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Using The Expectancy-Value Theory To Understand Why Women Persist Or Leave Collegiate Stem Programs: A Mixed Methods Study

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USING THE EXPECTANCY-VALUE THEORY TO UNDERSTAND WHY WOMEN PERSIST OR LEAVE COLLEGIATE STEM PROGRAMS: A MIXED METHODS STUDY

by

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ABSTRACT

Concerns have been raised about the ability of the U.S. to maintain its global technological competitive advantage in the future because of American college students' attitudes—particularly women—toward STEM programs and careers (Chen, 2013; Ehrenberg, 2010; Palmer & Wood, 2013). Many female students graduate from high school academically well-prepared to pursue STEM majors, and many choose to pursue STEM majors in college, yet many also leave those majors (Chen, 2015; Hill, Corbett, & Rose, 2010). Theories such as perceived value and expectations for success (Eccles et al., 1983), self-efficacy (Bandura, 1977, 1986), and self-determination (Deci & Ryan, 1985) have been advanced as a way to understand this phenomenon.

The main purpose of this study was to examine the reason that women persist in or switch from STEM majors and to examine how they differ in their reasons for their decisions. This study adopted Eccles et al.'s expectancy-value theory of achievement motivation as the theoretical framework and used an explanatory-sequential mixed-methods research design (QUAN→qual=explain results). Three hundred and fifty-six individuals from a large Midwestern research university took part in an online survey during the quantitative portion of this study, and 9 were invited to participate in follow-up focus group interviews.

Findings indicate that participants were influenced to persist or switch from STEM programs because of a variety of academic and institutional, career, financial, social, and psychological factors, with the latter appearing to be the most important factors. The majority of those who left STEM majors ("switchers") did so during the first 2 years of college. The quantitative results revealed that those who stayed in STEM programs ("persisters") placed higher value on STEM fields, had higher expectations for success in STEM careers, and scored higher on the perceived success in STEM courses subscale than their STEM switcher counterparts. Perceived success in STEM courses and perceived value of STEM fields predicted expectations for success in STEM careers. Findings are discussed in light of Eccles et al.'s (1983) expectancy-value theory and practical implications of the study are discussed.

CHAPTER I

INTRODUCTION

Over the years, the United States has enjoyed its status as a world leader in science and technological innovation; and science, technology, engineering, and math (STEM) fields have been considered the drivers of this innovation in the U.S. economy (Olson & Riordan, 2012; Palmer & Wood, 2013). However, concerns have been raised in recent years about the ability of the U.S. to maintain its global technological competitive advantage in the future, because of the attitudes of its college students toward the STEM fields (Chen, 2013; Ehrenberg, 2010; Palmer & Wood, 2013).

Various sources suggest that STEM jobs are expected to make up an increasingly significant portion of the U.S. workforce in the future (Chen, 2013; Ellis, Fosdick, & Rasmussen, 2016; Olson & Riordan, 2012). Because of this, the President's Council of Advisors on Science and Technology (PCAST, 2012) report suggests the need for academic institutions in the U.S. to increase the current supply of STEM graduates by one million in order to meet the demands of the workplace over the next decade (Chen; Ellis et al., 2016; Olson & Riordan). The implication of the PCAST's report is that the demand for STEM workers would exceed the supply if the academic institutions in the U.S. were unable to produce more STEM graduates over and above the current graduation rates in the foreseeable future (Langdon, McKittrick, Khan, & Doms, 2011), a situation that would have serious ramifications. The PCAST's report further reveals that increasing the retention of STEM majors by even a small percentage would be a fast, cost-efficient, way to produce the additional STEM graduates required for the U.S. workplace (Chen, 2013; Ehrenberg, 2010; Ellis et al., 2016; Olson & Riordan, 2012).

Since one of the major pathways to STEM-related jobs is through collegiate STEM degrees, higher education has a key role to play in meeting the anticipated high demand for STEM graduates. However, research suggests that the percentage of STEM degrees among all college graduates in the U.S. has been decreasing for the past decade (Olson & Riordan, 2012; Watkins & Mazur, 2013). This attrition (loss) in STEM graduates is attributed to the fact that academic institutions in the U.S. lose many potential STEM graduates (including high-performing students) each academic year; many of whom would have contributed substantially to the U.S. economy if they had stayed in the STEM fields (Chen, 2015; Lowell, Salzman, Bernstein, & Henderson, 2009; Seymour & Hewitt, 1997). For instance, Wilson et al. (2012) noted that generally in the U.S. less than half of the first-year students who declare STEM majors go on to graduate with STEM degrees. Similarly, the results of a longitudinal study involving U.S. beginning postsecondary students, conducted by the RTI International over a 6-year period between 2003 and 2009, revealed that about half of the freshmen who declared STEM majors at the start of college left their STEM fields by spring 2009. The RTI International study further indicated that of the total number of students who left their STEM fields, about half of them switched to non-STEM fields, while the remaining half left STEM fields by dropping out of college without earning any degrees (Chen, 2013).

So, who leaves STEM fields? And why do they leave? The answers to both questions are highly varied and continue to be the subject of intense research. One approach to answering the first question is to find out what kinds of students are most likely to leave. Research in this area has led to some consensus. The STEM literature indicates that women, racial minorities (Means, Wang, Young, Peters, & Lynch, 2016), students from low-income backgrounds (Shaw & Barbuti, 2010), and first-generation students (Shaw & Barbuti) leave STEM fields at higher rates than their counterparts. For example, a study by the U.S. Department of Education suggests that over 32% of college female students (as compared to 25% of male students) who declare a STEM major are likely to switch to non-STEM majors before they graduate (Davignon, 2016). Findings from Ellis et al.'s (2016) study also suggest that women are 1.5 times more likely than men to leave the STEM pipeline (Soe & Yakura, 2008) after taking an introductory calculus course.

The consistent findings with regards to the first question have led many researchers to focus their efforts on answering the second question: Why do women and other underrepresented groups leave STEM fields at higher rates than other groups? Previous research indicates that there are various reasons, including poor grades and performance in STEM classes compared to non-STEM classes (Ost, 2010; Rask, 2010), loss of interest in STEM majors (Johnson, 2012), growing interest in non-STEM majors (Watkins & Mazur, 2013), lack of role models and mentors (Drury, Siy, & Cheryan, 2011), feelings of isolation because too few peers pursue STEM majors (Chen, 2013), and perceived discrimination on the basis of sex, race or ethnicity in STEM education and workforce (Hill, Corbett, & Rose, 2010). Many of these reasons are interrelated, of course, creating more difficulty in developing a clear picture of the situation.

Some scholars maintain that the underrepresentation of women in STEM fields is attributable to attitude rather than aptitude (e.g., Else-Quest, Mineo, & Higgins, 2013).

This may be true, because women who leave STEM fields are often just as capable as those who remain in STEM fields (Chen, 2015; Hill et al., 2010). Still other scholars maintain that the underrepresentation of women in STEM fields is linked to the value that they attach to, and their expectations for success in, STEM fields and careers (e.g., Eccles, 2007; Zarrett, & Malanchuk, 2005).

The current study sought to contribute to the discussion of why women leave or stay in the STEM pipeline by using the expectancy-value theory (Eccles et al., 1983) to examine whether female STEM switchers and persisters differ in terms of their expectations for success in STEM careers, the value that they place on STEM fields, and their perceived success in STEM courses.

The Need for the Current Study

STEM attrition and persistence have been the subject of intense research in recent years (see Table 1 under Surveyed Literature on STEM Persistence and Attrition, Chapter II). As noted earlier, prior studies have examined rates of switching and persistence among college STEM students, and concluded that women were likely to switch from STEM fields at higher rates than their counterparts (Davignon, 2016; Shaw & Barbuti, 2010). Factors that influence STEM major attrition (e.g., poor performance in the STEM major) and persistence (e.g., interest in the major) have also been discussed extensively in the literature (Chen, 2013; Edzie, 2014; Johnson, 2012). See Chapter III for more examples of factors associated with STEM persistence. Previous studies on STEM attrition and persistence have also revealed that the majority of students who have enrolled in STEM programs and later switched have done so during the first year of college (Watkins & Mazur, 2013).

In spite of the contributions that have been made by previous researchers, which provide insight into why college students persist in or leave STEM majors and at what point in their college careers those who leave normally do so, the literature review reveals a gap which the current study seeks to address. First, while Chen (2013) noted that the majority of participants who entered STEM and later switched ended up pursuing business majors, the STEM majors that participants switched *from* were not identified. Furthermore, because the results of Chen's study were reported in aggregate, it is difficult to know specifically what majors the *female* participants entered after switching. It would be interesting to identify what majors women are leaving STEM majors for and why.

Griffith (2010), on the other hand, has reported on the STEM majors that students have switched out of and the new majors they have entered after switching. She notes that biological science majors are those most frequently reported as abandoned by female STEM switchers (52%), whereas engineering was the STEM major reported as most frequently abandoned by male switchers (38%). The results of Griffith's study also indicate that the majority of female STEM switchers did not switch into non-STEM majors; instead, they switched from one STEM major to another, most often from life and natural sciences majors to engineering majors. However, the reasons that the majority of female STEM switchers switched to engineering majors were not explored by Griffith's study. It would also be interesting to study females who switched from STEM to non-STEM majors, and to explore their reasons for doing so. Knowing which STEM majors females are likely to switch from would guide educators and policymakers in recruitment and retention efforts.

Eccles et al.’s (1983) expectancy-value theory of achievement motivation posits that the expectations for success that individuals hold regarding a task, and the value that they place on that task, can influence their choice, performance, and persistence. It is possible that female STEM switchers and persisters differ in terms of their expectations for success in STEM careers and the value that they place on STEM fields. However, no studies have quantitatively examined and compared the perceptions of female STEM persisters and switchers toward the STEM fields and careers using the expectancy-value theory of achievement motivation.

Finally, it is possible that the way a student perceives success in her STEM course can have a negative (or positive) influence on her persistence in that course and future courses. However, no studies have examined and compared the perceptions of STEM persisters and switchers toward STEM courses using Hall, Hladkyj, Perry, and Ruthig’s (2004) perceptions of academic success scale (PASS), which assesses how successful a student feels or felt regarding her academic work. Academic grade point average (GPA) has often been used as a measure of a student’s success in a STEM course and a predictor of persistence (Chen, 2013; Griffith, 2010). However, a student’s success in a course should not only be judged in terms of cumulative GPA. Other variables (e.g., new knowledge gained in the course) need to be taken into account as well. Hall et al.’s PASS was used in this current study to assess how successful students felt about their STEM courses because, apart from grades, the scale examines other variables thought to influence students’ perceived success in a course (see Appendix D for the full scale). The current study sought to fill these critical gaps in the extant literature by addressing the issues discussed above.

The Genesis of the Current Study

Initial Study

The author begun to develop an interest in STEM education research as a student of instructional design and technology (IDT) and as an information technology (IT) professional. Through his IDT classes and IT career, the researcher became aware of the underrepresentation of women in STEM programs and careers in general and computer technology (CT) fields in particular (see Key Terms and Definitions in this chapter for examples of STEM and CT majors and careers.

It was against this background that the researcher decided to conduct an empirical study in the fall of 2014 to examine the perceptions of men and women regarding CT majors and careers. The goal of the initial study was to develop a quantitative instrument to test and determine whether male and female college students were different in terms of their expectations for success in CT careers and the value they placed on CT majors and careers. Thus, the survey instrument that was developed was based on the expectancy-value theory of achievement motivation (Eccles, 2007; Eccles et al., 1983; Wigfield & Eccles, 2000). The instrument consisted of three subscales—value, interest, and expectations for success; thus, the three subscales were referred to as the VIES instrument.

To achieve the goal of the initial study, a paper and pencil survey was administered to a purposive sample of male and female students at a large Midwestern university in the U.S., hereafter-called the target university. One hundred and eighty-four students completed the survey. A confirmatory factor analysis was performed to verify the factor structure and underlying constructs (Holtzman & Vezzu, 2011) of the VIES subscales. Results of this confirmatory factor analysis provided support for the validity of the VIES subscales for measuring attitude toward CT. Results of the study indicated that male student scores were significantly higher than their female counterparts on all of the VIES subscales, suggesting that the female students placed less value on, and had lower expectations for success in, CT majors and careers. The results also suggested that the female participants had lower personal interest in pursuing CT majors, and that value was the most predictive factor in explaining interest in pursuing a degree in a CT major. The final manuscript of the initial study was published in the *International Journal of Gender, Science and Technology (*Appianing & Van Eck, 2015*).*

As noted above, the initial study established that the VIES instrument measured attitude toward CT and that male college students had more positive attitudes toward CT than did female students. However, the data distribution of majors and gender did not allow for meaningful analysis of how women in CT majors differed from those in non-CT majors (particularly, those who left CT majors) in terms of their attitudes toward CT. Furthermore, while the VIES instrument appears to be a valid measure of attitudinal *differences* by gender, it cannot provide any evidence for the underlying *reasons* behind those differences.

To address these limitations, the current study utilized the VIES instrument to quantitatively examine whether the VIES scores of women *in* STEM majors differed from those of women who *switched* from STEM majors, and to explore the underlying reasons behind any such differences in VIES scores through focus group interviews. In addition to these changes, the current study also extended the previous study's scope to include women in science, engineering, and math majors, rather than focusing only on those in technology-related majors, in order to get an adequate sample size and to extend the power of the study to address the significant problem of recruitment and retention of women in STEM.

Theoretical Framework

The expectancy-value theory of achievement motivation (Eccles et al., 1983) guided the design of the current study. Specifically, this theory influenced the design of the quantitative data collection instrument and analyses. The expectancy-value theory of achievement motivation purports that expectancies and values play key roles in influencing an individual's choice to pursue (or not) and persist in STEM majors and careers (Eccles, 2007; Zarrett, Malanchuk, Davis-Kean, & Eccles, 2006). That is, the individual's decision about whether to pursue a STEM major depends on her expectations for success and the perceived value or importance she attaches to pursuing that major (Else-Quest et al., 2013; Zarrett & Malanchuk, 2005). Chapter II presents a comprehensive discussion of the expectancy-value theory and its relevance to the current study.

Purpose of the Current Study

The purpose of this mixed methods research study was threefold. First, to examine quantitatively the factors that influence women to persist in or switch collegiate STEM majors. Second, to examine quantitatively whether women in STEM majors and those who left STEM majors were different in terms of the value they placed on STEM fields, their expectations for success in STEM careers, and their perceived success in STEM courses. Third, the current study incorporated a qualitative strand that explored the quantitative study results that needed further clarifications. The inclusion of a measure of qualitative study significantly extended the scope of the initial study.

