluated throughout this study.

Synthesis of Research Literature

Although each student's experience is unique, the literature identifies common obstacles for undergraduate women in STEM fields including: levels of academic preparation, methods of instruction, stereotypes and bias, and levels of support that will be explored in this section. Intervention strategies, which have been previously proposed, will be discussed as well.

Understanding Potential Barriers

Levels of academic preparation. Drawing from Astin's (1993) model, it is first important to consider the inputs, which have the power to influence persistence rates of undergraduate women in STEM majors. One such input is academic preparation. It has been shown, for instance, that college level mathematics serves as a gateway course to other STEM fields (NRC, 2006; PCAST, 2012), and math and science preparation has been shown to be one of the strongest predictors of degree attainment (Gayles & Ampaw, 2014). High school science grades in particular tend to be influential, as well as taking more AP STEM classes, demonstrating the importance of prior preparation (Griffith, 2010; Kokkelenberg & Sinha, 2010; Morganson et al., 2015).

Yet, many students with an interest in STEM and the capacity to do well lack the academic skills necessary to be successful (PCAST, 2012). As a result, they find themselves struggling with the math required in introductory STEM courses, often receiving little support from the university (PCAST, 2012). For women, this appears to be even more common, as Beasley and Fischer (2012) report that women in STEM tend to enter majors with slightly less preparation than their male peers. More specifically, they tend to have less experience with calculus and physics, while undergraduate males are more likely to take calculus, physics, and engineering in high school (Blickenstaff, 1993; NRC, 2006). Thus, male students have an advantage when it comes to fulfilling prerequisite classes, while women are placed under additional pressure (NRC, 2006).

What is interesting, is that while undergraduate women tend to outperform male students in introductory STEM courses, lower grades have been linked to lower rates of persistence for women more so than for men (Rask & Tiefenthaler, 2008). Furthermore, upon failing a course in their major, men are more likely to retake it, while women are more likely to pursue a different field (Felder, Felder, Mauney, Hamrin, & Dietz, 1995). Men also tend to attribute their failure to lack of effort or inequitable treatment, whereas women tend to view it as a lack of ability (Felder, Felder, Mauney, Hamrin, & Dietz, 1995). Additionally, as the ratio of grades earned in non-STEM courses to STEM courses increases, women are more likely to switch majors, making them even more vulnerable when they lack proper preparation (Griffith, 2010).

Consequently, the goal should be that women enter college equally prepared to study STEM (Blickenstaff, 1993; NRC, 2006). But, in the case that they do not, it is still possible to offer students opportunities to gain these skills. Two of the proposed intervention strategies include the implementation and subsequent funding of summer bridge programs and remedial courses offered at the undergraduate level (George-Jackson, 2014; PCAST, 2012). Tutoring and academic support services might also contribute to student success, alleviating stress and assisting them in overcoming this potential barrier to STEM degree attainment. It should be noted, however, that the impact of these programs is not limited to undergraduate women, as they are likely to benefit all students.

Methods of instruction. Moving on to the environmental component of Astin's (1993) model, it is possible that the methods of instruction traditionally utilized in STEM classrooms may serve as a second barrier to the persistence of women in these majors (NRC, 2006; PCAST, 2012; Tsui, 2007). One study, for example, found that 90% of students who abandoned STEM majors identified pedagogy as a concern (Seymour & Hewitt, 1997), and high performing students frequently cite "uninspiring" introductory courses as a contributing factor to their departure (PCAST, 2012, p. i). The problem, it seems, is the utilization of a traditional lecture format, which involves passive listening instead of active learning, and may negatively affect the experience of both men and women in the classroom (Douglas & Cox, 2009; PCAST, 2012). Failure to address societal contributions and real-life applications may also contribute to the loss of women in STEM (Espinosa, 2011; Morganson et al., 2015; Su & Rounds, 2015), as does the repetition of classic experiments, which limit creative endeavors (PCAST, 2012). Furthermore, STEM courses have been criticized for being impersonal due to large lectures, professors who seem unapproachable, and grading practices that seek to *weed out* students, fostering competition instead of community (Espinosa, 2011; Seymour & Hewitt, 1997; Tsui, 2007). This not only has the potential to affect the experience of women in STEM, but that of all students.

As a solution, it has been proposed that STEM faculty adopt teaching methods that have been empirically tested (PCAST, 2012). Some of these include the use of real-world problems, interpersonal collaboration, research courses that give students the opportunity for discovery and the emphasis of societal relevance (Douglas & Cox, 2009; Espinosa, 2010; Morganson et al., 2015; PCAST, 2012; Su & Rounds, 2015). It has also been suggested that lectures be broken up with time to process and discuss in order to gauge student understanding and give professors the opportunity to reorganize their lectures accordingly (Douglas & Cox, 2009). Last, there is the recommendation that courses be taught with a more narrow focus that covers greater depth, as opposed to breadth (Tai & Sadler, 2001). Yet, most faculty have little experience using these alternative methods and are unfamiliar with the impact they have on learning for all students, not just undergraduate women.

Bias and stereotypes. Another environmental factor that may act as a barrier for undergraduate women in STEM is the presence of bias and stereotypes, as society tends to convey the message that being a woman is incompatible with STEM (Eccles, 2005; NRC, 2006; PCAST, 2012). With respect to Tinto's (1993) theory, this has the potential to deter integration into one's field. Traditionally, this has been manifested in the use of exclusively male images, the wording of problems and examples, and the limited attention given to contributions to the field made by women (Blickenstaff, 1993). Yet, it remains present in the form of microaggressions or harassment as the ideas of women are patronized or discredited, in their failure to identify with the field and in their low performance due to expectations that men are more likely to excel (Alter, Aronson, Darley, Rodriguez, & Ruble, 2010; Beasley & Fischer, 2012; Dawson, Berstein, & Bekki, 2015). In fact, professors have the tendency to overestimate exam scores earned by male students, while underestimating those earned by girls (Warrington & Younger, 2000).

In addition to this, there is the notion that one cannot pursue a career in STEM and have a family (Ferriman, Lubinski, & Benbow, 2009), as well as the idea that for a woman to major in STEM she must look or act a certain way (Goldman, 2012). It is also common for undergraduate women to feel the need to prove their worth in STEM majors, as others challenge whether they belong in their field, or possess the necessary intelligence based on their appearance (Goldman, 2012). These ideas are then perpetuated by the underrepresentation of women in these fields including the low numbers of women faculty (Blickenstaff, 1993; Dawson, Berstein, & Bekki, 2015). As a result, it is important to advocate for a change in the way children are socialized, greater representation of women in the field, and more positive portrayals of women in STEM. One way to accomplish this last goal is through the implementation of Women in Science and Engineering (WISE) programs and living-learning communities, which help convey women's compatibility with STEM fields (Fox, Sonnert, & Nikiforova, 2009; George-Jackson, 2014; Rosenthal, London, Levy, & Lobel, 2011; Szelenyi & Inkelas, 2011; Szelenyi, Denson, & Inkelas, 2013).

Levels of support. The final environmental factor, which contributes to undergraduate women's departure from STEM, is the level of available support. Closely related to stereotypes and bias, it has been suggested that women in STEM majors lack the role models and mentorship opportunities that might otherwise contribute to their success due to low numbers of female faculty and peers (NRC, 2006; PCAST, 2012)[1]. Others have proposed that inadequate advising and less encouragement overall leave women less knowledgeable about career opportunities and less likely to perceive STEM majors as worth it (NRC, 2006; Raymond & Brett, 1995). Female[1] students may also become dissatisfied with campus climate due to a lack of social integration and the perception that they are ignored or excluded (Gayles & Ampaw, 2014).

In contrast, it has been found that interaction with faculty outside of the classroom has a positive effect on degree completion for undergraduate females[1] (Gayles & Ampaw, 2014). This may be even more powerful when the professors are women, as they are able to understand the unique challenges women face in STEM fields (Berstein, Jacobson, & Russo, 2010; Carell, Page, & West, 2010). Exposure to graduate students who are women, relationships with peers, participation in STEM related clubs and the opportunity to be a role model are also correlated with degree completion, as are STEM-specific advisors (Espinosa, 2011; Griffith, 2010; Morganson et al., 2015). Furthermore, Rosenthal, London, Levy, & Lobel (2011) suggest that the perception of academic, social and psychological support, not only contributes to an individual's sense of belonging, but allows one to successfully navigate stereotypes and bias. As a result, in addition to the intervention strategies already mentioned, mentoring programs, research requirements, first-year cohorts, and STEM-specific orientations may contribute to the retention of undergraduate women (George-Jackson, 2014; Vieyra, Gilmore, & Timmerman, 2011;).