Research Questions

The current study addressed four primary and three sub-questions:

1. What factors can account for whether women switch or persist in STEM majors? The sub-questions for research question 1 are:
    a. What are the characteristics of college female STEM switchers? (e.g., age, year of study STEM major was switched, and resident status)
    b. Which STEM majors are college women likely to switch from and which non-STEM majors are they likely to switch to?
2. Do women who persist in STEM majors significantly differ from women who switch STEM majors in terms of their scores on the perceived value of STEM fields and expectations for success subscales?
3. Is there a significant difference between female STEM persisters and switchers in terms of their scores on the perceived success in STEM courses subscale?
4. Do college women's perceived academic success in STEM majors and the value they place on STEM fields predict their expectations for success in STEM careers?

Assumptions

The researcher made certain assumptions about the present investigation, which were in line with the assertion by Ariola (2006) that "assumptions are so basic that without them the research problem itself could not exist" (p. 135). First, the researcher made the assumption that although women are underrepresented in the STEM fields, STEM education will continue to be an integral part of the university curriculum. Second, it was assumed that participants responded to the survey and focus group interview questions fully and as honestly as possible because (a) participation in the study was voluntary, and participants had the option to withdraw at any time with no penalty; and (b) the responses of participants were kept anonymous and confidential to the extent possible (Simon, 2011). Lastly, it was also assumed that the focus group's interview data reflected the real college experiences of STEM persisters and switchers.

Delimitations of the Study

According to Simon (2011), delimitations of a research study are those aspects of the study that are within the control of the researcher and that limit the scope and set the boundaries of the study. Examples include the study's focus and purpose, the research questions and variables to be tested, the choice of theoretical framework, as well as the population of interest. In terms of the study's focus, the present investigation centered only on female students at the target university. Thus, unlike the initial study, male students were excluded.

Regarding the population or sampling frame (Särndal, Swensson, & Wretman, 2003), two categories of students at the target university were considered, which was in line with the purpose of the current study. The first category included undergraduate and graduate female students who were STEM majors. The second category comprised undergraduate and graduate students who had previously declared STEM majors, but who later switched to non-STEM majors. Female students who left STEM majors by dropping out of school were excluded. Likewise, female students from other academic majors were not considered. Also, the current study did not focus on racial minorities who may have experienced some of the same factors that influence women to switch or persist in STEM majors.

The Office of Institutional Research (OIR) at the target university, on behalf of the researcher, recruited participants for the current study via email. The sample population was randomly drawn using potential participants' email addresses compiled by the OIR. The email addresses included female students (i.e., current female STEM students and female students who initially declared STEM majors, but later switched to non-STEM majors) who registered for classes at the target university in the spring of 2016.

The recruitment email included a hyperlink to a Qualtrics online survey. Only those students who took part in the online survey and who consented on the survey to participate in a follow-up focus group study were included in the qualitative study.

Also, the design of research questions and variables that were tested in the current study were based on what the researcher considered as gaps in the literature. Thus, it is possible that other important variables relating to STEM persisters and switchers were not considered in this study. Furthermore, the choice of research methodology was influenced by the results of the initial study, a review of related literature, and the expectancy-value model. As regards the theoretical perspectives, the current study used the expectancy-value theory to guide the analyses, interpretation, and discussion of the results.

Key Terms and Definitions

Academic Destination Majors: The STEM majors that participants pursued following their exit from STEM majors.

Black: Any person having origins in any of the black racial groups of Africa; except those of Hispanic origin (Common Data Set Initiative, 2010).

Collegiate: Collegiate refers to post-K-12 education. That is, all the schooling that takes place after primary and secondary education.

Computer Technology Careers/Jobs: These types of jobs usually involve roles such as "designing and developing software and hardware systems; providing technical support for computer and peripheral systems; and creating and managing network systems and databases" (Anderson, Lankshear, Timms, & Courtney, 2008, p. 1305). The initial study focused on "hard" computer jobs (Zarrett & Malanchuk, 2005) including computer programmer, computer engineer, database administrator, network administrator, systems administrator, and information systems/technology specialist (Burger, Creamer, & Meszaros, 2007). This was because research suggests that women are particularly underrepresented in these jobs (Kirkup, 2011; Valenduc, 2011).

Computer Technology Majors: The following academic programs were defined as computer technology majors in the initial study: Computer Science, Information Systems and Communication, and Industrial Technology and Graphic Design.

*Continuous and Past Students: "*Continuous students" refers to those students who took part in the online survey during the summer of 2016 and registered for classes in the fall of 2016 at the target university. "Past students" refers to those students who graduated in May 2016 from the target university but took part in the online survey during the summer of 2016.

First-Generation Students: Students who are the first members of their families to attend college or university (Chen, 2013).

Freshman: A first-year undergraduate student (Common Data Set Initiative, 2010).

Hispanic: Any person of Mexican, Puerto Rican, Cuban, Central or South American, or other Spanish culture or origin, regardless of race (Common Data Set Initiative, 2010).

Non-STEM Fields: These are all of the major academic disciplines that do not fall under the STEM fields. Examples include business, education, and languages.

Non-STEM Major: These are all academic programs that are not listed as STEM majors.

Past STEM majors: The STEM majors that participants previously pursued before switching their STEM majors.

Qualtrics: A Web-based research surveying software, which facilitates the design, distribution, and analysis of survey data.

Sampling Frame: Consists of a list of individuals or population from which the researcher wishes to draw a sample (Särndal, Swensson, & Wretman, 2003).

STEM Attrition: Refers to course enrollment choices that result in potential STEM graduates leaving STEM fields (Chen, 2013).

STEM Attrition Rate: Is the number of STEM major leavers divided by the total number of STEM major entrants (Chen, 2013).

STEM Major Entrant: A college student who declares a STEM major.

STEM Fields: In this study, Science, Technology, Engineering, and Math are defined as the STEM fields.

STEM Persisters: A subgroup of participants who at the time of the current study were enrolled in STEM majors.

STEM Switchers: A subgroup of participants who chose and left STEM majors by switching to non-STEM or different STEM majors.

STEM Majors: In this study, the following academic programs are designated as STEM majors: Aerospace Sciences, Biology, Computer Science, Information Systems, Industrial

Technology, and Psychology. See Appendix E for the full list of programs defined as STEM majors. The list of programs was provided by the OIR at the target university.

Target University: The research site or academic institution where the data for the initial and current studies were collected.

Underrepresented Minorities: Blacks, Hispanics, and American Indians/Alaska Natives (Chen, 2013).

CHAPTER II

LITERATURE REVIEW

The current study focused on female persisters and switchers in collegiate STEM programs. Specifically, the study sought to examine the factors associated with STEM persistence and attrition as it relates to women in higher education. This chapter, which examines the relevant literature that informs the current study, is divided into four main sections. The first section provides a general overview of the STEM pipeline, which helps to highlight the need to recruit and retain more women to join STEM programs and workforces and to understand the reasons for persistence and attrition. The second section discusses the theoretical framework that provides support for the study, with a focus on expectations and subjective task value. The third section discusses empirical studies that have examined STEM persistence and attrition. The last section summarizes the empirical related studies and provides a description of research questions, variables, and hypotheses that were derived from the review of related literature.

The State of Women in Collegiate STEM Degree Programs

Women's underrepresentation in postsecondary STEM education is a major concern in the United States (Chen, 2013; Cohoon & Aspray, 2006; DuBow, 2014; Griffith, 2010). This section provides an overview of the state of women in collegiate STEM programs, with particular emphasis on "hard" sciences including computer science, engineering, and math. Various sources indicate that women are underrepresented in hard sciences than areas such as biological and life sciences (Chen, 2015; Dave et al., 2012;

National Science Foundation, 2016). For example, the National Girls Collaborative Project 2016) noted that, in 2013, women earned 57.3% of bachelor's degrees in all fields of study and 50.3% of science and engineering bachelor's degrees. However, while women received about half of the science and engineering bachelor's degrees awarded, their participation differed significantly by specific field of study. For example, women received more than half of bachelor's degrees awarded in the biological sciences; however, their share in other STEM fields such as computer sciences (17.9%), engineering (19.3%), mathematics (43.1%), and physical sciences (39%) was relatively low (National Girls Collaborative Project).

Similarly, data provided by DuBow (2016) also accentuate women's low participation in computer and information sciences at the undergraduate level. DuBow noted that in 1985, the percentage of women who received computer science bachelor's degrees in the U.S. was 37. However, women's share of the computer and information sciences bachelor's degrees awarded in 2014 was only 17%. This information suggests that women's share of computer and information sciences degrees has been decreasing consistently over the past three decades.

Female participation in science and engineering at the graduate level is no different from the picture painted of the undergraduate level. In 2013, 45% of the graduate students who enrolled in science and engineering programs in the U.S. were women, with large proportions entering psychology, biological sciences, and medical and other health sciences programs. In contrast, the proportions of the female graduate students who enrolled in engineering, computer science, and physical sciences (e.g., physics) were relatively low (Espinosa, 2015; National Science Foundation, 2016), Despite the low rates of participation of women in collegiate science and engineering programs, some institutions in the U.S. are making headway in this area. For example, in 2012, an equal number of men and women registered for introduction to computer science classes at Stanford University. This was also the case at the University of California (UC) Berkeley in 2014 (Finley). In 2013, Stanford University experienced a 21% increase in women's enrollment in computer science programs. This was an appreciable increase since it was more than double the enrollment figure (12.5%) for 2008. Similarly, women's enrollment in computer science majors at the Berkeley almost doubled to 21% from 2009 to 2013 (Barasch, 2014).

These enrollment trends at Stanford University and UC Berkeley, if sustained and reproduced at other institutions, could have a major impact in closing the gender gap in STEM fields and workforces. It should be noted, however, that initial interest in STEM programs does not necessarily predict long-term persistence. This is because women have been found to leave STEM fields at higher rates than their male peers (Chen, 2015; Hill et al., 2010). The next section discusses why women are underrepresented in STEM fields, highlighting the assumptions underlying the "leaky" pipeline metaphor.

Why Women Are Underrepresented in Collegiate STEM Programs and Workforces

Previous research has consistently reported that women are underrepresented in STEM programs and workforces, especially in the engineering, technology, and math fields (e.g., Barker & Aspray, 2006; Burger et al., 2007; Chen, 2015; Dave et al., 2012; Espinosa, 2015; Klawe, Whitney, & Simard, 2009; National Science Foundation, 2016; Singh, Allen, Scheckler, & Darlington, 2007; Thomas & Allen, 2006). The STEM literature indicates that equally capable girls in the United States decide against science and technology and other STEM-related fields before they even leave high school (Klawe et al., 2009; Meszaros, Lee, & Laughlin, 2007; Singh et al., 2007). However, this situation is not limited to the United States alone. A study conducted among high school students in Australia indicated that a majority of the female students dropped information technology as a subject by junior high school (Thomas & Allen, 2006). Sáinz and López-Sáez (2010) also noted that while girls in Spain tend to excel in science and technology-related studies in relation to their male peers, they tend to choose nontechnical subjects "while planning their academic and professional future" (p. 578). Similar results have been found in other European countries (e.g., see Palmen, 2011; Sáinz, 2011).

The "Leaky Pipeline" Metaphor

The reality borne out in scholarly research is that the underrepresentation of women in STEM fields is essentially a "leaky pipeline" issue (Morgan, Gelbgiser, & Weeden, 2013; Soe & Yakura, 2008). The leaky pipeline metaphor refers to the continued loss of girls and women from STEM fields at various educational transition points on their way to STEM careers—that is, from elementary through secondary school (middle and high school) to college and graduate school (see Figure 1).

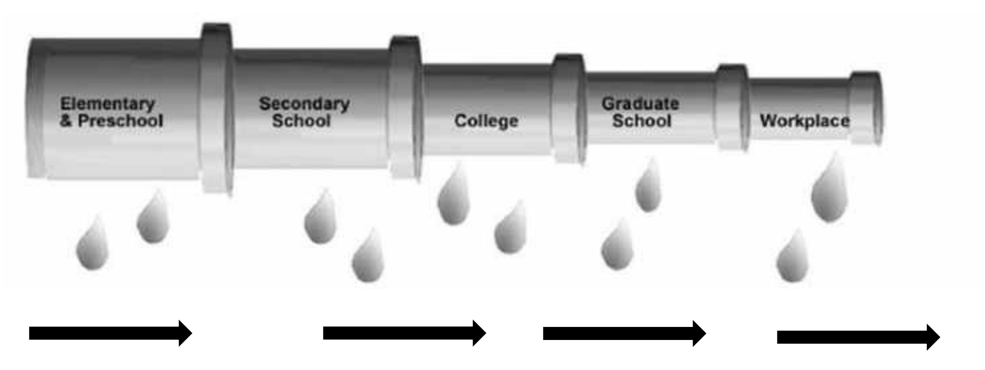


Figure 1: The "leaky pipeline."

Note. Illustration adapted from Soe and Yakura (2008, p.179).

As illustrated in Figure 1, the STEM pipeline represents five distinct segments.

The first four segments correspond to the various educational stages (elementary and preschool, secondary school, college, and graduate school), whereas the last segment corresponds to the workplace. As can be seen in Figure 1, the STEM pipeline flows from one stage to the next, and the flow (or "supply") of girls/women diminishes as we move across to higher educational stages (Soe & Yakura, 2008). For example, more girls and young women are found in STEM classes at the precollege level than at the postsecondary level.

It is assumed that women are more likely to "leak out" from the STEM pipeline than their male peers (Ellis et al., 2016), either by choosing other educational and vocational options or failing to progress through the stages of the pipeline (Soe & Yakura, 2008). This implies that by the time women reach the end of the pipeline, they are substantially underrepresented. In other words, a leak at one stage of the pipeline logically accounts for the shortage in later stages of the pipeline (Soe & Yakura, 2008; Varma, 2010).

This shortage often shows up in student enrollment in advanced STEM courses. For instance, in 2007, Harris, Kruck, Cushman, and Anderson (2009) reviewed total student enrollment at James Madison University in the state of Virginia, U.S., during the fall semester and found that while 61% of the student population was female, the computer information systems department had an enrollment of only 18% female students, while the computer science department had merely 7% female students. Evidence also suggests that in the United Kingdom (UK), only 20% of girls continue from General Certificate of Secondary Education physics to General Certificate of Education Advanced Level (GCE A Level) physics; and in 2011, almost half of all the secondary schools in the UK did not send any girls to complete the A-level physics (Muffitt, 2014).

In recent years, however, the leaky pipeline metaphor has come under serious criticism. First, some scholars argue that the leaky pipeline metaphor assumes a linear relationship between STEM education and careers. In other words, the leaky pipeline metaphor assumes that students do not switch fields and that career progression is a one-way flow without interruptions (Miller & Wai, 2015; Soe & Yakura, 2008). Second, other scholars argue that the idea of a leaky pipeline metaphor needs to be abandoned entirely (e.g., Miller, 2015), because the STEM pipeline may no longer be leaking more women than men (Ceci, Ginther, Kahn, & Williams, 2014; Miller & Wai, 2015). Therefore, it is unfair to stigmatize women who decide to switch from the STEM pipeline in search of other alternatives (Miller, 2015).