Summary

When considering the retention of undergraduate women in STEM majors, it is helpful to consider both Astin's (1993) IEO model and Tinto's (1993) theory of student departure. While Astin (1993) focuses on identifying the precollege characteristics and environmental factors that affect persistence, Tinto (1993) proposes that students' departure is due to the perception of insoluble problems, such as feeling that they do not belong. As a result, Tinto (1993) stresses the importance of integration into the field. Yet, there are several barriers identified in the literature including academic preparation, methods of instruction, bias and stereotypes, and levels of support that have the power to negatively affect women's persistence in STEM.

Additionally, there is the expectation that students will experience these barriers in varying degrees at different institutions (Griffith, 2010; Sonnert & Fox, 2012). Consequently, given that many of the previous studies have been conducted at large research universities, these variables may have different effects at colleges with less research activity (Beasley & Fischer, 2012; Espinosa, 2011; Gayle & Ampaw, 2014; George-Jason, 2014; Griffith, 2010). Taking this into account, it seems that while insufficient academic preparation, unconducive methods of instruction, and the presence of bias and stereotypes are certainly problematic in some environments, the effects of all these barriers may be counteracted through increased levels of support. This might also be the most realistic intervention considering that changing the way individuals are socialized, implementing widespread curriculum reform, or drastically increasing the representation of women in the field will involve change on a significantly larger scale. Furthermore, increased support ties into the larger goal of education that necessitates the encouragement and sustenance of all students' learning.

As a result, it is recommended that the development and continued funding of bridge programs, tutoring and academic support services, WISE programs and living-learning communities, mentorship programs specific to women in STEM, additional research opportunities, and STEM-specific advising, be made a priority. Still, it should be recommended that the need for and effectiveness of these programs continue to be assessed at a wide range of institutional types in order to justify their existence and provide additional documentation of the impact they have on the retention of undergraduate women in STEM majors. Ultimately, it is the hope that these interventions will serve as environmental factors, which will influence retention, as women in STEM are incorporated into the university, as well as their chosen field (Astin, 1993; Tinto, 1993).

Conclusion

In conclusion, the departure of undergraduate women from STEM majors is especially concerning giving that women leave at higher rates than their male peers (PCAST, 2012; Chen & Soldner, 2013). Thus, the purpose of this literature review was to examine the potential barriers faced by women in STEM majors that may negatively influence their persistence. In order to do so, the work of Astin (1993) and Tinto (1993) was utilized as a framework for understanding student retention and departure, and existing research was reviewed and evaluated. In the end, insufficient levels of preparation, unconducive methods of instruction, the presence of bias and stereotypes, and inadequate levels of support were identified as potential factors contributing to the departure of undergraduate women.

Much of this research, however, has been conducted at large research institutions. As a result, it is still unclear as to why undergraduate women depart from STEM majors at liberal arts institutions. In addition to this, many of the studies, which have been conducted, are quantitative in nature and may not tell the entire story. Therefore, it seems warranted to adopt a qualitative approach in order to explore the reasons why undergraduate women at liberal arts institutions switch from STEM to non-STEM majors. This may also allow for more informed recommendations as to how these institutions can encourage the persistence of future undergraduate women in STEM fields.

Chapter Three: Research Design

Introduction

This study sought to better understand the reasons undergraduate women switch from STEM to non-STEM majors at a large liberal arts institution in the Midwest, and the ways this institution might encourage their persistence. A qualitative, phenomenological research design was utilized to learn from participants' lived experiences as STEM majors, and the circumstances, which lead to their departure. This design was chosen since many of the existing studies utilize quantitative data to explore the departure of undergraduate women from STEM, but few use qualitative methods to identify the factors students perceive as meaningful or contributing to their change in major. By identifying the recurrent factors, a more accurate depiction of women's departure from STEM majors at a large liberal arts institution in the Midwest was achieved. The research questions that guided this study were:

1. What reasons do these students identify as important in their decision to switch from STEM to non-STEM majors?
2. In what ways, if any, is gender tied to their decision to switch majors?
3. What changes, if any, could institutions implement to encourage the persistence of future undergraduate women in STEM?

In this chapter, the participants and research design of this study are described, along with the methods for data collection, and data analysis.

Participants

Participants in this study were current undergraduate women at a large liberal arts institution in the Midwest who switched from STEM to non-STEM majors. Participants were selected utilizing criterion-based purposive sampling. In this sampling method, participants are selected based on attributes considered pertinent to the study from which there is potential to learn (Merriam, 2009). Students who met this criterion were then randomly sampled. After Institutional Review Board (IRB) approval (see Appendix A), the director of institutional analysis was asked to email students who fit this criterion, given the director's access to institutional data. The email included a brief description of the study, and provided my contact information for those interested in participating (see Appendix B). Interested participants were provided with a consent form (see Appendix C). A total of nine participants responded to the email, but based on one participant's unique experience, her data was excluded from the final sample. As a result, the final sample consisted of eight participants.

Research Site

The research site was a public, liberal arts institution in the Midwest, classified as a master's large institution, with a reported enrollment of over 25,000 students. Fifty-nine (59.6%) percent of the total population identifies as female and over 22,000 of these students are undergraduates. Yet, excellent teaching is central to the institution's student-centered mission and the average class size is only 26 students. In all, the institution offers over 120 degrees. Eighty-seven (87) of these are offered at the undergraduate level. This includes STEM degrees in: biochemistry, biology, biomedical sciences, biostatistics, cell and molecular biology, chemistry, computer science, engineering (electrical, interdisciplinary, mechanical, product design and manufacturing), geology, information systems, mathematics, physics and statistics.

The institution seeks to support STEM students and women in particular through: student success centers for chemistry, mathematics, science, and engineering; a WISE living-learning community; a Women in STEM initiative from the college of engineering; a TRIO Student Support Services STEM program; and, organizations such as: Women in STEM Fields, Women in Computing, and the Society of Women Engineers. There is also a women's center, which advocates for gender justice and reflects the institution's value of inclusiveness.

Research Design

As previously stated, a qualitative, phenomenological research design was utilized in this study to learn from participants' experiences as STEM majors, and the circumstances, which lead to their departure. At its core, phenomenology is the study of an individual's "conscious experience of their life-world," and is based on the assumption that meaning exists within shared experiences (Merriam, 2009, p. 25). With respect to Astin (1993), the inputs and environmental factors that seem to shape these students' experiences or affect their decision to switch majors (i.e., the outcome in this scenario) were explored. Factors that affected their commitment to educational goals (i.e., their major in this scenario) or impeded their incorporation into the field were also examined, as well as their perception of insoluble problems, which led them to switch majors (Tinto, 1993). By identifying common factors amongst participants, it is possible that the institution might be able to address them in the future to promote student success and retention.

Since I was acting as the instrument, it was also important to address my position or reflexivity (Merriam, 2009). This requited me to reflect on and understand my biases, dispositions and assumptions about the research:

> *As a recent graduate from a doctoral research university, who was originally interested in pursuing a STEM major, I identify personally with this phenomenon. I also advise undergraduate students majoring in biochemistry, biology, biomedical sciences, cell and molecular biology and chemistry at the research site for this study. Within this role, I engage in conversations with students who are in the process of declaring or switching their major of study. Yet, it was only after reading the memoir of a female physics major*

who left the field in graduate school, that I began to reflect on my own experience and became interested in women's departure from STEM. My own reasons for leaving included: inadequate preparation for chemistry after receiving advance placement (AP) credit and unconducive methods of instruction, as the traditional lecture format was less challenging than that of other disciplines.

Data Collection

With this research design, data was collected using semi-structured one-on-one interviews that were audio-recorded to ensure accuracy (Fraenkel, Wallen, & Hyun, 2012). These interviews took place on-campus in quiet locations to ensure confidentiality and encourage participants to give honest responses. I offered to meet participants wherever was most convenient. Interview questions (see Appendix D) reflected the goals of this study, and were approved by the institution's IRB and my thesis committee. Yet, the use of a semi-structured format allowed me to ask follow-up questions as well.

In order to ensure that there is enough time, I allowed for an hour with each participant, yet interview times varied from 20 to 40 minutes depending on the flow of conversation. At the start of each interview, participants were asked to adopt a pseudonym to protect their identity. It was also made clear that they were able to opt out of questions. My goal was to remain neutral throughout each interview, and avoid discussing my own experiences, despite the fact that they had the potential to mirror that of my participants. To accomplish this, I sought to identify and temporarily set aside any biases or assumptions I may have, prior to interviewing participants (Merriam, 2009).

After all interviews were conducted, a third-party transcription service was utilized to transcribe the audio recordings. Audio recordings and transcriptions were stored on a password-protected computer. Hard copies of transcriptions were stored in a locked filing cabinet in my office on campus.

Data Analysis

Once the data was collected, transcriptions were coded line-by-line using *open coding* to identify "any segment of data that *might* be useful" (Merriam, 2009, p. 178). *Axial coding* was then used to group these data segments or *codes* into *concepts* based on similarity (Merriam, 2009). Related concepts were then grouped to form *themes* (Merriam, 2009). These themes were refined to best reflect the data. Detailed notes were kept throughout the decision-making process. Final themes sought to answer the research questions that were central to this study (Merriam, 2009). Names for these themes came from participants, the literature, and my observations. A peer reviewer then reviewed these themes and sub-concepts to ensure accuracy.

To enhance the credibility of this study, I intentionally sought data that proposed "alternative explanations" or challenged my own expectations (Merriam, 2009, p. 219). Yet, acknowledging my reflexivity added to the study's credibility as well. To ensure dependability, I made certain that the results were consistent with the data collected, and that the description of data collection and notes on the decision-making process throughout data analysis, served as an *audit trail* (Merriam, 2009). Transferability was achieved through the description of the research site and participants, as well as the inclusion of evidence to support the findings such as quotes from participants (Merriam, 2009).

Summary

In order to address the research questions, which guided this study, a total of eight semi-structured, one-on-one interviews were conducted. Participants were current undergraduate women at a large liberal arts institution in the Midwest who have switched from STEM to non-

STEM majors. Participants were interviewed about their experience within STEM fields at this institution, as well as their decision to switch majors, using the interview questions included in Appendix D. Interviews were audio-recorded, transcribed, and coded. Overarching themes were identified and findings are presented in Chapter 4.

Chapter Four: Findings

Context

A total of nine participants responded to the email invitation sent to a random, criterion-based, purposive sample of undergraduate women who had switched from STEM to non-STEM majors at one large Midwest liberal arts institution. Based on one participant's unique experience, her data was excluded from the final sample, as she no longer fit the required criterion. As a result, eight participants were included in the final sample. Each of these participants were asked to select a pseudonym and provide demographic information including their age, current year in college, former STEM major(s), current non-STEM major(s), and the year they switched from a STEM to non-STEM major. At the time the study was conducted, participants' ages ranged from 19-21 years old and were in their third or fourth year of college. In cases where participants declared multiple STEM or non-STEM majors, all majors were included. Demographic information is summarized in Table 1.

Table 1

Demographic Information

Pseudonym	**Age**	**Current Year**	**Former STEM Major(s)**	**Current Non-STEM Majors(s)**	**Year Switched**
Irene	19	3	Biology	Hospitality/Tourism	2
Riona	20	3	Biochemistry	Anthropology/Writing	2
Madison	20	3	Computer Information Systems ➔ Computer Science	Writing	3
KLB	21	4	Statistics ➔ Mathematics	Photography	3
Julia	20	3	Computer Information Systems	Public Relations	1

Hannah	21	4	Electrical Engineering ➔ Computer Science	Business	3
Michelle	20	3	Mechanical Engineering /Mathematics	Undecided	3
Ruby	20	3	Biology	Non-profit/Public Administration	2

Findings

As stated previously, the purpose of this study was to explore the reasons undergraduate women switch from STEM to non-STEM majors at a large Midwest liberal arts institution. From participants' narratives, four main themes emerged, as significant in their departure from STEM. Several of these themes were accompanied by sub-concepts. These themes and sub-concepts are summarized in Table 2. Interwoven throughout participants' narratives regarding these themes, however, is a discussion of gender and the changes this institution might implement to encourage the persistence of future undergraduate women in STEM.

Table 2

Emerging Themes and Sub-Concepts

Theme	**Sub-Concept**
Academic Difficulty	Indication of failure Lack of preparation Failure to access academic support
Methods of Instruction	Lack of engagement Ineffective communication Impersonal interactions

Sense of Belonging	Issues of representation Feeling like an outsider Stereotype threat
Career Expectations	

Academic Difficulty

When participants were initially asked about their experiences as STEM majors, they generally cited academic difficulty as the most salient factor contributing to their decision to switch majors. Within this theme, three sub-concepts emerged: (1) indication of failure, (2) lack of preparation and (3) failure to access academic support.

Indication of failure. For many participants, academic difficulty was marked by an external indication of failure. In some cases, this was amplified by the fact that participants had never failed before. Irene, for example, a former biology major who was a top advanced biology student in high school, found herself on academic probation her first year. She also had to retake biology over the summer and years later she still has trouble bringing this up. "I felt like I let myself down," she explained, "[I went from] 'I'm so good at this in high school, I'm better than anyone else,' to 'I'm barely passing this class or I'm completely failing.'" Looking back, "[she still doesn't] know if it was specifically because of [her] major or just because it was [her] freshman year, but [she] blamed it on biology being [her] major." As a result, she decided to switch to hospitality and tourism. "Now, [her] classes are a lot easier," she's "never gotten less than an A," and she's happy, despite her boyfriend's criticism that it's a "fluff major."

Riona, a former biochemistry major, who was also in advanced science throughout high school, shared a similar account. "I ended up with a D+ in chemistry my first semester, so I had to retake chemistry," she shared, but then, "I got another D+ in calculus." As a result, "dropping the biochemistry wasn't really a decision that [she] discussed." Instead, "it was just kind of a foregone conclusion." It was at this point, that she decided to switch her major to anthropology and writing. For others, the decision was a little more complicated. Ruby, for example, was on academic probation as well, but ultimately decided to switch her major based on comments made by her professor and academic advisor. Reflecting on this experience, she recalled, "It was difficult… [And] my test scores were significantly lower than the people I was sitting around." So, when "the professor was like, 'well, if you're struggling, then you might not want to be here,'' she wondered if it was worth it. She also met with an advisor, who "basically said [she] wasn't able to do it. She was like, 'yeah, I'd be surprised if you could do this and actually graduate." So, listening to their advice, Ruby switched to non-profit and public administration.

KLB's situation was also more complicated. Following their grandfather's death at the beginning of the semester, they struggled with drug abuse and depression, falling behind on homework and skipping classes. For them, failure was accompanied by the sense that maybe they did not belong in school. "I remember [the] night that I got [the] letter in the mail," they recalled, "It said, 'hey, you failed all your classes, so you have to pay back your loans.'" They were "so upset about failing, [they were] just like, 'well, I don't even want to go to school anymore.'" Thus, faced with the realization that they were going to have to try harder if they wanted to stay in school, KLB decided to switch from mathematics to photography, providing them with a healthier coping method that allowed them to focus more on school.

For Michelle, the decision to switch her major was even harder. In fact, it was not until her third year of college when she was placed on jeopardy of dismissal that she decided to abandon her mechanical engineering major. "It was very hard for me to switch [majors]," she explained, "I didn't want to leave [engineering] because I didn't want to feel like I was giving up on myself." But when grades came out for winter semester, she was forced to reconsider. "I had to review it and reflect [on it]," she recalled, "I had to [decide], 'Is this the best thing for me to do?' money-wise, time-wise, [is it worth it]?" In the end, she decided that it was not.