As a result of the criticisms of the leaky pipeline metaphor, many scholars have moved towards more nonlinear concepts like "pathways" (e.g., Leventman, 2007; Valenduc, 2011), arguing that pathways are a better representation of the nonlinear path that collegiate students may take (Espinosa, 2015). For example, Leventman distinguishes between three STEM pathways: the "traditional," "transitional," and "self-directed" pathways. Leventman further argues that the traditional pathway relates to individuals who obtain STEM degrees in a formal school setting and go on to work as professionals in STEM fields. The transitional pathway has to do with individuals who initially obtain degrees in non-STEM fields and go on to work in nontechnical or non-STEM fields, but then transition to work in STEM fields after acquiring graduate degrees in STEM-related fields. In many respects, the self-directed pathway is similar to the transitional pathway, except that individuals who transition to work in STEM -related jobs through the self-directed pathway do not have formal graduate STEM (or related) degrees.

In spite of the criticisms, the leaky pipeline metaphor provides an appropriate visual representation of the underrepresentation of women in STEM fields (Soe & Yakura, 2008), particularly, in the hard sciences such as engineering, computer science, math, and physical sciences (e.g., physics) where the lack of women is more pronounced (Ceci et al., 2014; Chen, 2015; Miller & Wai, 2015; National Science Foundation, 2016).

Factors That May Influence Girls and Women to Leak Out of the STEM Pipeline

The underrepresentation of women in STEM fields has been attributed to a number of factors including cultural, social, and psychological factors. This section discusses some of the main factors that have been identified as reasons that girls and women may leak out of the STEM pipeline.

The stereotypical "nerd." One factor often cited for the loss of women from the STEM pipeline has to do with the perception that the STEM profession is filled with stereotypical "nerds," leading some women to choose what they perceive to be more people-oriented majors or occupations (Anderson et al., 2008; Howe, Berenson, & Vouk, 2007; Harris et al., 2009; Papastergiou, 2008; Thomas & Allen, 2006). In a study of male and female first-year students at the University of Melbourne, Australia, for example, Thomas and Allen reported that 85.7% of the female participants said they stopped studying IT at the secondary school level because they "didn't want to be classified a nerd" (p. 170).

Lack of female role models/mentors. Another factor is the lack of role models/mentors, both in the school environment and in the STEM workforce (American Association of University Women, 2010; Dryburgh, 2000; Harris et al., 2009; Klawe et al., 2009; Muffitt, 2014; Vriesman, 2017; Weissmann, 2015). In the Thomas and Allen (2006) study of Australian students, participants were asked to "name any women they know who work in the IT industry" (p. 173). The results of the study showed that 59.2% of the participants could not name any female professionals in the IT industry. When participants were also asked to name any IT role models portrayed in the media, more than half of the total number of participants said they did not know any, and 8.2% listed cartoon characters as role models. On the basis of this result, Thomas and Allen concluded that female IT professionals are not normally reported in the news, shown on television shows, or portrayed in movies.

However, the situation may be improving in recent times as there are several more female role models in the tech industry than there were a decade ago. For example, American technology executives include Marissa Mayer (the current president and chief operating officer of Yahoo), Sheryl Sandberg (the chief operating officer of Facebook), and Danese Cooper, who was appointed in the spring of 2014 as the first ever head of open source software of PayPal (Barasch, 2014; Finley, 2014; Somerville, 2014). Yet, a recent study (Bell & White, 2013) showed that almost half (45.3%) of the 150 Silicon Valley companies did not have women as executive officers.

STEM is a male domain/field. The STEM literature indicates that girls, college students, and parents have the notion that STEM-related fields are male domains (see Archer, 2013; Papastergiou, 2008; Thomas & Allen, 2006; Vriesman, 2017). The observation made by Vriesman highlights the point, "As a child, I can remember occupations like mathematicians and scientists being depicted as male roles. From a very early age, we're conditioned to think of those occupations as male-only. It warps the minds of our girls into thinking they are not welcome in those realms—even if they're talented and interested in them!" (Vriesman, 2017, para. 3).

Archer (2013) has interviewed the parents of some young UK students about their views on science-related careers. The findings from the interviews indicated that half of the parents considered science to be a male-dominated field. Considering the influence that parents have on the career aspirations and educational choices of their children, these findings are troubling, and perhaps are what lead girls to describe STEM fields as "geeky" and "uncool" (Papastergiou, 2008; Thomas & Allen, 2006). The perceptions of parents and students in this regard are supported by the reality that many women in STEM fields experience. As many as 50% of women working in STEM will leave their field because of a hostile work environment (Hewlett, Luce, & Servon, 2008). A study also shows that when men and women are working in STEM fields dominated by men and are both successful, they are all rated as equally competent. However, women are less likely to receive positive ratings on the interpersonal side of things; for instance, women may be described as cold and pushy (Hill et al., 2010).

Not all studies, however, show that women perceive STEM as a male domain. For example, while men in China dominate the IT-related fields, Chinese women believe that IT is an occupation for both men and women (Black, Jameson, Komoss, Meehan, & Numerico, 2005). Surprisingly, graduate-level college women in China even prefer to pursue careers in IT rather than other professions (Black et al., 2005). Similar results can be seen in Malaysia as well, where women dominate computer science classes and IT-related jobs (Lagesen, 2008; Mellstrom, 2009). Culture may, therefore, play a role in these perceptions of STEM careers.

Self-efficacy beliefs and anxiety. The underrepresentation of women in certain STEM fields (e.g., computer science) has been attributed to self-efficacy beliefs and anxiety. Self-efficacy simply refers to the belief that individuals hold about their abilities to successfully perform a task (Bandura, 1977). For example, previous research has reported that female students tend to have higher computer anxiety (CA) and lower computer self-efficacy (CSE) than their male peers (Laosethakul & Leingpibul, 2010). CSE has to do with an individual's perceptions of his or her ability to accomplish a task using computers, whereas CA refers to the tendency of an individual to be uneasy, apprehensive, or fearful about the current or future use of computers (Laosethakul & Leingpibul).

In recent times, however, male and female students have been increasingly exposed to technology both at home and in the school environment. Thus, it is possible that increased exposure to technology in formal and informal environments as a learning, social, and leisure toolset may change CSE and CA for women.

A study of elementary school-aged girls and their attitudes toward technology, for example, found that girls and boys both feel that technology as a career is appropriate for boys and girls, based in part on common experiences and exposure to technology (Van Eck & the AIM Lab, 2006). Given the magnitude of the gender disparity in computer science and technology majors and professions (DuBow, 2014), the number of computing jobs expected in the next 7 years (DuBow, 2016), and the complexity of factors that contribute to CSE and CA as well as major and career selection, merely waiting for the next generation to develop higher CSE and assuming that this will automatically lead to technology career choices by women is unlikely to solve the problem.

Given the assumption that many potential female scientists and engineers, for example, leak out of the STEM pipeline, especially at the postsecondary education level, it is imperative for all stakeholders in education to take the necessary steps that will help to retain the bulk of women who enter college with the intention of pursuing STEM majors. However, sound retention strategies can only be based on knowledge and understanding of why STEM entrants persist or leave collegiate STEM fields (Ehrenberg, 2010). This point demonstrates the need for more research on STEM persisters and switchers/leavers. The current study contributes knowledge in that direction. The next section addresses the need to increase the gender balance in STEM programs and workforces.

The Need to Increase the Gender Balance in STEM Programs and Workforces

The need to encourage more women to join STEM fields was highlighted in the Introduction. This section provides additional discussion about the need to increase the gender balance in collegiate STEM programs and workforces. There are several reasons why it is important to increase the gender balance in STEM education and workforces. First, STEM careers offer good career prospects with high pay (Langdon et al., 2011). According to Langdon et al., college graduates represent a major source of labor for the STEM fields; and in the U.S., women have earned about 57% of all bachelor's degrees since the late 1990s (Jeffrey, 2012; National Science Foundation, 2014). However, the proportion of females working in the STEM fields is low compared to that of their male counterparts. For example, in 2015, only 25% of the computer science workforce were women, and less than a quarter of the Chief Information Officers serving in Fortune 100 companies were women (DuBow, 2016). Recruiting more women into the STEM fields will thus create better jobs and financial opportunities for a large section of the U.S.

populace since women constitute more than half of undergraduate students every year (National Science Foundation, 2014).

Second, about one million STEM jobs are expected to be created in the U.S. labor market by 2024 (DuBow, 2016); therefore, more STEM professionals are expected to enter the labor market over the next decade. Thus, making the STEM fields more gender-inclusive would increase the number of qualified men and women who could be employed to fill future STEM jobs (Del Giudice, 2014).

Third, what is designed and built by industry must meet the needs of a diverse U.S. population. This is best done when the makeup of a given industry reflects the larger makeup of society. The gender gap in STEM fields thus presents an economic and societal challenge that must be addressed. One need look no further than the automotive industry for a powerful example. In the mid-1990s, Ford included more women engineers on the design team for the Windstar minivan (a vehicle mostly used by women). The Windstar had lost market share to minivans from Toyota and Dodge. While there were only 50 women out of 200 engineers on the project, the ratio was nonetheless significantly higher than other automakers. The women engineers added features previous (male) engineers had not considered, including a baby-mode dome light (low power mode designed not to wake sleeping babies when the door was opened), crevice protectors that caught wayward French fries, and a switch to prevent automatic door-locking when a key was in the ignition (for when parents have to jump out of the car to tend to children). Sales of the Windstar quickly rebounded in 1999 and the women engineers were featured prominently in the ad campaigns (Barker & Aspray, 2006).

The software industry has begun to follow suit in this regard, having been criticized for designing game software that appeals predominantly to males. Increasing the number of women in game software development may help to ensure that design teams will incorporate features that are more engaging to women (Barker & Aspray, 2006). However, more women will need to pursue computer science-related careers if this is to happen. These two examples provide further evidence for the Kellogg School of Management's study, which showed that teams that are more diverse are able to make better decisions and have a better chance of finding solutions to problems (Phillips, Liljenquist, & Neale, 2010). The next section discusses the expectancy-value theory of achievement motivation, which was the theoretical framework that was adopted for the current study.

Theoretical Framework

Earlier, the leaky pipeline metaphor was used to illustrate how women become underrepresented in STEM fields and careers, and some factors that may explain why women move away from the STEM pipeline were also discussed. This section discusses the expectancy-value theory of achievement motivation, which focuses on the reasons that women may either persist or move away from the STEM pipeline. Specifically, this section describes the key components of the expectancy-value model, with particular emphasis on expectations for success and the subjective task value.

The Expectancy-Value Model

Perhaps the two most important decisions that students have to make while in college concern their academic major and future career choice. Research has shown that men and women differ in terms of their educational and vocational choices (Eccles, 1994). In the STEM fields, for instance, the proportion of women in the medical, biological, and social sciences (especially psychology) is relatively high, whereas in disciplines such as physical sciences, engineering, and computer sciences, women are underrepresented as compared to men (Eccles, 2011b; Rask, 2010). One of the theories that helps to explain the disparities between men and women in terms of their educational and vocational choices is the expectancy-value model developed by Eccles, Wigfield, and their colleagues, which can be seen in Figure 2 (Eccles, 1994; Eccles, 2005; Eccles et al., 1983; Wigfield, 1994; Wigfield & Eccles, 1992; Wigfield & Eccles, 2000).

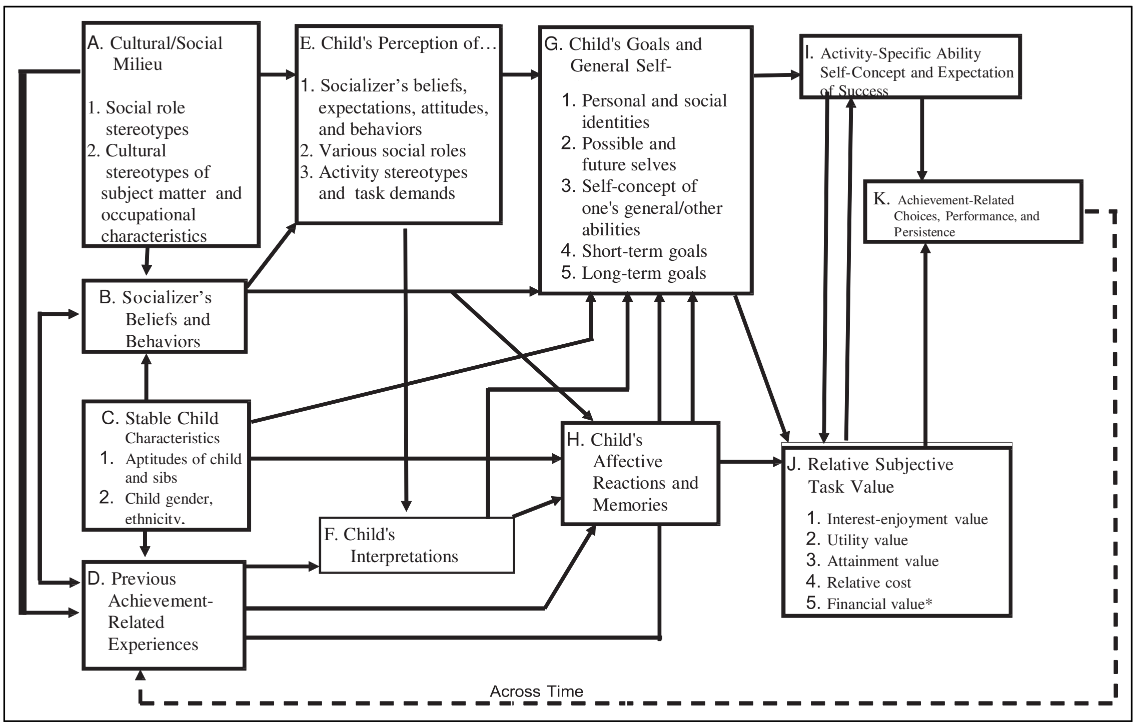


Figure 2. Expectancy-Value Model of Achievement-Related Choices.
Note. Illustration adapted from Eccles (2011a, p. 512).
*Financial value was added by the current study.

Figure 2 depicts the expectancy-value model of achievement-related choices or tasks. Achievement-related choices in this present study refer to STEM majors and careers. The model was originally developed by Eccles and her colleagues as a framework for understanding the factors that contribute to the differences in math achievement between male and female students as they move from late elementary school through to high school (Eccles et al., 1983).