Lack of preparation. When asked to explain why they were failing, participants indicated that they believed they were academically unprepared or lacked the necessary experience or background knowledge to be successful. In Irene's case, she had never had to study in high school, "so coming to college [she] didn't study [either]." Yet, "for STEM, you have to study [and] that's probably why [she] thought it was so hard… [She] went into college thinking it [was] going to be like high school and it wasn't." This was something Riona experienced as well. Yet, in Riona's case, this was further complicated by the fact that she was allowed to skate by in high school without actually learning the material. "My [chemistry] teacher was [also my] coach," she explained, so "a lot of the time, he'd just give me the A." Further, because she was also "one of those people who never learned how to study... When [she] had to study for chemistry, because chemistry was hard, [she] couldn't figure out how."

For participants with majors in technology and engineering, this lack of preparation was even more pronounced. Michelle, for example, did not realize that she would have to learn both mechanical and electrical engineering for her major and felt "completely unprepared." "I'd never coded in my life," she explained, "the only code I had ever seen was when I turned on my computer [and I was like] 'okay, I'm just going to wait for it to go away." Similarly, while Julia was "comfortable with computers in terms of Microsoft Office," she quickly realized that computer information systems was "a whole different ball game." Unlike her classmates, she had no prior experience with programming. "There was one girl" she explained, "[who] just seemed to know everything, [like the class] was just a warm up for her," but "everyone in [else seemed to have] the same sort of mentality." As a result, she decided to "get out while [she] still could," switching to public relations, where her lack of experience was not such a hindrance.

Hannah, a former electrical engineering major, described a similar divide between her and her classmates. "It seemed like a lot of them had been tinkering before college, building stuff or already doing robotics," she noted, "[but] I didn't really have that background and didn't feel like there was a good way to catch up." She also felt that there was a distinct "advantage if you had already done this before." Yet, unlike Julia, she noted that was more common with the men. "Not to make assumptions," she said, "but I think… they're kind of encouraged to do that stuff when they're kids… Or dad [teaches] them." Despite the fact that her dad was in engineering as well, "[she doesn't] really remember any invitations to learn about [the field]." Her experience in computer science was similar, but there seemed to be "a little less of a divide," because it was "more likely that you would dabble into computer science on your own." Still, she thought, "It'd be cool if they had an introductory class to the introductory classes [to] bring you up to speed if you haven't had that kind of background." She also thought it would be helpful if teachers "[taught] without the assumption of background knowledge," and wished there was a push for women in STEM earlier to help "counteract that kind of disparity of knowledge."

For Madison, the gap in experience between genders was even more apparent, as her two-week course learning Java in high school, paled in comparison to the experience of the men in her classes. "I think all the guys in the class had been doing this type of programing since they were in high school," she explained, "it just seemed like they had more exposure to computer science, so they were way ahead, whereas I had just done a little bit of tinkering around the summer before I started." She went on to explain that there was also a significant gap between the two introductory classes. "Everyone else was pretty much excelling in the class and I had no idea where they were like getting all this stuff from," she recalled, "it had to be from external experience." As a result, she found herself struggling "with the basics," while the other students were "struggling on a whole different level." This helped fuel her decision to switch majors.

Failure to access academic support. The third sub-concept, which emerged from participants' narratives regarding academic difficulty, was that while they were aware of the academic support available, they failed to take advantage of it. In Irene's case, this was because she was "just too afraid to go." In Riona's, it just did not seem worth it. "I would go to office hours and try to figure things out with my professors," she explained, "[but] I just could not understand it to save my life." With Madison, there was an issue of timing since the tutoring center for computer science, "[isn't] the same as the math center where you can just drop in." As a result, it was "a lot harder to fit into [her] schedule." Likewise, while Ruby and KLB knew about the math center as well, Ruby was not sure if there was help available for her specific field and KLB was not sure if the math center was open during the summer, admitting that while they "knew [they] needed help, [they were] kind of embarrassed about trying to find [it]."

Michelle, however, seemed to struggle the most when attempting to access the academic support available. She was frustrated to find out, for instance, that there were not any engineering tutors available. She was further deterred by her interactions with graduate assistants who "weren't as helpful as [she] thought they would be," and did not really seem to want to help her. "They [were] really rude and… standoffish" she explained, "and I'm like you're supposed to be assisting us and helping us because that's your job – that's what you're here for – to help me understand what I'm not getting in class." In comparison, the tutors that she has now for Spanish and history have been very helpful, suggesting that she would have benefited from similar support if it had been available for engineering.

Methods of Instruction

Upon further reflection, participants focused on their experiences within STEM classrooms. Within this theme, three sub-concepts emerged (1) lack of engagement, (2) ineffective communication, and (3) impersonal interaction.

Lack of engagement. The first sub-concept that emerged was lack of engagement. Irene, for example, characterized her biology classes as “stereotypical,” explaining that, “you’re in a lecture hall, you have three exams and that’s your grade.” She also disclosed that she “just didn’t see the need to go because [her professor] would just lecture straight off the PowerPoint and the PowerPoint would be [online] anyways.” When she did go to class, however, she noticed that “a lot of people around [her] weren’t paying attention either,” explaining that “the professor could’ve done something to keep [them] more engaged… so that people [didn’t] just have their mind wander off.” She also recognized that not going to class most likely contributed to the academic difficulty she experienced in biology.

Likewise, Riona shared that she and her classmates were frustrated with a STEM professor who “lectured [and] basically just read off of a PowerPoint.” In comparison, her writing major “[doesn’t really have lectures], so it’s a lot of reading other peoples writing and big group discussions.” She felt that this was not only beneficial because it kept them more engaged, but pointed out that “hearing all the different perspectives and everything helps a lot because it makes you think about things in a way that you normally wouldn’t.” Ruby found that her current major was more engaging as well. As opposed to STEM, where she was told, “these are the facts and this is how it is,” her current major was, “an open space” for collaboration and discussion, which values different perspectives because, “[they] need everyone.” This also contrasts with Michelle's experience in STEM, where "it was kind of figuring it out on your own and just basically independent work," indicating a lack of any real engagement.

Ineffective communication. The second sub-concept that emerged was ineffective communication. Suggesting that, "with so many other people struggling to understand, it was [at least partly] the professor," Riona explained that her adjunct instructor "didn't explain things in a way that [she] thought [she] could understand them." She also shared that a friend, who persisted in chemistry, "basically taught herself" that semester. Ironically, "one of [Riona's] ACT [writing] questions was whether or not teachers should have the ability to be knowledgeable about their subject or communicate their subject." Now, as well as then, she believed that "communication is definitely better," sharing that while she "doesn't doubt" that her STEM professors "were qualified," she did not think they "communicated their knowledge very well."

Likewise, Ruby appreciated one instructor's ability to "explain [things] in [more] than one way," sharing that while she does not know if "he was reading facial expressions or just body language, but he could tell when you were understanding how he was saying it," and altered his explanation if you were not. In biology, however, "there were a lot of questions that [she] felt like [she] couldn't ask," but when people did ask questions, her professor "answered it in the same way that she explained it the first time." For Ruby, this was frustrating because, as she points out, "if a student is re-asking a question, they didn't understand it [the first time], so maybe going over a different course of action of how to do it, maybe [that] would have helped."

Michelle also pointed out the ineffective communication in her engineering classes, explaining that, "in class, not much lesson went into teaching [them] how to code… [There wasn't] a lesson on 'oh, here is how [you do this].'" Instead, "the instructions for [their] homework was just 'make a code for a dice game.'" "It didn't really help you know 'what do

[you] have to do to make this code,'" Michelle explained, "It was just like, 'here it is' and 'I need you to do it and have it done.'" In her opinion, it would have been more effective if the instructor had actually explained what he wanted or indicated what inputs they should use.

Impersonal interaction. The third sub-concept that emerged was impersonal interaction, as participants commonly criticized STEM classrooms for their lack of personal interaction. In reference to biology, Irene stated, "classes are big [and] the professors don't really even know who you are." She also felt that her STEM professors were not very understanding and "didn't care about you specifically," disclosing that she has "all these personal issues all the time," and when she would try to talk to her STEM professors, "they were like, 'oh, tough nubs.'" As a result, she did not "want to talk to them or tell them [what] was going on in [her] life because [she] felt like they weren't really going to do anything about it anyway." In comparison, she shared that "classes [in her current major] are smaller, all the professors know your name, and there's [more] personal interaction." She also "emails [her] professors now, and [is] like, "I can't come to class,' and they're like, 'oh, okay, well we'll just email you this.'" For Irene, this willingness to be more accommodating has made a big difference.

KLB shared a similar experience. "All of my [STEM] professors were very… stale," they explained, "[the professors] were very straightforward… they didn't seem super friendly… And I think that was a big thing for me – I want to feel like I can approach my professors." Struggling with drug abuse and depression, they wished their STEM professors had taken an interest in them. "I wish [my] professors would have been more [concerned]" they shared, "at least emailed me and been like, 'hey, what's going on? I'd like to talk to you in person.'" They also wished professors were more inclined to reach out to "students that are afraid to ask for help." In photography, they explained their professors are more approachable and they feel like they can “discuss the issues [they are] having.” In fact, one professor even let them skip an introductory class that was beyond their level. “I felt much more comfortable talking to him,” they explained, “I [feel] more comfortable in [photography]. I [feel] like it fits my personality better. I’m a pretty goofy person, so I like being in a classroom of other people that are more talkative.”

Julia also shared that “STEM can sometimes [be impersonal].” “You’re not always dealing with people,” she explained, “especially in computer information systems… you’re dealing with computers.” She went on to suggest that it might have been beneficial if “they had emphasized how [the work would] affect people,” but recognized that she was still learning the basics. In comparison, “public relations is solely based on human interaction” she stated, “[and that makes] it easier to talk to your students.” Likewise, Madison found that writing affords more human interaction. As opposed to STEM, where one of her professors, “encouraged [them] not to come to him directly because when you’re in the real programming field, you can’t just go up to your boss and ask him how to do it,” and it “felt like everyone was on their own,” her writing professors foster “a sense of community” and collaboration.

Ruby was missing this sense of community as well. Describing her experience in STEM as highly competitive, she explained, “there was a big emphasis on [competition], so you were looking around at the people in the room and they weren’t on your team… they were all against you.” Yet, she felt that for women especially, “it’s important for us to stick together and to empower each other, rather than look at each other as competition.” And, she was disappointed that this was not true of her STEM classrooms.

Sense of Belonging

Within this theme, three sub-concepts emerged: (1) issues of representation, (2) feeling like an outsider, and (3) stereotype threat.

Issues of representation. As participants expanded on their experiences in STEM classrooms, issues of representation began to emerge. Michelle, for example, was "one of four females in her class" and "one of two African American females." "Not many women go into [mechanical engineering]" she explained, "and, on top of that, there's not many Black women that go into that area." Still, her professors were both women and she did not sense any sort of separation between genders. Likewise, Irene shared that biology was predominantly men, whereas her current major is predominantly women. She indicated that this is "a complete difference," and that while she "doesn't think it really affected [her]," she admits she "feel[s] more comfortable in a class where there are more [women because she] feel[s] [more] comfortable talking to them, making friends, [and] actually asking [them] for help."

KLB also shared that they feel more comfortable around women. Whereas their calculus professors were men who they felt "like [they] couldn't approach," their statistics professor was a woman and they "felt very comfortable talking with her." As a result, they felt as if it would have been beneficial to take more class with women professors. "Not that they would [have had] better information," they explained, "but that, you know, I would feel more comfortable with them." They also explained that this lack of female representation "played a big role in [them] not feeling comfortable in the program," and that if there had been more women they "might have stayed in the major a little bit longer." "I'm comfortable with guys, don't get me wrong," they stated, "[but] there was literally, you know, maybe a handful of girls in the class with like 40 or 50 men" and this did little to encourage their persistence.

A member of Women and Computing, Madison was still affected by the lack of representation in the classroom. "In the classes themselves," she explained, "I was always outnumbered." In fact, in one computer information systems class, she was one of two women in a class of 30 students, which made for an “intimidating” environment. She went on to explain that, like KLB, she felt more comfortable around her female professors, but that this general lack of representation definitely affected her decision to switch majors. “I was taking a creative writing class at the same time,” she shared, “and it was completely the opposite. I think there were like two other guys… and I definitely felt more comfortable in that class.”

Likewise, Julia, who lives in the WISE living-learning community and appreciates their efforts to support women in STEM, explained what it was like to be in a “highly male-populated field.” “It was definitely kind of daunting” she said, “because I think that me and one [other] girl… were the only, if not close to the only, girls in the class.” Reflecting on this now, she finds herself thinking that maybe, “if there had been more women in there, [she] may have stuck with it.” “It could have been different,” she said, “because sometimes it’s easier to approach someone… it’s easier to talk to someone of the same gender,” and while she does not think it is relevant, her major now is mostly female. In response to whether this influenced her decision to switch majors she stated, “not inherently, but maybe it kind of played into it… If there had been more females, it may have been a reason for me to stick it out another semester.”

For Ruby, however, it was actually an issue of overrepresentation. “It was kind of intimidating because you looked around [and there was] maybe 10 guys in [our] entire biology class,” she shared. As a result, she not only “realized how competitive of a field it is,” but also that she was “competing against a lot of females.”

Feeling like an outsider. The second sub-concept that emerged was that participants often felt like an outsider that did not belong in their STEM major. Julia, for instance, shared that she initially “clung” to the other female student in her class, before realizing that she was not struggling either – a realization that resulted in further isolation. Irene, who also lived in the

WISE living-learning community, shared a similar experience, explaining that she felt “super disconnected,” because the other women in her building seemed to have “a completely different mindset.” “I felt like I wasn’t really like [them],” she explained, “they would study all the time,” and seemed “really closed off.” She also feels that the resident assistants could have “encouraged a little bit more connectedness.”

Likewise, while Madison was involved in the Computer Science Club and Women in Computing and felt that there was definitely a sense of community, she shared that “especially being [at] such a low level just taking [her] 100 level classes, [she] didn’t feel as much a part of that community because [she] was just learning the basics.” “Everyone else was talking about really complex stuff and I was like, ‘I just learned how to make a program,’” she recalled. And, “to make matters worse,” she found that she was not able to talk to the other woman in her class. “I think she was about the same level as me,” she shared, “but she had an easier time talking to the guys and getting help.” Further, she felt a divide between herself and the members of Women in Computing because “they kind of all understood [it] better,” which was “kind of intimidating.”

KLB described a similar situation. “I didn’t feel very connected to [the other students in my class], [because] I didn’t feel like I could relate to them,” they explained, “there were a lot of engineering majors in my math classes and I was like ‘oh god, I’m not an engineer[ing] major.’” Further, because they were dealing with depression, “[they] didn’t really want to talk to people,” giving them no indication if other students were struggling. As a result, while “[the other students] might have had the same struggle [and] might not have understood the homework [either], it was the fact that they had each other,” while KLB was lacking a support system. Hannah then took this one step further, acknowledging that she takes her relationships with her peers into consideration, “because those are the type of people you’ll probably be working with later on." Yet, she "didn't feel like [she] got along well with them… [Because she had a] different kind of mindset" than the others and consequently "felt out of place."

Stereotype threat. The third sub-concept that interfered with participants' sense of belonging was stereotype threat. KLB, for instance, reported "feeling like, 'Oh I'm a girl. I'm not smart enough,'" adding that they also felt "a little inferior," or "inadequate" in comparison to the men in their classes. Similarly, Hannah recalled that "[she] was always hesitant to ask [the] men in class for help because [she] didn't want [it] to seem like [she] was stupid." As a result, she only asked the women in her class for help, which may have placed her at a "disadvantage." "You don't want it to seem like you don't know because you're a girl," she explained, "you don't want to look bad." She also noticed that the men "assumed that [she] would do the coding part and [they] would do the actual building part," suggesting that they did not think she wasn't capable. Further, while part of her thought that she would not be successful because she was a woman, she also "[felt] like [she] was doing a disservice to women by leaving… like she was contributing to the problem… [Or] betraying women," illustrating the extent these stereotypes affected her.

Career Expectations

A smaller theme, which emerged from participants' narratives, was the influence of career expectations on their decisions to switch majors. Irene, for example, shared that she believes that she would be "bored" in STEM now that she, "realizes [that] stuff isn't like what you see on T.V [and] stuff isn't like the movies." Having watched Bones since she was nine years old, Riona was influenced by popular culture as well, but shared that she was at least realistic enough to know that "[she] would be stuck in a lab and wouldn't have a hot FBI agent who would take [her] away and marry [her]." Likewise, KLB shared that they switched to mathematics because “you could do more with it.” Madison explained that because, “[there] wasn’t as much programming as [she] thought there would be” in computer information systems, she switched to computer science, and Hannah indicated that her internship was a defining factor. “I didn’t really like it,” she explained, “I saw more of the world…and wasn’t really into it… it was a lot of tiny, tiny detail[s].” Additionally, while her second internship was better than the first, she recognized that there were not many job openings in this particular area of the field.