The basic premise of the expectancy-value model is that an individual's choice of achievement-related tasks, his or her performance, and his or her persistence are most directly predicted by his or her expectations for success on those tasks and the extent to which he or she values the tasks (Eccles, 2007; Eccles, 2011a; Eccles, 2011b; Wigfield, 1994). A corollary to this premise is that value and expectations for success may either support or work against each other. For example, although a female student may expect to do well in a STEM major, she may decide not to choose that major because of the low value she attaches to the major.

Essentially, the individuals' expectations and subjective task values are shaped over time by several personal and cultural/social influences (Eccles, 2011a; Eccles, 2011b; Eccles, 2007; Wigfield, 1994). As can be seen in Figure 2, influences from one's cultural/social milieu include social role and cultural stereotypes of subject matter and occupational characteristics, an individual's gender, the beliefs and behaviors of socializers (e.g., parents and teachers), and the abilities and previous achievement-related experiences of the individuals. Personal influences include ability beliefs, an individual's perceptions of socializer's beliefs, expectations, social roles and stereotypes, and the perceived difficulty of the various tasks. Personal influences also include one's goals, self-schemata, and affective memories, as well as one's interpretations of one's own previous achievement-related experiences and the various social influences (Eccles, 2011a; Eccles, 2011b; Eccles, 2007; Wigfield, 1994). The current study focused on the segments of the model that deal specifically with expectations for success and subjective task value. This is because expectancy and value constructs are presumed to directly influence achievement-related choices, performance, and persistence (Wigfield & Eccles, 2000), which are of particular interest to the current study.

Expectations for success. Wigfield and Eccles (2000) defined expectations for success as the individuals' beliefs about how well they expected to perform on a given task. Expectations for success per se are influenced by several factors including self-efficacy beliefs (Eccles, 2005), one's perceptions of the difficulty level of various tasks one can choose from (Eccles, 2007), as well as the expectations of significant others, for example, parents and teachers (Eccles et al., 1983). However, this study will focus on the influence of self-efficacy beliefs on expectations. This is because researchers have linked self-efficacy beliefs to expectancies, performance, and persistence in achievement-related tasks (Eccles, 2005; Wigfield, 1994; Wigfield & Eccles, 1992).

Self-efficacy beliefs. Self-efficacy is a cognitive construct that refers to the beliefs that individuals hold about their abilities to successfully execute those activities necessary to achieve desired outcomes (Bandura, 1977, 1986; Hutchison, Follman, Sumpter, & Bodner, 2006). Self-efficacy beliefs can influence an individual's behavior either negatively or positively, depending on how the individual perceives his (or her) ability in relation to a given task. For example, an individual who has a high self-efficacy would be more willing to engage, work harder, and persist longer in the face of failure, challenges, and difficulties than an individual who doubts his own abilities (Renninger & Hidi, 2016).

Hutchison et al. (2006) distinguish between self-efficacy and self-confidence. To them, self-efficacy denotes a given level of attainment and the strength of a person's belief that that level of attainment can be achieved, whereas self-confidence refers only to the strength of a belief in a person's ability. Hutchison et al. illustrate the difference between self-efficacy and self-confidence as follows: "I believe I can correctly solve calculus problems" (self-efficacy statement). "I am confident in my mathematical abilities" (self-confidence statement).

Research has linked self-efficacy beliefs of students, particularly students in collegiate STEM programs, to their interest (Bong, Lee, & Woo, 2015; Lent et al., 2003), performance (Hackett, Betz, Casas, & Rocha-Singh, 1992; Pajares, 1996), and persistence (Lent, Brown, & Larkin, 1984; Multon, Brown, & Lent, 1991). Regarding the link between self-efficacy and interest, the research findings of Bong et al. (2015) are worthy of note. In a cross-sectional and longitudinal study involving more than 7000 Korean high school students from different subject areas, Bong et al. found statistically significant stronger correlation between interest and self-efficacy in mathematics and science than in language arts.

In terms of self-efficacy and performance, Hackett et al. (1992) conducted a quantitative study of male and female students from diverse racial/ethnic backgrounds (N=197), and concluded from their study that self-efficacy beliefs of students, in combination with other academic and support variables (e.g., GPA and faculty) were the strongest predictor of college academic attainment. Concerning self-efficacy and persistence, Lent et al. (1984) quantitatively examined the self-efficacy beliefs of 42 male and female undergraduate students in science and engineering majors and reported that students with high self-efficacy belief ratings generally achieved higher grades and persisted longer in technical/scientific majors than those with low self-efficacy ratings.

Similarly, Multon et al. (1991) examined 18 studies on self-efficacy and persistence, which were conducted between 1981 and 1987, and found a statistically significant relationship between self-efficacy beliefs and college major persistence in their meta-analytic investigation. Thus, taken together, the above studies indicate that self-efficacy has a close relationship with interest, performance, and persistence.

Research has shown that, compared to men, women in general have lower self-efficacy in STEM majors (Backer & Halualani, 2012), particularly mathematics, chemistry, engineering, and computer science majors (Beyer, 2014; Louis & Mistele, 2012). Studies also indicate that women who tend to switch (or leave) collegiate STEM majors have lower STEM self-efficacy than women who persist (or stay) in STEM majors, although the switchers may have better or equal levels of academic achievement as the STEM persisters (Backer & Halualani, 2012; Hutchison et al., 2006).

The literature identifies four primary influences from which self-efficacy beliefs are formed. These include mastery experience, vicarious experience, social persuasion, and physiological reaction (Hutchison et al., 2006; Plunkett, Iwasiw & Kerr, 2010; Rittmayer & Beier, 2009; Zimmerman, 2000). The following paragraphs describe these four influences on self-efficacy beliefs.

Mastery experience. This has to do with the individual's previous success (or failure) at performing a given task. All things being equal, success enhances one's perceived self-efficacy, whereas failure decreases it (Plunkett et al., 2010). For example, if a student earned an A on her first chemistry test, then she is likely to feel confident that she can earn a high grade on her next chemistry test; however, if she failed her first chemistry test, then she is more likely to doubt her ability to do well on her subsequent chemistry tests (Rittmayer & Beier, 2009).

Vicarious experience. This refers to the knowledge and confidence that an individual gains by observing others (e.g., role models) perform a task in a certain area or field (Hutchison et al., 2006; Rittmayer & Beier, 2009). This is especially influential when the individual is unsure of her abilities to achieve success in that specific field or has no experience in that field (Hutchison et al.). Consider this example. A female first-year student saw a female engineering professor teaching a class and concluded, "If this female professor has completed an engineering major and become a professor, so can I." Thus, "… efficacy beliefs can depend on the extent to which individuals see similarities between themselves and those whom they observe" (Hutchison et al., p. 40).

Social persuasion. This refers to the feedback, encouragement, and support that a person receives from others, especially significant others such as parents and teachers (Plunkett et al., 2010; Rittmayer & Beier, 2009). In short, it is the "verbal judgements" of others (Hutchison et al., 2006). When feedback is positive and encouraging, it is likely to increase self-efficacy beliefs; on the other hand, a negative feedback tends to decrease it. While negative feedback is most likely to decrease self-efficacy beliefs, a positive feedback may not necessarily increase it (Rittmayer & Beier). This is because positive feedback is most effective when it is realistic and consistent with the individual's actual ability and previous performance (Rittmayer & Beier). For example, a student who got a D+ on her first math test should be encouraged to aim at a B rather than an A. Similarly, a student who got a C on her first math test should be encouraged to aim for a B+ rather than an A+. Social persuasion influence plays a key role in traditionally male-dominated professions (Hutchison et al., 2006).

Physiological reaction. This relates to the physical reactions and emotions (e.g., fear of failure, fatigue, stress, anxiety, and nervousness) that an individual experiences during the task execution (Hutchison et al., 2006; Plunkett et al., 2010; Rittmayer & Beier, 2009; Zimmerman, 2000). For example, if the fear and stress levels experienced by the individual during the task execution were very high, the individual might interpret this to be an indication of poor performance and abilities, and therefore develop a weak sense of self-efficacy beliefs (Plunkett et al.; Zimmerman). Conversely, if the individual did not experience any fear or anxiety at all, the individual may experience a sense of joy and accomplishment that may engender a high sense of self-efficacy.

Subjective task value. Eccles (2005) describes task value as "… a quality of the task that contributes to the increasing or decreasing probability that an individual will select it" (p. 109). The quality of the task is defined by Eccles (2005) in terms of four components: (1) attainment value, (2) intrinsic (interest) value, (3) the utility value, and (4) cost value. While Eccles et al.'s (1983) subjective task value components do not explicitly include a financial value as a predictor of achievement-related choices, one study did find that financial value predicted achievement-related choices—that is, the decision to pursue postgraduate training (see Hagemeier & Murawski, 2014). As a result, the current study has included the financial value construct in the subjective task value components (see Figure 2). The following paragraphs describe each of the components of the subjective task value.

Attainment value. Attainment value is defined as the personal importance individuals attach to doing well on a given task (Eccles 2005; Wigfield & Eccles, 2000). In other words, how well the given task fits the individual's self-identity. Consider, for example, a female student (Juliana) from a middle-class family that is well respected and known in the community as "a family of medical doctors." Juliana is also currently enrolled in a medicine major at her university. The attainment value of such a medicine major for Juliana would be high, ostensibly because doing well in this major would affirm her personal or social identity (Eccles, 2005; Eccles et al., 1983).

Intrinsic (interest) value**.** The intrinsic value component addresses the question: Does the female student enjoy the STEM major? Thus, intrinsic value has to do with the inherent, immediate enjoyment the individual gains from engaging in a given task or the anticipated enjoyment the individual expects to get while engaging in the task (Eccles, 2005; Eccles et al., 1983). To a certain degree, intrinsic value is similar to the idea of intrinsic motivation (Wigfield, 1994).

Utility value. The utility value component addresses the question: Is this STEM course very instrumental in meeting the long or short-term goals of the student? (Eccles, 2007). Utility value, therefore, refers to the usefulness of the task or how a given task fits into the future goals/plans of the individual, for example, career goals (Eccles 2005; Wigfield & Eccles, 1992; Wigfield & Eccles, 2000). For example, Mercy is aspiring to be a medical doctor and is currently enrolled in the premedical program at Noble University. Although Mercy is a good student, she dislikes chemistry classes. However, all pre-med students in her college are required to take the physical chemistry elective course as one of the requirements for gaining admission into medical school. While Mercy dislikes chemistry classes, she may want to take the physical chemistry elective course because of her career aspiration and the instrumentality of physical chemistry in helping her achieve that aspiration. The value of physical chemistry in this regard would be high for Mercy because of its long-term usefulness (Eccles et al., 1983). Thus, to a large extent, utility value is similar to extrinsic motivation, because the activity (physical chemistry course) was a means to an end rather than an end in itself (Eccles, 2005).

Relative cost. Cost refers to what the individuals would have to give up in order to engage in a given task (Eccles, 2005; Wigfield, 1994). Eccles et al. (1983) define cost in terms of the effort required to succeed in the task, the time lost for other valued tasks, and the psychological cost of failure or emotional trauma resulting from failure. Students have limited time and energy to accomplish all the tasks they set for themselves to do (Eccles et al.). More often than not, it becomes necessary for them to choose among various tasks. For example, a student might decide to forgo attending a movie show during the weekend in order to do her biology assignment paper. The relative cost is the movie show the student did not attend. A female aviation student may also decide to delay starting a family in order to accumulate more "flying hours." It is also a common practice for a student to avoid taking a course she is not certain she can do well in (Eccles et al., 1983), because she feels that getting a lower grade in that course might lower her GPA, which may not be good for her psychological wellbeing. Furthermore, a low GPA might hinder her chances of enrolling in certain academic programs.

Financial value. In this study, financial value refers to all the monetary benefits the individual gains from pursing a STEM major (e.g., scholarships, stipends, tuition waivers, and financial aid) or the anticipated monetary benefits the individual expects to gain from working in a STEM field (e.g., good salary).

Surveyed Literature on STEM Persistence and Attrition

In order to become familiar with previous empirical work on why women persist or leave STEM majors, the researcher conducted a review of the literature on issues related to student persistence and attrition in STEM fields. While the literature on STEM persistence and attrition abounds, the researcher targeted empirical studies within the last 7 years, that is, from 2010 to 2017. The decision to select studies within this time frame was largely influenced by the limited time available to conduct the study.

To locate the relevant literature, key words such as “STEM persistence,” “STEM attrition,” “students persisting in STEM majors,” “students leaving STEM majors/fields,” and factors influencing STEM persistence and attrition” were entered into search engines including Google and Google Scholar. While the search criteria generated numerous relevant studies, the decision was made to select only 15 of them for analysis. This decision was also based in part on the limited time available to conduct the current study. Furthermore, the researcher felt that 15 studies would be adequate to provide evidence on the research regarding STEM persistence and attrition. In order to gain a balanced perspective on previous empirical studies, the criteria for the selection of the 15 studies were year of publication, methodological approach used, type of data collected, disciplinary context, participant type, and study/gender focus (see Table 1). Most of the studies included in Table 1 focused on STEM fields in general; however, four of the studies concentrated on a specific STEM major such as chemistry (Philipp, 2013), engineering (Geisinger & Raman, 2013), math (Rasmussen & Ellis, 2013), or physics (Watkins & Mazur, 2013).

To facilitate presentation and discussion, the 15 studies selected for analysis were grouped according to the methodological approach used, namely, quantitative, qualitative, mixed methods, and literature review. For each methodological grouping, the studies were analyzed in terms of the differences and similarities between the methodologies employed. Following that, the results obtained across the various studies were also discussed.