Other Considerations

Beyond the four main themes, two other considerations emerged. The first was that several participants reported having negative experiences with academic advisors. Ruby, for instance, shared that she was deterred from her major by an advisor she met while on academic probation. Michelle shared a similar account, as her advisor “basically [told her], ‘oh, you should switch to a different college.’” Advisors were further criticized for being unhelpful or unresponsive, and it seemed that participants viewed their primary roles as scheduling, rarely utilizing them as a resource when deciding to switch majors. Yet, participants also seemed generally unaware that professional advisors existed, instead relying on faculty advisors.

The second consideration was that the majority of participants were quick to qualify their experiences or blame themselves for their negative experiences in STEM majors. Despite dealing with personal issues that interfered with her ability to focus on school, for instance, Irene calls herself “lazy,” and described herself as, “an anxious mess.” Likewise, KLB, who was dealing with drug addiction and depression, called themself “a bozo,” suggesting that they just needed “to try harder.” They also stated that while they wish their professors had asked them what was going on, “it’s not [the professors] responsibility.” Riona was also quick to point out that she was, “not blaming it all on the professors,” acknowledging that there was also, “the fact that

[she] didn't know how to study." And, Madison suggested that the other women "were [just] more dedicated to the major," noting that her male professor, did not "display any sort of outward or blatant bias… [She] just isn't very good at guy talk… and the guys [got] along with him better."

The most obvious example of this, however, is Hannah, who is very clear that her observations could have been "coincidental," conceding that she like coding better and that "there wasn't anything too obviously negative," about her interactions with the men in classes. She then went on to explain that, "it was always just [her] making assumptions about what other people were thinking," and that she was just, "projecting [her] own… lack of confidence or intelligence in those fields on other people." Further, she stated that, "knowing that [STEM is] what you want to do helps kind of silence some of [these concerns]," implying that it was her own fault for not being entirely committed. Last, she explained, that part of why she switched was that she just did not find engineering or computer science all that interesting.

As a result, participants seemed to be reluctant to suggest that they may have persisted if the circumstances had been different. In fact, many of them concluded that that they were much happier in their current majors. Still, there are moments when a counter narrative shows through. KLB, for instance, shared that they "think [they] probably could have been a statistics major." Julia wondered if our interview "[brought] up a good point," suggesting that if there had been more women she "may have stuck with it," and Hannah shared she "really enjoy[s] math, so seeing potential [to go] more toward STEM again [for graduate school is] exciting to [her]." And, Ruby remained convinced that she could have been successful in her STEM major, entertaining the idea that she might pursue biology or some other STEM-related program at another school. It is possible then, that participants' commitment to their current majors is at least partially to resolve the cognitive dissonance they might otherwise experience.

Summary

A total of 8 participants were interviewed for this study. In regard to the reasons why undergraduate women switch from STEM to non-STEM majors, four main themes emerged. These themes included (1) academic difficulty, (2) methods of instruction, (3) sense of belonging, and (4) career expectations. Additional sub-concepts emerged within the majority for these themes. While discussing academic difficulty, for instance, participants generally mentioned some external indication of failure, lack of preparation and their failure to access academic support. When asked to expand on their experience with the classroom, they generally described a lack of engagement in the classroom, ineffective communication and impersonal interactions. Further, they noted issues with representation, feeling like an outsider and stereotype threat, which seemed to detract from their sense of belonging or connection to the field. Finally, additional considerations regarding participants' negative experiences with academic advisors and tendency to qualify their experiences or accept responsibility for their departure from STEM seemed to emerge from participants' narratives.

Chapter 5 discusses these findings in relation to the existing literature and the theoretical framework. This chapter also discusses the implications of these findings, focusing specifically on their potential to provide insight on how institutions might encourage the persistence of future undergraduate women in STEM.

Chapter Five: Conclusion

This chapter provides a summary of this study, drawing connections to the theoretical framework and discussing the relationship between the findings and existing research on this topic. Recommendations are also shared based on the findings of the study and suggestions from the participants. Finally, recommendations for future research are included based on this study's limitations and outstanding questions that have yet to be answered.

Summary of the Study

The purpose of this study was to better understand the reasons undergraduate women at a large, Midwest liberal arts institution switched from STEM to non-STEM majors, and the changes this institution might implement to encourage the persistence of women in STEM in the future. A qualitative, phenomenological research design was utilized to learn from participants' lived experiences as STEM majors, and the circumstances, which lead to their departure. The research questions that guided this study focused on the reasons participants identify as important in their decision to switch from STEM to non-STEM majors, the ways in which gender may have been tied to this decision, and changes the institution might implement to encourage the persistence of future undergraduate women in STEM. Existing research identifies levels of preparation, methods of instruction, bias and stereotypes, and levels of support as factors contributing to women's departure, but much of this data is quantitative and from large research institutions.

Participants for this study were recruited using random, criterion-based purposive sampling. To be eligible for participation, students had to be current undergraduate women at a large liberal arts institution in the Midwest who switched from STEM to non-STEM majors. Participants were recruited by email (see Appendix B) and data was collected through semi-structured interviews that were audio-recorded to ensure accuracy. While interview protocol was followed, the use of a semi-structured format permitted the use of follow-up questions. Audio-recordings were then transcribed and coded to identify emergent themes and sub-concepts.

Through data analysis, four main themes emerged, as significant in participants' departures from STEM. These themes included: (1) academic difficulty, (2) methods of instruction, (3) sense of belonging, and (4) career expectations. Many of these themes were accompanied by several sub-concepts and two additional considerations emerged as well. Interwoven throughout participants' narratives regarding these themes is a discussion of gender and the changes this institution might implement to encourage the persistence of future undergraduate women in STEM. These findings were elaborated on in Chapter 4.

Conclusion

While participants initially cited academic difficulty as the reason they decided to switch from a STEM to non-STEM major, the majority went on to explain that this was accompanied by some external indication of failure. When asked to explain why they thought they were failing, however, participants often revealed a lack of preparation or experience that was greatly affecting their ability to succeed in their former STEM major. They also indicated that while they knew about the academic support available, they generally failed to take advantage of it. Further, when asked to describe the differences between their STEM and non-STEM major(s), participants described a lack of engagement, ineffective communication, and impersonal interactions as characteristic of their STEM classrooms. This then led them to discuss issues of representation, feeling like an outsider, and in some cases, stereotype threat. Unrealistic career expectations and negative advising experiences seemed to play a role as well. Yet, despite the fact that many participants discussed gender, most expressed that this did not affect their decision to switch majors; at times though, a counter-narrative emerged.

What was interesting was that while many participants were involved in initiatives to support women in STEM and felt they benefited from increased representation, this did not equate persistence. Further, many participants shared that they felt they were distinctly different from the other women in their field. This was generally because the other women seemed to be experiencing less academic difficulty or else seemed to be of a completely different mindset and were difficult to relate to as a result. Thus, instead of strengthening their connection to the field, participants found their proximity to these women as further indication that they did not belong. It also meant that they were unlikely that they would ask for help, despite the fact that they reported feeling more comfortable approaching women in their field.

In terms of recommendations, participants shared that they would have benefitted from introductory courses that started at a lower level, teaching without the assumption of background knowledge, and more engaging methods of instruction. They also wished their faculty would have been able to communicate information better, were more accommodating, and more willing to reach out to students who are afraid to ask for help. Increased representation and an earlier push for women in STEM were suggested as well. Finally, Irene shared she would have benefited from the knowledge that college is different from high school and Ruby expressed a desire for an environment that was less competitive and more supportive.

Discussion

From a theoretical standpoint, Astin's (1993) IEO model and Tinto's (1993) theory of student departure provide a valuable framework for interpreting the findings of this study. To begin with, Astin suggests that students enter college with pre-determined characteristics (or inputs) that influence persistence. In this study, gender, academic preparation, interest in STEM, career expectations, and the internalization of STEM stereotypes were all significant inputs. Yet, participants were also impacted by environmental factors. These factors included the lack of engagement in STEM classrooms, ineffective communication, impersonal interactions, issues of representation, peer interactions that resulted in feeling like an outsider, and negative experiences with advisors. These factors then contributed to the outcomes, which included indications of failure, failure to access academic support, stereotype threat, the tendency to qualify their experiences or accept responsibility, and ultimately, their decision to switch majors.

Tinto (1993) addresses the importance of students' integration into the academic and social communities of the institution. Applying this to STEM specifically, students must also be integrated into the field. Participants in this study, however, reported issues of representation, feeling like an outsider, and indications of stereotype threat that jeopardized their integration into their former STEM major(s). This was true even when participants were involved in initiatives to support women in STEM and should have more likely to experience social integration. They also experienced insoluble problems, which Tinto identifies as the largest contributing factor to students' departures. In fact, participants consistently cite academic difficulty and the sense that they did not belong, as integral in their decision to switch majors. Further, just as Tinto describes, participants' negative experiences in their former STEM major(s) seemed to decrease their commitment to the field. As a result, most participants claim that they are happier now and would have switched majors regardless. Yet, as indicated by the counter-narratives presented, some participants remain at least partially committed to their former STEM field.

Despite being conducted at a large liberal arts institution as opposed to a large research institution, many of the findings from this study are consistent with existing literature on the barriers experienced by women in STEM. Academic preparation, for instance, was identified by this study, as well as existing research. While the literature suggests that high school science grades and AP STEM classes are associated with persistence (Griffith, 2010; Kokkelenberg & Sinha, 2010), participants in this study experienced academic difficulty despite taking advanced classes in high school. Moreover, while the literature suggests that students receive little support from the university (PCAST, 2012), participants in this study revealed that they simply failed to take advantage of the academic support available.

Findings from this study are also consistent with the literature that suggests that women enter STEM majors with slightly less preparation than men (Beasley & Fischer, 2012). Yet, while previous research indicates that this is problematic in calculus, physics, and engineering (Beasley & Blickenstaff, 1993; NRC, 2006), participants in this study indicated that the men in their classes had more experience with coding and programming. Additionally, while failing grades contributed to participants' decisions to switch majors (Rask & Tiefenthaler, 2008), many did choose to retake classes, despite the finding that this is more common in men (Felder, Felder, Mauney, Hamrin, & Dietz, 1995). To alleviate this gap in knowledge, participants suggested that the institution offer additional introductory courses at a more basic level. This is again consistent with the literature, which calls for summer bridge programs and remedial coursework (PCAST, 2012; George-Jackson, 2014). Yet, while it is also important that tutoring and academic support services are available, this study suggests that it is equally important to ensure that students are comfortable utilizing the services available.

What is surprising is that despite the institution's commitment to teaching at this liberal arts institution, participants still identified concerns with the methods of instruction that were used in STEM classrooms. Participants' frustration with the lack of engagement, for instance, parallels the literature's criticism of the traditional lecture format, which involves passive listening instead of active learning (Douglas & Cox, 2009; PCAST, 2012). Participants also described their STEM classrooms as impersonal and their STEM faculty as unapproachable, which is again consistent with the literature (Seymour & Hewitt, 1997; Tsui, 2007; Espinosa, 2011). Moreover, while there was no specific mention of grading practices designed to weed out students, one participant stressed the competitive nature of the environment, the general lack of encouragement, and the sentiment that if you were struggling you did not belong.

Participants also seemed to have internalized the bias and stereotypes identified by existing literature. While it is up for debate as to whether or not they actually experienced these stereotypes, it seems that they were at least affected by stereotype threat. As a result, the participants felt the need to prove their worth in their STEM majors, especially when it came to proving their intelligence, similar to what Goldman (2012) found. Unfortunately, this interfered with the participants' ability to ask for help, as they were fearful that they would confirm stereotypes that women are not smart enough. They were also hesitant to ask for help from men. To combat this, the literature advocates for increased representation of women and WISE living-learning communities to convey women's compatibility with STEM fields (Fox, Sonnert, & Nikiforova, 2009; George-Jackson, 2014; Rosenthal, London, Levy, & Lobel, 2011; Szelenyi & Inkelas, 2011; Szelenyi, Denson, & Inkelas, 2013). Nevertheless, this study suggests that this is not enough, as several participants lived in the WISE living-learning community and still departed from STEM. Thus, it seems that women must also *identify* with the other women for these initiatives to be successful.

Finally, while role models were not specifically addressed in participants' narratives, they did mention the lack of representation amongst faculty and peers (NRC, 2006; PCAST, 2012).

They also mentioned inadequate advising and Ruby mentioned a distinct lack of encouragement. Yet, while the literature suggests that women may be less knowledgeable about career opportunities within STEM (NRC, 2006; Raymond & Brett, 1995), participants in this study had unrealistic career expectations. Additionally, while participants disclosed little about their interaction with faculty outside of the classroom, they felt more comfortable asking women for help, as women seemed more approachable. This finding is again consistent with the literature (e.g., Berstein, Jacobson, & Russo, 2010; Carell, Page, & West, 2010). Still, just as the WISE living-learning community was not enough, neither was participation in STEM related clubs. Participants involved in the Computer Science Club, Women in Computing and the Society of Women Engineers still left STEM majors. This again demonstrates the importance of identifying with their peers within their major.

Recommendations

With the growing need for STEM professionals in the current economy, the departure of undergraduate students from STEM majors is particularly alarming (OSTP, 2016). Furthermore, because women tend to leave these majors at higher rates than men, this not only represents a potential issue of inequity, but signifies an alarming loss of talent and ability (Blickenstaff, 2005; OSTP, 2016; Su & Rounds, 2015). It also symbolizes the loss of diverse perspectives, which might otherwise lead to more complete answers and descriptions, more accurate explanations, and more universal designs within STEM fields (Blickenstaff, 2005). The findings of this study provide faculty, staff, and policy makers with a better understanding of the reasons why undergraduate women switch from STEM to non-STEM majors at one large Midwest liberal arts institution. The findings also suggest that the barriers experienced by women in STEM at large research institutions are present at liberal arts institutions as well. This study concludes with recommendations for practice and policy within STEM education at the undergraduate level.

To begin with, students may benefit from introductory coursework that begins at a lower level and teaching without the assumption of background knowledge. It is also important that students know what a major entails prior to declaring it and that they are encouraged to seek help when they need it. While it is important that academic support is available and flexible enough to fit with students' schedules, for example, it is equally important that students feel comfortable utilizing the resources available. Still, increased preparation and earlier exposure to STEM fields seem to be the most effective strategy for combatting this widespread academic difficulty.

Moving on to methods of instruction, it seems that students might benefit from more engaging STEM classrooms that offer opportunities for discussions and incorporating diverse perspectives. Yet, students might also benefit from more effective communication within STEM classrooms. It might be recommended, for instance, that faculty offer additional explanations or more detailed instructions. Faculty might also seek to explain concepts in multiple ways, situating the knowledge in the learner's own context, so that they are more likely to understand it. Faculty might also try to make themselves more personable, taking a more direct interest in their students. For instance, faculty might try to be more intentional about reaching out to students who seem to be struggling in order to communicate their support. Finally, an increased sense of community within STEM classrooms and an emphasis on how STEM fields are connected to people might further benefit students.

Increased representation of women in the field is another large-scale change that might increase students' sense of belonging. However, students might also benefit from the knowledge that others are struggling and that there is no one type of woman who is successful in STEM.

This might be accomplished through increased participation in initiatives to support women in STEM beyond those that naturally gravitate toward them. It might also be accomplished through increased sensitivity to women of various preparation levels within these organizations, the ability to explain things at lower levels, and increased connectedness within the WISE living-learning community–anything to showcase the wide range of women who succeed in STEM fields. Further, it seems that students might benefit from initiatives to counteract the assumption of traditional gender roles and resulting stereotype threat.

Students might also benefit from exploring career opportunities early on and considering a wealth of possibilities since a single job shadow or internship is not representative of an entire field. Further, students might benefit from the knowledge of professional advisors and the recognition that academic advisors are for more than just scheduling. They can also discuss students' decisions to switch major, for instance, and have the potential to serve as additional support. Last, it seems imperative that we validate students' experiences and challenge them to consider alternative explanations for their growing dissatisfaction with STEM majors. It is important to recognize, for instance, that while students may discount the role of gender in their decision to switch majors, it does not mean that their gender is not affecting them.