Table 1. Surveyed Literature on STEM Persistence and Attrition by Year of Publication

Author(s)	Year	Method	Data Type	Discipline	Participants	Study Focus
Griffith	2010	Quan	Longitudinal survey (national)	STEM	Grad/Ugrad *N*= unknown	*Persistence,* women & racial minorities
Hughes	2010	Qual	Interviews	STEM	Ugrad *N*=26	*Persistence,* women
Price	2010	Qual	Longitudinal data	STEM	Ugrad *N*=Unknown	*Persistence,* women & racial minority
Rask	2010	Qual	Longitudinal data	STEM	Ugrad *N*=5044	*Attrition,* male & female
Shaw & Barbuti	2010	Quan	Longitudinal data & survey	STEM	Ugrad *N*=54336	*Persistence & attrition;* male & female

Table 1, continued

Author(s)	Year	Method	Data Type	Discipline	Participants	Study Focus/
Beasley & Fischer	2012	Qual	Longitudinal, interview	STEM	Ugrad *N*=3008	*Attrition,* women/racial minorities
Chen	2013	Qual	Longitudinal, interviews, student demographic data	STEM	Mixed: Ugrad/ Associate Degree *N*=90000	*Attrition*, male & female
Geisinger & Raman	2013	Lit. review	Literature review	Engineering	50 studies reviewed	*Attrition*
Philipp	2013	Quan + Qual	Surveys, interviews, reflection papers, observations	STEM–Chemistry based course	Ugrad *N*=594	*Persistence,* male & female
Rasmussen & Ellis	2013	Quan	Survey	Math–Calculus	Mixed: Ugrad/ Assoc. Degree/ Grad *N*=unknown	*Attrition,* male & female

Table 1, continued

Author(s)	Year	Method	Data Type	Discipline	Participants	Study Focus/
Watkins & Mazur	2013	Quan	Longitudinal data	Introductory physics course	Ugrad N=1177	*Attrition,* male & female
Brandt	2014	Quan	Survey	STEM	Ugrad N=181	*Persistence,* Women
Edzie	2014	qual→ QUAN	Focus group interview & survey	STEM	Ugrad N=278	*Persistence,* women
Morganson et al.	2015	Qual	Focus group interview	STEM	Ugrad N=34	*Persistence,* male & female
Minutello	2016	Qual	Interviews	STEM	Ugrad N=20	*Attrition,* male & female

The following paragraphs discuss the 15 studies included in Table 1 in terms of quantitative, qualitative, mixed methods, and literature review approaches.

Quantitative Studies on STEM Persistence and Attrition

Of the 15 studies selected for review, 5 of them used quantitative methods exclusively (see Brandt, 2014; Griffith, 2010; Rasmussen & Ellis, 2013; Shaw & Barbuti, 2010; Watkins & Mazur, 2013). Three of the five quantitative studies included longitudinal and survey data (Griffith; Shaw & Barbuti; Watkins & Mazur), while two of them (Brandt and Rasmussen & Ellis) exclusively used survey data. Three of the quantitative studies involved participants from undergraduate programs, while two of the studies focused on both graduate and undergraduate programs. With the exception of Shaw and Barbuti's (2010) study, which included both STEM persistence and attrition, all the other quantitative studies focused on either persistence or attrition. This suggests that more quantitative research that focuses on both STEM persistence and attrition may be needed. The current study contributes to filling this gap in the extant literature.

In terms of persistence, Griffith (2010) reported that women and racial minority groups had lower average persistence rates in STEM majors than their male and nonminority counterparts. However, she noted that these differences in persistence rates were explained by the differences in prior academic preparation and educational experiences. She also noted that the characteristics and educational policies of the institutions involved in the study played a key role in students' choice to persist (or not to persist) in STEM fields. That is, Griffith found that students from institutions with more undergraduates than graduates or no graduate programs at all were more likely to persist in STEM fields. She noted further that students from participating institutions where a significant proportion of the educational budgets were allocated to research rather than other educational expenditures had lower rates of persistence in STEM fields. She also observed that, of the students in the sample population who switched from STEM majors, a majority did so within the first 2 years of college, while a relatively smaller percentage switched from STEM majors between their sophomore and senior years. Findings from Griffith's study also suggested that higher grades in STEM classes in relation to non-STEM classes increase persistence in STEM majors.

Unlike Griffith (2010), who examined the important influences on students in STEM programs from first year through senior years, Shaw and Barbuti (2010) focused on the personal and contextual factors that influence undergraduate students to either persist in or switch from STEM majors in the third year of college. Forty-one percent of the sampled population (*N*=54336) identified themselves as STEM persisters, while the rest (59%) identified as STEM switchers. Findings from Shaw and Barbuti's study showed differences by gender and first-generation college status for both persisters and switchers. In other words, the results of the study indicated that persisters had higher cumulative GPAs than switchers in STEM majors (d = -0.47) such as architecture and related services, mathematics, and statistics during the first 2 years of college; suggesting that persisters performed better academically than switchers. Shaw and Barbuti concluded that students' poor performance in STEM majors, especially in the first year of college may influence students to switch to non-STEM majors. In terms of gender, the statistical analysis showed that females (49%) were more likely to switch from their intended STEM majors than their male (32%) counterparts. The analysis also revealed that first-generation students had more of a tendency to switch from STEM majors than those students whose parents had college educations (44% versus 36%). Shaw and Barbuti's (2010) study further revealed that participants who took three or more advanced placement (AP) exams in STEM and also had strong background in math and science were more likely to persist in STEM than students who took fewer or no AP exams at all. Additionally, STEM switchers had lower science self-efficacy ratings and lower rates of doctoral degree goals than did persisters.

Brandt (2014) has also examined the factors that influence students to persist in collegiate STEM majors. However, unlike previous related research that focused on male and female students in collegiate STEM programs, Brandt surveyed only female undergraduate students (181) in technology majors at two universities. The survey results indicate that only 34% of the sample population switched majors, suggesting that a majority of the participants (66%) were committed to graduating with STEM degrees. Strong academic preparation in science and math; self-confidence; and support from family, friends, and mentors were reported by a majority of the participants as the factors that influenced their persistence in STEM majors. Of the 34% of the participants who switched majors, 32% did so after the first semester, 26% after the second semester, and 42% after the second year. This is consistent with the findings of Griffith's (2010) study.

According to Thomas (2013), of the total number of freshman students who entered STEM colleges at North Carolina State University in 2009, 40% withdrew by their second year of college: 11% from the College of Engineering, 11% from the College of Life and Agricultural sciences, and approximately 18% from the College of Physical and Mathematical Sciences. These statistics support Brandt and Griffith's research findings on STEM attrition that most of the collegiate STEM attrition usually occurs within the first two years.

Interestingly, the majority of participants (58%) in the Brandt study who switched majors moved to a related major. For example, some participants initially started with chemical or civil engineering and later switched to mechanical engineering. Only 9% of the participants switched from physical science/engineering majors to life sciences. This result is a bit surprising considering the fact that the National Science Board (2012) data indicate that female students are more often attracted to biology/life sciences than physical sciences such as engineering and physics.

The quantitative studies discussed so far have focused on factors that influence STEM persistence. However, two of the quantitative studies included in Table 1 focused on STEM attrition (see Rasmussen & Ellis, 2013; Watkins & Mazur, 2013). Using national online survey data about Calculus 1 instruction at colleges and universities in the U.S., Rasmussen and Ellis examined the characteristics of undergraduate students who started with Calculus I and later switched out of the calculus sequence courses, and their reasons for doing so. The calculus courses were intended to prepare participants for STEM fields, particularly engineering and the physical sciences. Of the 440 participants identified as Calculus I switchers, about 60% were female. Some of the reasons that the switchers gave for not continuing to Calculus II included classroom experiences in Calculus I, lack of conceptual understanding of Calculus I, and poor grades in Calculus I. Participants were then asked to share some of their classroom experiences. While persisters and switchers were not significantly different in terms of their mathematical preparation, the switchers indicated, for example, that they were unable to follow the class lecture, and because of this, they did not contribute to class discussion; instead, they copied whatever they saw on the board. This suggests the need for more research on different instructional approaches and their impact on STEM persistence and attrition.

Watkins and Mazur's (2013) research work among undergraduate students provides insight into how the use of a variety of instructional approaches impacts STEM persistence and attrition. In a cross-sectional and longitudinal study of 1177 undergraduate students, Watkins and Mazur compared the percentages of students who switched out of a STEM major after taking an introductory physics course taught using only the traditional lecture method versus one taught using peer instruction. Their results indicated that almost twice the percentage of students switched their STEM majors after they had taken part in the traditional lecture-based physics course. This result suggests that a majority of the students preferred the use of the peer instruction pedagogy, since it is student-centered and promotes student interaction, engagement, and ability to think critically. Based upon the results of their study, Watkins and Mazur concluded that "providing opportunities for students to think, respond, and interact in class may have a substantial impact on the retention of students in STEM disciplines" (p. 36). On the basis of the results of Watkins and Mazur's study, one could infer that the students who switched from the Calculus sequence courses in Rasmussen and Ellis's (2013) study probably also did not like the traditional lecture approach to teaching calculus.

Qualitative Studies on STEM Persistence and Attrition

Seven of the fifteen studies examined used qualitative methods exclusively to explore STEM persistence and attrition (Beasley & Fischer, 2012; Chen, 2013; Hughes, 2010; Minutello, 2016; Morganson, Major, Streets, Litano, & Myers, 2015, 2015; Price, 2010; Rask, 2010). The type of qualitative data collected included longitudinal, focus groups, and interviews. All of the qualitative studies analyzed sampled undergraduate students, which presupposes that more qualitative research regarding STEM persistence and attrition would be needed at the graduate level. Accordingly, the current study sampled a mix of students in undergraduate and graduate STEM programs in order to gain a balanced perspective on the research problem and also contribute to filling the gap in the existing literature.

With respect to persistence, Hughes (2010) identified a number of factors that influenced women to persist in collegiate STEM programs. These included precollege and college success (particularly in math and science); support from parents, teachers, and faculty; and peer support networks at the college level. These factors were discussed in light of Eccles's (2007) expectancy value model and Butler's (1999) conception of gender. Price (2010) also found that black students were more likely to persist in a STEM major if they enrolled in a STEM course taught by a black instructor. Morganson et al. (2015) used focus group interviews to test the tenability of the three tenets of the embeddedness theory (fit, links, and sacrifice) within the context of STEM persistence. The results of their study provided strong support for the tenability of the embeddedness theory because all three of the tenets were cited by students as factors that influenced their STEM persistence.

Morganson et al. (2015) defined *fit* in relation to STEM majors as the extent to which individuals perceive a match between their abilities or interests and the characteristics of their fields of study. The construct of fit parallels Eccles et al.'s (1983) intrinsic value. *Links,* in the context of STEM majors, refer to the extent to which individuals have ties to other people and activities in a STEM major. These STEM major links include peers, having a role model, being a role model, cultural icons, professors, and advisers. *Sacrifice* refers to what the individuals would lose if they were to *switch* from a STEM major. This loss could include either tangible or psychological costs associated with switching from a STEM major. Examples of things lost include prestige, future salaries, and career prospects. The construct of sacrifice is different from Eccles et al.'s *cost value*, which refers to what an individual would lose by *pursing* a STEM major.

Concerning attrition, Rask (2010) reported that grades received in STEM courses, and, to some extent, the relationship between grades received in STEM courses and those received in non-STEM courses, are important predictors of the decision to continue (or not to continue) taking courses in a STEM major. Chen (2013) also found that poor performance in STEM classes in relation to non-STEM classes was linked to the increased probability of switching STEM majors.

Beasley and Fischer (2012) also found that stereotype threat had negative impact on all the different groups in the sample population. That is, women, minorities, and white men were all likely to switch from STEM majors because of a stereotype threat. In a more recent empirical study, Minutello (2016) identified five obstacles that demoralized undergraduate students at a large research university and led them to switch their STEM majors to non-STEM majors. These factors included disengaging curricula, competitive culture, disappointing grades, demanding time commitments, and unappealing career options.

Mixed Methods Studies on STEM Persistence and Attrition

Two of the fifteen studies selected for analysis used a mixed methods approach to investigate collegiate STEM persistence. One of the two mixed methods studies used a convergent parallel mixed method design (Philipp, 2013), denoted as QUAN + QUAL, which means that both the quantitative and qualitative data were collected at roughly the same time (Creswell & Plano Clark, 2011). The other mixed methods study used an explanatory-sequential design (Edzie, 2014), denoted as qual→QUAN, which means that the qualitative data were collected first, followed by the quantitative (Creswell & Plano Clark). (The uppercase in the denotation "qual→QUAN" indicates that the quantitative method was dominant over the qualitative method). The two mixed methods designs described above were influential in in the development of the explanatory-sequential mixed-methods approach (QUAN→qual=explain results, Creswell & Plano Clark, 2011) used in the current investigation. The explanatory-sequential approach is explained in detail in Chapter III of this report.

Participants in the two mixed method studies analyzed included mainly undergraduate students (although teaching assistants and faculty were also involved in the Philipp's [2013] study), with Edzie's study focusing on only female students while Philipp's study sampled both male and female students. The quantitative components in these mixed methods studies relied on surveys, whereas the qualitative strands employed focus groups, interviews, observations, and reflection papers.

In terms of persistence, Philipp (2013) compared a group of university students taking an introductory chemistry course (CHEM 201) taught by undergraduate teaching assistants (UTAs) with another group of students who were taught by traditional graduate teaching assistants (GTAs) in terms of their likelihood to continue on to a more advanced chemistry course (CHEM 202). The statistical analysis indicated that students were three times more likely to persist to CHEM 202 if they were taught by a UTA during the introductory chemistry course. This result illustrates the role that instructors play in terms of influencing students to persist in collegiate STEM programs. The statistical analysis also showed that students with strong college grades and ACT math scores were more likely to persist in the chemistry sequence courses.

Edzie's (2014) study on women in STEM also provides additional insight on factors that influence STEM persistence. The themes that emerged during her qualitative focus group interviews suggested that altruism (the desire to help others), passion for the STEM major, influential stakeholders (e.g., parents and teachers), precollegiate experiences (e.g., field trips and high school STEM club), and exposure to different career opportunities in STEM were important factors that influenced the participants to enroll and persist in collegiate STEM majors. Edzie examined some of these themes further in her quantitative study. The results of the quantitative study suggested that students rated career goals as the most influential factor that kept them motivated in their

STEM majors. Career goals were followed by desire to pursue the major, personal motivators, parents/family, challenging major, friends, and faculty in that order. Some of these persistence factors (e.g., career goals, family, faculty, friends, and personal motivators) were tested during the quantitative portion of the current study.

Literature Review on STEM Persistence and Attrition

The last of the 15 studies selected for analysis adopted the literature review approach. The researchers (see Geisinger & Raman, 2013) reviewed 50 studies on student attrition from engineering majors with a view to understanding the factors that contribute to students' decision to leave collegiate engineering programs prior to graduation. In all, they identified six broad factors that influence student attrition from engineering majors. These factors included classroom and academic climate (e.g., inadequate teaching and advising and lack of cooperation), grades and conceptual understanding, self-efficacy and self-confidence, high school preparation (e.g., in math and science), interest and career goals, and race and gender (e.g., women and racial minorities have the tendency to leave STEM at higher rates than other groups).

Analysis Across the Different Research Approaches

The related literature reviewed revealed several factors that influence women to persist in collegiate STEM programs. However, factors such as precollege and college experiences or successes, particularly in math and science, and support from parents, peers, and teachers (Brandt, 2014; Edzie, 2014; Geisinger & Raman, 2013; Griffith, 2010; Hughes, 2010; Shaw & Barbuti, 2010) were identified as key persistence factors as they were reported across the various research methodologies. Academic grades (both relative and absolute grades) were also reported as predictors of STEM persistence and attrition across different research approaches (Geisinger & Raman; Griffith; Philipp, 2013; Rasmussen & Ellis, 2013). Three of the fifteen studies reviewed indicate that women are more likely than their male counterparts to switch out of STEM majors (Geisinger & Raman; Griffith; Rasmussen & Ellis; Shaw & Barbuti). Also, three of the quantitative studies reviewed point out that a majority of students who switch out of STEM majors do so during the first 2 years of college (Brandt; Griffith; Shaw & Barbuti).

Of the 15 related studies that were subjected to analysis, none of them considered age or resident status (i.e., whether the student is a domestic or international student) as factors that could influence the decision to switch or persist in STEM majors. Furthermore, only Hughes (2010) discussed the perceptions of female STEM persisters and switchers toward STEM fields using Eccles et al.'s (1983) expectancy-value model. However, Hughes's study was purely qualitative; therefore, the current study will benefit from quantitative examination of the perceptions of female STEM persisters and switchers regarding STEM fields using the expectancy-value model. For example, it will be interesting to test quantitatively whether STEM persisters and switchers significantly differ in terms of the value they place on STEM fields and how well they expect to perform in STEM fields.

In the 15 studies reviewed, successes and experiences in STEM courses were reported as key influences on STEM major persistence, although none of the studies used the Perceived Academic Success Scale (see Hall et al., 2004) to assess how successful STEM persisters and switchers felt about their STEM courses. Research that reported on students' academic success in STEM courses used only cumulative GPA (e.g., Shaw & Barbuti, 2010). However, students' success in a course cannot be measured only in terms of the final grade they received in the course. Other factors (e.g., knowledge and understanding gained in the course, ability to meet deadlines and goals set) also need to be considered. Furthermore, none of the studies examined considered whether perceived success in STEM courses and the value that students place on STEM fields predict their expectations for success in STEM careers.

How This Study Addressed Gaps in the Literature

The current study sought to fill the void in the extant literature by addressing the issues raised above. First, the current study examined whether participants' age and educational level had any influence on their persistence or attrition in STEM majors. Second, the current study examined whether female students significantly differed in terms of the value they placed on STEM fields and their expectations for success in STEM careers based on their age and educational level. Third, the present investigation examined whether women who persisted in STEM majors were significantly different from women who switched from STEM majors based on their scores on the perceived value of STEM fields and expectations for success subscales (see Chapter III for full descriptions of value of STEM fields and expectations for success in STEM careers subscales). Fourth, the current investigation examined whether there was a significant difference between female STEM persisters and switchers in terms of their scores on the perceived success in STEM courses subscale (see Chapter III for the description of the perceived success in STEM courses subscale). Lastly, the present study examined whether female students' perceived success in STEM courses and the value that they placed on STEM fields predicted their expectations for success in STEM careers.

Research Questions and Hypotheses

Overall, the current study addressed four primary questions and two sub-questions. Four relevant hypotheses were also considered. These research questions were derived from the knowledge and understanding gained from the review of related literature discussed above. Walonick (2012) distinguishes between two types of research questions. These are "testable" and "non-testable" research questions. According to him, non-testable research questions do not need to be answered by performing statistical tests. Instead, they are best answered by summarizing the responses of participants in descriptive tables. To him, testable research questions require statistical tests to be performed in order to address the responses of participants. Walonick opines further that every testable research question as a necessity must have an associated hypothesis. In this current study, research questions 1, 1a, and 1b are non-testable questions, whereas research questions 2, 3, and 4 are testable questions (see questions below). Thus, only research questions 2 to 4 have associated null hypotheses. Following is a listing of the research questions addressed in the current study, as well as the associated hypotheses that were tested. A description of the statistical analyses that were performed to test the null and alternative hypotheses (Creswell, 2014) developed is provided in Table 4 in Chapter III.

Question 1. What Factors Can Account for Whether College Women Switch or Persist in STEM Majors?

Question 1a. What are the characteristics of college female STEM switchers? (e.g., age, year of study STEM major was switched, and resident status).

Question 1b. Which STEM majors are college women likely to switch from and which non-STEM majors are they likely to switch to?

Question 2. Do Women Who Persist in STEM Majors Differ Significantly from Women Who Switch STEM Majors in Terms of Their Scores on the Value of STEM Fields and Expectations for Success in STEM Careers Subscales?

Null Hypotheses:

H_1: There is no significant difference between STEM persisters and STEM switchers in terms of value of STEM fields.

H_2: There is no significant difference between STEM persisters and STEM switchers in terms of expectations for success in STEM careers.

Alternative Hypotheses*:*

H_{A1}: STEM persisters will have significantly higher scores on the value of STEM fields subscale than do STEM switchers.

H_{A2}: STEM persisters will have significantly higher scores on the expectations for success in STEM careers subscale than do STEM switchers.

Question 3: Is There a Significant Difference Between Female STEM Persisters and Switchers in Terms of Their Scores on the Perceived Success in STEM Courses Subscale?

Null Hypothesis:

H_3: There is no significant difference between STEM persisters and STEM switchers in terms of their scores on the perceived success in STEM courses subscale.

Question 4: Do College Women's Perceived Success in STEM Courses and the Value That They Place on STEM Fields Predict Their Expectations for Success in STEM Careers?

Null Hypothesis:

H_4: The level of expectations for success in STEM careers is not affected by the value that college women place on STEM fields or their perceived success in STEM courses.

Description of Research Variables and Their Rationale

The researcher sought to examine the relationships between several research variables during the quantitative phase of the current study. These research variables, which were classified as dependent and independent variables, were determined based on the researcher's understanding of the literature reviewed and how these variables would help in answering the main and sublevel research questions designed for the current study. In this section, the dependent variables of interest are discussed first. Following that, the independent variables are also discussed.

Dependent Variables. The dependent variables in this study consisted of value of STEM fields, expectations for success in STEM careers, and perceived success in STEM courses. These dependent variables are described in detail in Chapter III of this report. Value of STEM fields was used to assess the degree to which participants valued STEM fields and careers, whereas expectations for success in STEM careers was used to measure the degree to which participants assessed their abilities to do well in STEM-related jobs. Perceived success in STEM courses was used to assess the degree to which participants felt satisfied with their performances in STEM courses.

The value of STEM fields and expectations for success in STEM careers constructs are situated in the expectancy-value model. While the expectancy-value model has been used to explain college major selection and career choices in general (e.g., Eccles, 2007), little research has quantitatively examined the extent to which female college students' expectations for success in STEM careers and the value they attach to STEM fields influence their STEM persistence and attrition (see earlier discussion about the empirical related studies). Also, no research has examined the perceptions of female college persisters and switchers regarding their performance in STEM courses using the perceived success in STEM courses scale. Therefore, it was important to examine these dependent variables in relation to the independent variables developed for this current study in order to shed some light on these areas. The analyses of the dependent variables contribute to the testing of the null hypotheses. The current study hypothesized that women with lower levels of expectations for success in STEM careers and/or lower perceived value of STEM fields would be less likely to persist in STEM majors (irrespective of their level of academic achievements in the STEM fields) than women with higher levels of expectations for success in STEM careers and value of STEM fields.

Independent Variables. The independent variables included background variables such as STEM major status, age, educational level, year of study, resident status, and academic destinations for STEM Switchers. Each of these independent variables below has been discussed in light of existing literature.

STEM major status. STEM major status is an independent variable with two levels, that is, STEM "persisters" and STEM "switchers." STEM persisters were defined as those college women who, at the time of the current study, were enrolled in STEM classes/majors or had graduated with STEM degrees. STEM switchers, on the other hand, were defined as college women who at the time of the current study had switched from any of the STEM majors designated in this study or had graduated with non-STEM degrees, having initially declared STEM majors.

As discussed earlier, no study has quantitatively examined and compared STEM persisters and STEM switchers in terms of perceived value of STEM fields, expectations for success in STEM careers, and perceived success in STEM courses. Thus, it was important to examine the STEM major status variable in relation to the dependent variables in order to contribute to knowledge in these areas. Analysis of the STEM major status variable contributes to the testing of null hypotheses 1 through 4. The current study hypothesized that STEM persisters would have higher scores on the perceived value of STEM fields, expectations for success in STEM careers, and perceived success in STEM courses subscales than would STEM switchers.

Year of study. Year of study was defined as the number of months or years that a student has been enrolled in the STEM major or program. Several authors have linked year of study and the likelihood of switching STEM majors (e.g., Brandt, 2014; Thomas, 2013; Watkins & Mazur, 2013). Specifically, these authors found that students were more likely to switch STEM majors during the first or second year of college. However, these studies focused on both male and female students. Only one study specifically reported on the year of study that college women switched from STEM majors (see Brandt, 2014).

Thus, it was important to investigate the year of study in which female STEM switchers in this sample population switched from STEM majors. Analysis of the year of study variable contributes to answering non-testable research question 1a. Therefore, hypothesis formulation was not necessary.

Age of STEM switcher. It is important to note the difference between the age of participant and age of STEM switcher variables. The former has to do with the age of any individual who participated in the online survey, whereas the latter concerns the age of any STEM switcher. One of the objectives of the current study was to examine some characteristics of STEM switchers, including their age. Chen's (2013) excellent work in his study on STEM attrition examined a number of characteristics of STEM switchers. For instance, he noted that proportionally more females than males left STEM fields by switching to non-STEM majors. However, Chen (2013) did not consider the age of those students who left STEM by switching to non-STEM majors. It could be that older female students are more likely to switch STEM majors than young female students or vice versa. Thus, it is important to examine the age of STEM switchers. Accordingly, age of STEM switcher was treated as a categorical variable with five levels. Analysis of the age of STEM switcher variable contributes to answering non-testable research question 1a. Therefore, hypothesis formulation was not necessary.

Resident status. In the context of this current study, resident status refers to a participant who is a citizen/permanent resident of the U.S. or a citizen/permanent resident of another country. A citizen/permanent resident of the U.S. was referred to in this study as a domestic student, whereas a citizen/permanent resident of another country was known as an international/foreign student. Resident status is an independent variable with two levels—domestic students and international students. Newlon (2013) noted that international students have a higher probability of staying with their STEM majors, particularly at the graduate level, than do domestic students. Thus, it is important to investigate whether this assertion is also true of international students in this sample population. Analysis of the resident status variable contributes to answering non-testable research question 1a. Therefore, hypothesis formulation was not necessary.

Academic destination for STEM switchers. These were the reported majors or fields that STEM switchers pursued following their exit from STEM majors. According to a study conducted by Chen (2013), most college students who enrolled in STEM majors and later switched to non-STEM majors ended up pursuing business, while education was one of the least reported destinations. However, Chen's study included males and females and the results were reported in aggregate; therefore, it is difficult to know the most popular destinations for female STEM switchers in his study. It may be that female students have unique fields that they enter after exiting STEM majors and may have reasons for entering those fields. Thus, it may be interesting for the current study to find out the academic destinations for female STEM switchers and to explore their reasons for switching into those majors. Analysis of the *academic destinations for STEM switchers* variable contributes to answering non-testable research question 1b. Therefore, hypothesis formulation was not necessary.

CHAPTER III

METHODOLOGY

Initial Study

The current research study evolved from an initial study carried out by the researcher during the spring and fall semesters of 2013 (see Appianing & Van Eck, 2015). The purpose of the initial study was to develop and validate a quantitative instrument (VIES Instrument) to measure male and female college students' perceptions of computer technology majors and careers, and to compare whether male and female college students differ in terms of their perceptions regarding computer technology fields.

The sample population was drawn purposively from undergraduate and graduate male and females of all academic disciplines at a Midwestern research university in the U.S. In all, 184 students participated in the initial study, comprising 105 females and 79 males. Participants represented 39 different academic majors, including accountancy, aviation, biology, chemistry, communication, social work, psychology, electrical engineering, educational foundations and research, nursing, computer science, and teacher education. Data were collected using the paper and pencil survey technique during class sessions with the permissions of instructors.

The VIES instrument, which was based on Wigfield and Eccles's (2000) expectancy-value theory of achievement motivation, consisted of three subscales (*perceived value of computer technology fields*, *interest in computer technology major,* and *expectations for success in computer technology careers*) made up of twenty-two items assessed on a five-point Likert-type scale (1 = strongly disagree, 5 = strongly agree). See Appendix A for the full VIES questionnaire with the VIES subscales. The VIES subscales asked participants to rate 22 statements that measured the value that they placed on computer technology fields, their interest in computer technology majors, and their expectations for success in computer technology careers. The value of computer technology fields subscale consisted of seven items (four positively worded and three negatively worded) that assessed the importance students attached to computer technology fields. An example item was "I would take a course in computer technology even if it were not required." The interest in computer technology major subscale was made up of seven items (four positively worded and three negatively worded) that measured the extent to which students were desirous of pursuing a degree in computer technology. An example item was "The idea of being in a computer technology class excites me." The expectations for success in computer technology careers subscale consisted of eight items (four positively worded and four negatively worded) that measured students' perceptions of their ability to accomplish their career goals in a computer technology career.

A confirmatory factor analysis, with varimax rotation, was used to examine the factor structure of the VIES subscales. All of the negatively worded items were reverse-coded prior to factor analysis. The results of the factor analysis indicated three distinct factors with strong item loadings (.61 to .86). Internal reliability was found to be sufficient for all the VIES subscales; therefore, none of the 22 items was removed. The Cronbach's alphas for coefficients were .87 for the value of computer technology field subscale, .90 for the interest in computer technology major subscale, and .89 for the expectations for success in computer technology careers subscale.

Current Study

The main purpose of the current study was to examine the factors associated with collegiate women's STEM persistence and attrition and to examine whether women STEM persisters and switchers differed in terms of the value they place on STEM fields, their expectations for success in STEM careers, and their perceived success in STEM courses. Examining the factors associated with STEM persistence and attrition, as well as perceptions among college women toward STEM, might provide insight into how women could be attracted to and retained in STEM programs and careers.

The current study used the explanatory-sequential mixed-methods design, in which the quantitative component preceded the qualitative strand. The quantitative study, among other things, was used to test the tenability of Wigfield and Eccles's (2000) expectancy-value theory of achievement motivation in relation to college women's perceptions regarding STEM fields and careers, while the qualitative study was used to support and explain the quantitative findings further. In this section, description may be found of the research paradigm and design, the different phases of the data collection process the instruments, population and sample of the study, and the data analysis technique used in this current study.

Research Paradigm

A research paradigm has to do with the fundamental beliefs or assumptions that guide a research study (Alghamdi, 2015; Creswell & Plano-Clark, 2011). In other words, a research paradigm is the epistemology underlying the study, or how the researcher gains knowledge about what he or she knows. Thus, epistemological beliefs inform the methodology that may be employed for a study, including the research design and the procedures used to gather, analyze, and interpret the research data (Creswell & Plano-Clark, 2011).