In the future, the research questions, which guided this study, should be investigated further with a larger sample size and using different methodological approaches and designs to determine whether the themes are truly representative of the larger population. Future research should also look to determine whether or not these findings hold true at other large liberal arts institutions. Future studies might also look at women who persisted in STEM at this particular institution and follow-up studies might be conducted to see if women feel the same way looking back on their decision to switch majors after the passage of time. Finally, future research should explore the ways in which initiatives to support women in STEM might be more effective for students who do not feel that they fit in with their peers.

Endnote

[1] While this study focused on gender and therefore explored undergraduate *women* in STEM, this particular article focuses on sex, using *female* instead.

Appendix A

IRB Determination Letter

DATE: October 31, 2016

TO: Nicole Rombach

FROM: Grand Valley State University Human Research Review Committee

STUDY TITLE: [958415-2] Reasons for Their Departure: A Look at Undergraduate Women who Abandon STEM Majors

REFERENCE #: 17-045-H

SUBMISSION TYPE: Response/Follow-Up

ACTION: EXEMPT

EFFECTIVE DATE: October 31, 2016

REVIEW TYPE: Exempt Review

Thank you for your submission of materials for your planned research study. It has been determined that this project:

Is covered human subjects research* according to current federal regulations and MEETS eligibility for exempt determination under category 2, 45 CFR 46.101. No research involving prisoners may be exempt.

Exempt protocols do not require formal approval, renewal or closure by the HRRC. Any revision to exempt research that alters the risk/benefit ratio or affects eligibility for exempt review must be submitted to the HRRC using the Change in Approved Protocol form before changes are implemented.

Any research-related problem or event resulting in a fatality or hospitalization requires immediate notification to the Human Research Review Committee Chair, Dr. Steve Glass, (616)331-8563 AND Human Research Protections Administrator, Dr. Jeffrey Potteiger, Office of Graduate Studies (616)331-7207. See HRRC policy 1020, Unanticipated problems and adverse events.

Exempt research studies are eligible for audits.

If you have any questions, please contact the Research Protections Program at (616) 331-3197 or rpp@gvsu.edu. The office observes all university holidays, and does not process applications during exam week or between academic terms. Please include your study title and reference number in all correspondence with our office.

*Research is a systematic investigation, including research development, testing and evaluation, designed to develop or contribute to generalizable knowledge (45 CFR 46.102 (d)).

Human subject means a living individual about whom an investigator (whether professional or student) conducting research obtains: data through intervention or interaction with the individual, or identifiable private information (45 CFR 46.102 (f)).

Scholarly activities that are not covered under the Code of Federal Regulations should not be described or referred to as research in materials to participants, sponsors or in dissemination of findings.

Appendix B

Email Invitation

Subject: Research Study For Former STEM Majors

Dear Student:

I have identified [redacted] as an institution where I would like to collect data for a research study. This email is a request for you to be involved in this study. The title of the study is, "**Reasons for Their Departure: A Look at Undergraduate Women who Abandon STEM Majors**."

You are being asked to reflect on your experience as a STEM major, and the reasons that you decided to switch to a non-STEM major, so that higher education researchers, practitioners, and I may learn more about undergraduate women's departure from STEM.

If you are willing to participate in the study, I would like to forward you the informed consent document, explaining your involvement and the study in further detail. I would also like to speak with you about scheduling a time when we could meet. You may contact me at rombacn1@gvsu.edu or (248) 917-1182 if you need any additional information. I look forward to hearing from you.

Sincerely,

Nicole Rombach
Graduate Student

Appendix C

Consent Form

Title of Study: **Reasons for Their Departure: A Look at Undergraduate Women who Abandon STEM Majors**
Principal Investigator: **Nicole Rombach, Graduate Student, GVSU**
Faculty Advisor: **Dr. Donald Mitchell, Jr., Leadership and Learning, GVSU**

PURPOSE
The purpose of this study is to explore the reasons undergraduate women abandon STEM majors at a large Midwest liberal arts institution. Participants will be asked reflect on their experience as a STEM major and the reasons they decided to switch to a non-STEM major, so that higher education researchers, practitioners, and I may learn more about women's departure from STEM.

REASON FOR INVITATION
You are being invited to take part in this study because you have been identified as a current undergraduate woman at the research site who has switched from a STEM to non-STEM major and is at least 18 years of age.

PURPOSE OF CONSENT FORM
This consent form gives you the information you will need to help you decide whether to be in the study or not. Please read the form carefully. You may ask any questions about the research, the possible risks and benefits, your rights as a volunteer, and anything else that is not clear. When all of your questions have been answered, you can decide if you want to be in this study or not. If you choose to participate, I will need verbal consent.

PROCEDURES
I will meet with you one time during the school year. I will meet at a location that is convenient for you and allows for privacy during the interview. The interview will last about 45-60 minutes.

RISKS
There is minimal risk that this study will result in emotional discomfort. Interviews will be conducted in a way that should not inflict any harm. However, the interview questions will ask you to reflect on your experiences and that may be uncomfortable. In that case that you experience emotional discomfort, I will stop the interview. If you feel that additional assistance in necessary, I strongly encourage you to contact:
GVSU University Counseling Center 616-331-3266 gvsucounsl@gvsu.edu

POTENTIAL BENEFITS TO YOU
I do not know if participating in this study will benefit you, however I hope that you will learn about yourself in the process and will benefit from reflecting on your experiences. If you are interested in the results of the study, I will be happy to share them with you.

POTENTIAL BENEFITS TO SOCIETY

This seeks to address a current gap in the literature concerning the departure of undergraduate woman from STEM. As such, there is the potential that the field of higher education will benefit from this study. More specifically, there is the potential to gain a better understanding of the reasons undergraduate women at a liberal arts institution switch from STEM to non-STEM majors. This information may benefit comparable institutions, as they seek to encourage the future persistence of undergraduate women in STEM. If successful, this could help address an issue of potential inequality, as women depart from these fields at higher rates than men. It could also help prevent the loss of talent, ability and diversity in STEM.

VOLUNTARY PARTICIPATION

Your participation in this research study is completely voluntary. You do not have to participate. You may quit at any time without any penalty to you. You also have the option of skipping any question that you do not want to answer. If you choose to withdraw from this project before it ends, I may keep information about you and this information may be included in study reports, or you can elect to withdraw your information from the study.

PRIVACY & CONFIDENTIALITY

The information you provide during this research study will be kept confidential to the extent permitted by law. Your personal information, including all responses to research questions, will not be linked in any way to your identity as a study participant, nor will your identity be included in the study results. All data will be kept in a locked filing cabinet in a locked office or saved on a password-protected computer, although federal government regulatory agencies and the Grand Valley State University Human Research Review Committee (a committee that reviews and approves research studies involving human subjects) may inspect and copy research records.

Interviews will be audio recorded to ensure accuracy. These recordings will only be used for analysis by researchers. After each interview I will have the data transcribed, double check the transcription against the audio recording, and erase the recording. The transcriber and I are the only ones who will have access to the recordings. However, the transcriber will not know your identity and will be bound by a nondisclosure agreement. Anything you say to me, or that I have on record, is between you and me and completely confidential.

COMPENSATION

As a thank you for participating in the study, you will be entered in a drawing for the chance to win a $20.00 Amazon gift card.

CONTACTS AND QUESTIONS

If you have any questions about this research project, please contact:

Nicole Rombach, Graduate Student (248) 917-1182 rombacn1@gvsu.edu

If you have any questions about your rights as a research participant, please contact:

GVSU Research Protections Office (616) 331-3197 hrrc@gvsu.edu

You will be given a copy of this information to keep for your records.

Appendix D

Interview Protocol

1. What STEM major were you?
2. Why did you originally choose that major?
3. What was your experience like as a STEM major?
4. When did you switch your major?
5. What major did you switch to?
6. What were some of the reasons you decided to switch to a non-STEM major?
7. What are some of the ways in which your gender might have affected your experience as a STEM major?
8. Are you happy with your current major?
9. What changes, if any, could the university implement to encourage future students' persistence in STEM?

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