There are several research paradigms (e.g., postpositivism, constructivism, and pragmatism) that convey different theoretical propositions about the nature of reality (Creswell & Plano-Clark, 2011; Mackenzie & Knipe, 2006; Teddlie & Tashakkori, 2009). Creswell and Plano-Clark differentiate between the above research paradigms as follows, "the postpositivist tends to view reality as singular… the constructivist views reality as multiple and actively looks for multiple perspectives from participants, such as perspectives developed through multiple interviews... the pragmatist views reality as both singular (e.g., there may be a theory that operates to explain the phenomenon of study) as well as multiple (e.g., it is important to assess varied individual input into the nature of the phenomenon as well)" (p. 41). Mills, Bonner, and Francis (2006) encourage researchers to carefully choose a research paradigm that is consistent with their beliefs about the nature of reality, so as to ensure a strong research design.

Considering the nature and goal of the current study, the pragmatist paradigm fits the general framework of the present inquiry. In particular, the use of both quantitative and qualitative data collection to inform the research problem being investigated is in line with the pragmatist view. The choice of research paradigm was also influenced by the fact that many mixed methods researchers see pragmatism as the paradigm that provides a philosophical foundation for mixed methods research (see Creswell & Plano-Clark, 2011; Lincoln, Lynham, & Guba, 2011; Somekh & Lewin, 2005; Teddlie & Tashakkori, 2009).

Research Design

Mixed Methods Research Design

This study employed a mixed methods research design to examine the perceptions of college women regarding STEM and the reasons that women may persist or switch from collegiate STEM programs. Thus, the research problem was addressed through the lens of the pragmatist paradigmatic view, by incorporating both quantitative and qualitative data collection approaches within this single study (Creswell & Plano-Clark, 2011).

Design Model

The specific mixed methods approach that was used in the current study is known as "the explanatory-sequential mixed-methods design," which is expressed as *QUAN→qual=explain results* (see Caruth, 2013; Creswell, 2012; Creswell & Plano-Clark, 2011; Knaggs, Sondergeld, & Schardt, 2015). The methodological approach employed is so-called because the data collection process comprised two main phases — quantitative (QUAN) and qualitative (qual). In this present study, the quantitative strand (Phase I), preceded the qualitative aspect (Phase II). Another important characteristic of this design model is that QUAN has priority over qual, with qual data being used to support and facilitate a better understanding of the quantitative result, or to help explain trends in the quantitative data (Creswell & Plano-Clark; Knaggs, Sondergeld, & Schardt; Teddlie & Tashakkori, 2009).

Design Model Features

The explanatory-sequential mixed-methods research design employed for this study is characterized by the following seven stages: (1) collection of quantitative data through online survey, (2) quantitative data analysis using SPSS software, (3) purposefully selecting participants for follow-up focus group interviews based on quantitative results, (4) developing follow-up focus group interview questions, (5) collection of qualitative data through focus group interviews, (6) analysis of qualitative data, and (7) presentation and interpretation of the quantitative and qualitative results (Creswell and Plano-Clark, 2011). Figure 3 (see below) shows the connection between the quantitative and qualitative data collection processes and how they exemplify the explanatory-sequential design methodology used in the current study.

Rationale for Research Design

One of the limitations of the initial study was that it was solely survey-based. Therefore, it did not allow for further exploration of some of the statistical results, such as the reasons why the female participants' scores on the VIES subscales were statistically lower than those of their male counterparts. That is, the quantitative study was insufficient to fully understand the research problem.

However, most mixed methods researchers recognize the wealth of knowledge that both quantitative and qualitative approaches can generate about the research problem compared to using either of the approaches alone (Creswell & Plano-Clark, 2007; Lincoln et al., 2011; Lund, 2012). Thus, the current study expanded the initial study's methodology by incorporating both quantitative and qualitative strands in order to allow for a more comprehensive exploration of the research problem. In other words, the explanatory-sequential mixed-methods research design was chosen primarily to help the researcher to identify quantitative results that need to be explored further with a qualitative strand (Knaggs, Sondergeld, & Schardt, 2015).

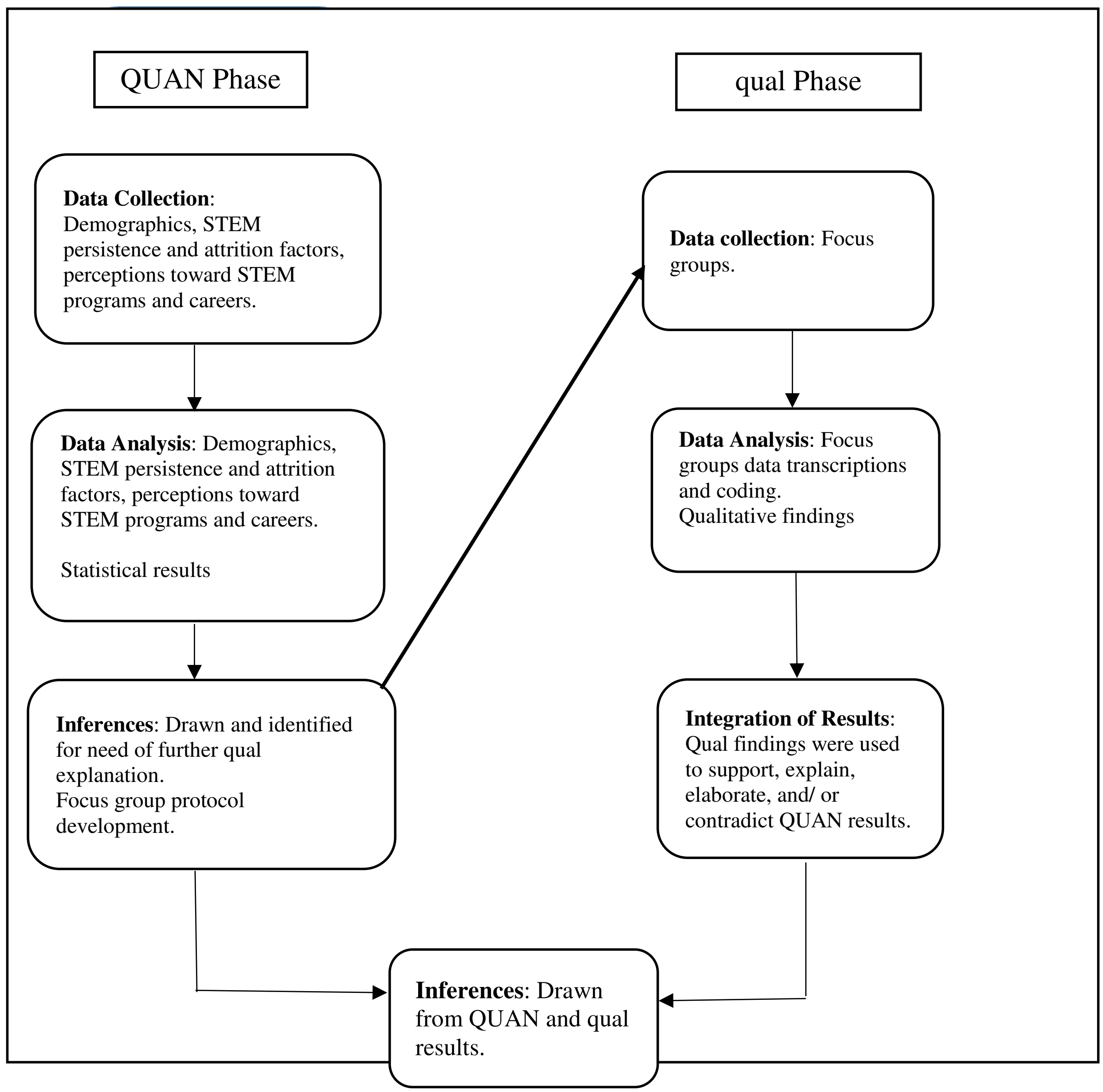


Figure 3. Explanatory-sequential mixed-methods Design.
Note. Illustration adapted from Knaggs, Sondergeld, and Schardt (2015, p. 14).

Phase I: Quantitative Study

The quantitative aspect of this mixed methods study was designed to achieve three main objectives. The first objective sought to examine the characteristics of the sample population in terms of whether they were domestic versus international students, STEM persisters versus switchers, continuous versus former students. The second objective sought to examine the factors that influenced participants to persist or switch from STEM. The third objective attempted to examine the perceptions of the survey participants in terms of the study's dependent variables including perceived value of STEM fields, expectations for success in STEM careers, and perceived success in STEM courses.

A key principle of quantitative research is the ability to survey a large sample of potential participants, which then provides the opportunity to generalize the research findings (Creswell & Plano Clark, 2007). Thus, the quantitative strand of this mixed methods research provided the opportunity for the researcher to generalize the results of the study to the larger population.

Participants

In order to achieve the purpose of the current study, two groups of students were targeted. The first group was made up of female students who were enrolled in STEM programs during the spring 2016 semester (see Appendix E for the list of majors identified as STEM majors in this current study). The second group consisted of female students who were enrolled in non-STEM majors during spring 2016 semester, but who at one time were enrolled in STEM majors or STEM programs. Table 2 (see below) displays the participants who took part in the online survey according to their academic majors.

In all, 2055 individuals were randomly chosen and invited to participate in the online survey. Out of the total number of people who were sent the invitation, only 392 responded to the online survey. Of the 392, 356 started and finished the survey, yielding a response rate of 17.32%. While this response rate is low as compared to the average online survey response rate of about 25% (FluidSurveys Team, 2014), the researcher explains later in this section some of the factors that may have accounted for the comparatively low survey response rate obtained for this current study.

As can be seen in Table 2, a large majority of the survey participants were biology, psychology, education, atmospheric sciences, and chemical engineering majors. A majority (about 76%) of the participants were undergraduate students, with the rest being graduate students. About 92% of the participants identified themselves as domestic students, with the remaining 8% being international students. The average age of the participants was 23.36 years (*SD* = 5.84). The data analysis also revealed that 297 of the total number of participants were STEM persisters, while 59 of them were STEM switchers.

Table 2. Frequency Distribution of Survey Participants by Academic Majors.

Majors	Frequency	Percent (%)
Accounting and Managerial Finance	4	1.1
Airport Management	3	0.8
Atmospheric Sciences	15	4.2
Banking and Finance	1	0.3
Biology	55	15.4
Chemical Engineering	14	3.9
Chemistry	7	2
Civil Engineering	8	2.2
Clinical Psychology	7	2
College of Business and Public Administration	1	0.3
Commercial Aviation	3	0.8

Table 2, continued

Majors	Frequency	Percent (%)
Communication Sciences and Disorders	9	2.5
Communications	3	0.8
Computer Science	1	0.3
Counseling	5	1.4
Criminal Justice	5	1.4
Earth System Science and Policy	2	0.6
Education	17	4.8
Electrical Engineering	6	1.7
English and Spanish	4	1.1
Entrepreneurship	1	0.3
Environmental Science	1	0.3
Forensic Science	8	2.2
General Studies	1	0.3
Geography	4	1.1
Geology	4	1.1
Graphic Design and Technology	3	0.8
History/Political Science	1	0.3
Human Resources	1	0.3
Information Systems	3	0.8
Interdisciplinary Studies	2	0.6

Table 2, continued

Majors	Frequency	Percent (%)
International Studies, German	1	0.3
Investments	2	0.6
Kinesiology	3	0.8
Law	3	0.8
Marketing and Communication	2	0.6
Math	7	2
Master’s in Business Administration (MBA)	1	0.3
Mechanical Engineering	8	2.2
Medical Laboratory Science	4	1.1
Medicine	9	2.5
Nursing	10	2.8
Occupational Therapy	3	0.8
Petroleum Engineering	10	2.8
Physical Therapy	4	1.1
Physics	1	0.3
Psychology	45	12.6
Rehabilitation and Human Services	1	0.3
Social Work	2	0.6
Sociology	2	0.6
Space and Studies Sciences	8	2.2

Table 2, continued

Majors	Frequency	Percent (%)
Speech & Language Pathology	3	0.8
Unmanned Aircraft Systems	2	0.6
Women and Gender Studies	1	0.3
Other (Missing)	22	6.2
Total	356	100

It is also important to note that out of the 356 participants who started and finished the online survey, 43 of them were past students, while the rest (313) were continuous students (see Chapter I, Key Terms and Definitions, for the description of continuous and past students).

Procedures

Recruitment and data collection. Since the design of the current study was explanatory-sequential mixed-methods research, the study proceeded with the collection of the survey data first, using an online survey tool called Qualtrics. An online survey was chosen over a paper and pencil survey because of the ability to reach a large population with Internet experience in geographically dispersed locations within the shortest possible time. Online surveys also offer the benefits of anonymity, easy data management, and cost-savings as compared to paper and pencil methods (Van Selm & Jankowski, 2006).

Recall that the current study focused on female students in STEM programs and female students who were previously in STEM programs (either they graduated or switched from STEM). However, the data on female students who met these study criteria were not available at the initiation of the study. This is because the OIR regulations at the target university prohibit the disclosure of sensitive data a priori to the public, including the sex of the student. As a result, it was arranged to have the OIR administer the survey to a representative sample of the population of interest on behalf of the researcher.

Given that the online survey was administered by the OIR, the researcher had no means of contacting the survey participants for the follow-up focus group study. To get around this problem, the researcher adapted the electronic consent portion of the online survey to include a statement that asked participants to consent to providing their names and email addresses on the survey. Thus, during the qualitative phase of the study, the researcher was able to use the email addresses shared by those participants who consented on the survey to create a purposive sample of focus group participants.

At the initiation of the quantitative study, the OIR randomly selected the official email addresses of 2055 female students from the target university's database. The list of email addresses was based on students who registered for STEM courses with the target university during Spring 2016. It is worth noting that the online survey was administered in the summer, when most students were on break. Thus, it is possible that some students were not checking their school email accounts within the time frame the survey was administered and, therefore, did not respond to the survey. These factors might have had a negative impact on the response rate for the survey.

The OIR sent out the initial invitation emails to the selected individuals (2055) to participate in the Qualtrics survey on June 15, 2016. The invitation emails included a hyperlink to access and complete the online survey. One week after the initial invitation email was sent, the OIR sent reminder emails to nonrespondents. A second email reminder was sent by OIR to nonrespondents on July 6, 2016. The purpose of these email reminders was to boost the response rate for the online survey (Fryrear, 2015; Nulty, 2008). The Qualtrics online survey was formally closed after 4 weeks of administration. This was to enable the researcher to screen the quantitative data in order to be able to initiate the qualitative focus group study during the first 2 weeks of the Fall 2016 semester, when students were less busy.

Participation incentives. While individuals who participated in the online survey were not paid, participants who completed the survey and also agreed on the survey to have their email addresses entered into a random drawing had the chance to win a $50 amazon.com gift card. The purpose of this raffle draw was to encourage more people to participate in the quantitative study. Participant number 212 was adjudged the winner of the raffle draw and sent an electronic card worth $50.00. The recipient of the gift card was determined by randomly generating a number between 1 and 356.

Measures

The VIES Questionnaire

The current study utilized the VIES questionnaire developed and used during the initial study with some modifications. The modified version of the VIES questionnaire consisted of 28 questions. It took participants about 5–10 minutes to complete the survey. See Appendix B for the full revised VIES questionnaire used in the current study.

The content of the revised VIES questionnaire was divided into six parts. The first part covered general information about the study and also included a portion in which participants were required to give their informed consent electronically. The second part covered background variables such as age, year in college, educational major, program of study, and resident status. A new question relating to whether or not participants had switched STEM majors was also included in the background variables, a change that was in line with the focus of the current study.

The third part of the VIES questionnaire required participants to indicate the factors that influenced them to switch or persist in STEM majors as the case may be. The fourth part addressed participants' perceived success in their previous or current STEM courses. Both the third and fourth parts were not considered in the original VIES questionnaire. They were included as part of the measurement of STEM attrition and persistence and of perceptions of academic success, respectively.

The fifth part of the questionnaire covered the VIES subscales, which addressed the participants' perceptions regarding STEM fields and careers. The final part of the questionnaire asked participants to indicate whether or not they would be interested in participating in a raffle drawing and follow-up focus group study. Overall, the VIES questionnaire consisted of four subscales. These subscales included one established scale (perceived success in STEM courses) and the VIES subscales, which were developed and validated during the initial study. Specific details about each subscale and how it was used in the current study are given below.

Instruments

VIES subscales. The current study adapted Appianing and Van Eck's (2015) 22-item VIES subscales to measure participants' perceptions regarding STEM fields and careers. In order to measure participants' perceptions regarding STEM specifically, each of the 22 VIES subscale items was adapted to include the word "STEM." Unlike the initial questionnaire, where the items for each subscale were grouped together, on the modified questionnaire, items from all 22 VIES subscales were combined (see question 26 of Appendix B). Example items from the adapted VIES subscales were “I would take a course in STEM even if it were not required” and “I would be able to succeed in a STEM field as well as most other people.”

Validity and reliability of the adapted VIES subscales. While the VIES subscales were validated during the initial study, it was imperative to reexamine the 22 VIES subscale items to ensure that they were psychometrically sound and acceptable in terms of construct validity. The decision to revalidate the VIES subscale items was influenced by several factors. First, the VIES subscales are not established scales; which means that the instruments have not been tried and tested in different empirical studies over time. Second, the sample size for the initial study was relatively small. According to Comrey and Lee (1992), a relatively small sample size could affect the reliability of survey instruments. Costello and Osborne (2005) have also maintained that it would be difficult to obtain replicable results of a research study if the sample used were somewhat small. Third, no steps were taken in the initial study to ensure that the sample size was adequate for factor analysis.

Factor analysis of the adapted VIES instrument. A confirmatory factor analysis was performed using SPSS Statistics 24 to examine the construct validity of the VIES subscales items. Prior to conducting the factor analysis, the researcher reviewed existing literature to learn what scholars say about sample size and factor analysis. While the literature indicated differing opinions regarding the sample size required to perform a factor analysis of scale items to which participants have responded, a number of studies (e.g., MacCallum, Widaman, Zhang, & Hong, 1999; Pett, Lackey, & Sullivan, 2003;

Tabachnick & Fidell, 2007; Williams, Onsman, & Brown, 2010) cite the work of Comrey and Lee (1992). In their work on the criteria for choosing a sample size, Comrey and Lee propose the following benchmark as a guide to determining the adequacy of total sample size for a research study: 50 = very poor, 100 = poor, 200 = fair, 300 = good, 500 = very good, and 1000 or more = excellent (p. 217). Thus, based upon Comrey and Lee guidelines, it can be concluded that the sample size (356) for the current study was good for factor analysis, whereas the sample size (184) for the initial study was between poor and fair. The disparity in sample sizes between the initial and current study could affect the reliability of the VIES instrument.

Apart from reviewing literature, statistical tests were also performed in SPSS to check whether the sample size for the current study was adequate for factor analysis. These tests include the Kaiser–Meyer–Olkin (KMO) test, which is a measure of sampling adequacy, and the Bartlett's Test of Sphericity, which tests the null hypothesis that the correlation matrix is an identity matrix (Hagemeier & Murawski, 2014). The value of the KMO ranges from 0 to 1. The sample size is said to be adequate for factor analysis if the value of KMO is greater than .50 and the Bartlett's Test of Sphericity result is statistically significant, that is, $p < .05$ (Field, 2009; Williams et al., 2010). For the current survey data, the value of KMO was .96, indicating that the sample size was adequate for factor analysis. Furthermore, the significance level of the Bartlett's Test of Sphericity was less than .01, indicating the absence of an identity matrix. The results of these two statistical tests thus suggested that the sample size in relation to the number of items of the VIES subscales was suitable for factor analysis.

The current study used the Principal Component analysis to test the underlying factor structure of the VIES subscales. In the process of determining the number of factors to extract, several criteria were used, including Kaiser's rule (eigenvalues > 1), the scree plot test, and the cumulative percent of variance extracted. This approach to selecting factor items is recommended by several studies (e.g., Costello & Osborne, 2005; Field, 2009; Williams et al., 2010).

After the listwise case exclusion analysis was completed in SPSS, the total number of participants did not change. All negative items were reverse-coded prior to analysis. To determine the factors to extract, all 22 VIES subscale items were included in the factor analysis. The first factor analysis test was performed with the following specifications: all absolute values below .10 were suppressed; the oblique rotation method (direct oblimin) with factor extraction via eigenvalues greater than 1 was used. The oblique rotation method was used because the results of the initial study suggested that the VIES subscales were correlated. In addition, the component correlation matrix coefficient computed in SPSS for the current survey data was .66, suggesting that the factors accounted for 66% of relationships within the data. A correlation matrix coefficients of .32 or greater is recommended (Costello & Osborne, 2005).

Results from the first factor analysis test produced three factors from the Principal Component analysis with eigenvalues greater than 1.0. The three factors extracted accounted for 67.33% of the variance. Commonalities were generally greater than or close to .70, but the pattern matrix displayed several weak and/or cross loadings items on all the factors. According to Costello and Osborne (2005), any survey item that loads at .32 or higher on two or more factors is a cross loading item. Conversely, the scree plot for the first factor analysis suggested two factors be extracted. Therefore, a second factor analysis was conducted with the decision to extract only two factors, as well as suppressing absolute values below .40 in order to eliminate weak and cross loading items. That is, an item was retained only if it loaded greater than or equal to .40 on the relevant factor.

After two factors were extracted (with absolute values below .40 suppressed) in the second factor analysis, the pattern matrix table in SPSS displayed two distinct factors, with 14 items loading on the first factor and 8 on the second factor. The two factors extracted accounted for 62.29% of the variance. The factor loadings were generally .60 or higher. The main reason why the Principal Component analysis extracted two distinct factors from the current survey data rather than three factors as in the case of the initial study may be due to the disparity in sample sizes (sampling error) between the two studies as explained earlier in this section. As pointed out earlier, factor loadings produced from larger samples tend to show "smaller standard deviations of loadings across repeated samples" (MacCallum et al., 1999, p.85).

All the 14 items that loaded on factor 1 were summed into one scale, while the eight items that loaded on factor 2 were also summed into another scale. Descriptive statistics including skewness and kurtosis scores were carefully examined in order to identify variables that were not normally distributed. Results of the descriptive statistics indicated that the individual items and summed scale distributions all approached normality based on the statistical values of skewness and kurtosis. For the summed scales, the skewness and kurtosis values were between the acceptable ranges of ±1.0, whereas the range for the individual items was between ±2, which is also considered acceptable (George & Mallery, 2005; Tabachnick & Fidell, 2013).

To determine the internal consistency of the two factors extracted, the Cronbach's alpha coefficients were calculated. The reliability coefficient for the first factor was .95, while that of the second factor was .90. Various literature sources indicated two main schools of thoughts as to what values for alpha are acceptable. The first school of thought is that values for alpha ranging between .70 and .95 are acceptable (e.g., Bland & Altman, 1997; George & Mallery, 2005). The second school of thought holds that values for alpha between .70 and .90 are acceptable (e.g., Streiner, 2003; Tavakol & Dennick, 2011).

While acknowledging the differing views regarding acceptable values of alpha, the current study adopted the second school of thought. This is because researchers within this school of thought made a strong case as to why the acceptable values of alpha should not exceed .90, maintaining that an alpha value greater than .90 may suggest redundancy. In other words, the scale items may be asking the same question in many different ways. Since the Cronbach alpha for factor 1 exceeded the .90 ceiling, all the fourteen items that loaded on factor 1 were screened for redundancy.

Addressing the issue of redundancy of the VIES subscales items. After reevaluating the 14 items that loaded on factor 1, the following 7 items were considered redundant; therefore, they were removed from all further analyses. Item 11 ("Being in a STEM class would be fun for me"), Item 12 ("The idea of being in a STEM class excites me")," Item 13 ("I would enjoy taking STEM courses"), and Item 6 ("I would enjoy working in a STEM field") were removed because they were too similar to Item 2 ("I would take a course in STEM even if it were not required") and Item 3 ("I find STEM related jobs very interesting"). Item 8 ("I am not interested in a degree in STEM") and Item 10 ("STEM classes are boring") were removed because they were too similar to Item 14 ("I dislike STEM courses"). In all instances, the researcher's decision to remove those items believed to be too similar were supported by the statistical analysis; that is, generally, those items had very high inter-item correlations (.7 to .85) across both of the two factors extracted. Item 7 ("I would rather do something else than take on a STEM related job") was removed to improve content validity, because the item was too ambiguous.

Following the removal of the seven items (Items 6, 7, 8, 10, 11, 12, and 13) from the VIES subscales, a third factor analysis was performed with the remaining 15 items by utilizing the same specifications used during the second factor analysis. As expected, the Principal Component extracted two factors, with both the scree plot test and the total variance explained table in SPSS confirming a two-factor solution. The total variance explained by the two factors extracted was 61.49%. Commonalities were generally between .50 and .75. Eight items loaded on factor 1, while seven items loaded on factor 2, with factor loadings ranging from .51 to .91.

Naming the two factors extracted. After carefully examining the rotated factor loadings, it was interesting to discover that the eight items that loaded on factor 1 reflected the VIES value subscale; therefore, factor 1 was named "Value of STEM Fields." The Value of STEM Fields subscale was used to assess the degree to which participants valued STEM fields and careers. In a similar vein, the seven items that loaded on factor 2 paralleled the VIES expectations for success subscale; therefore, factor

2 was named "Expectations for Success in STEM Careers." The expectations for success in STEM careers was used to assess the degree to which participants were expecting to do well in STEM-related jobs (see Table 3 for the modified VIES subscales).

The adapted VIES subscales reflect the expectancy-value model. It was determined that the perceived value of STEM fields subscale items reflected the four key components of the subjective task values identified by Eccles et al. (1983). The following illustrates how the value of STEM fields subscale items fit the the subjective task values.

Table 3. Rotated Factor Loadings, Reliability Coefficients, Means, and Standard Deviations

		Factor Loadings			
Factors	Items	1	2	*M*	*SD*
Value of STEM (α = .90)					
Item 3	I find STEM related jobs very interesting	.91		*4.24*	*.82*
Item 2	I would take a course in STEM even if it were not required	.86		*3.98*	*.95*
Item 5	STEM is an important field for me	.78		*4.27*	*.77*
Item 14	I dislike STEM courses (R)	.73		*4.03*	*.87*
Item 9	STEM is a good college major for me	.72		*4.00*	*1.01*
Item 4	I don't think working in a STEM field would help me achieve my professional aspirations (R)	.61		*4.15*	*1.03*
Item 19	I feel I would have something to be proud of as a STEM professional	.59		*4.33*	*.74*
Item 1	Working in a STEM field would be a waste of my time (R)	.51		*4.54*	*.75*

Table 3, continued

Factors	Items	Factor Loadings 1	2	*M*	*SD*
Expectations for Success in STEM Careers (α = .89)					
Item 20	I don't think I will succeed in a STEM field (R)		.88	*4.07*	*.95*
Item 18	I don't think I can make an impact if I take on a STEM- related job (R)		.85	*4.07*	*.95*
Item 16	I would certainly feel useless in a STEM-related job (R)		.73	*4.19*	*.87*
Item 15	I feel I have what it takes to succeed in a STEM-related job		.70	*4.07*	*.86*
Item 21	I would be able to succeed in a STEM-field as well as most other people		.68	*4.03*	*.87*
Item 22	I do not think I can achieve anything meaningful as a STEM professional (R)		.66	*4.26*	*.83*
Item 17	I feel I have a number of good qualities to be successful in a STEM field		.65	*4.17*	*.74*
Eigenvalues		8.09	1.14		
Percentage variance (%)		53.92	7.57		

Note. Total variance explained by the two factors = 61.49%.

"R" indicates that item was reverse-coded prior to analysis.

Intrinsic value (e.g., Item 2, "I would take a course in STEM even if it were not required"), *attainment value* (e.g., Item 19, "I feel I would have something to be proud of as a STEM professional"), *utility value* (e.g., Item 9, "STEM is a good college major for me") and *cost value* (e.g., Item 1, "Working in a STEM field would be a waste of my time"). The expectations for success in STEM careers subscale items also exemplified the expectation of success construct of Wigfield and Eccles's (1992) expectancy-value model. Example items of the expectations for success in STEM careers construct were given earlier on.

Test of normality of the final 15 items retained. All the items that assessed perceived value of STEM fields were summed into one scale. Higher scores meant participants valued STEM fields and careers more. Items measuring expectations for success in STEM careers were also summed into one scale. Higher scores meant higher expectations for success in STEM-related jobs. In order to identify inconsistencies or abnormalities in the distribution of the survey data, descriptive statistics were calculated and examined for both individual items and summed-scale distributions. Results of the descriptive statistics indicated that the individual items and summed-scale distributions all approached normality based on the statistical values of skewness and kurtosis.

For the summed scales, the skewness and kurtosis values were within the acceptable range of ±1.0, whereas the range for the individual items was between ±2, which is also considered acceptable (George & Mallery, 2010; Tabachnick & Fidell, 2013). However, the kurtosis value for Item 1 exceeded the +2 threshold, which was an indication that the item could be problematic. This abnormality may have been the result of the fact that a disproportionately high number of participants indicated that working in a STEM field would not be a waste of their time. Such a peaked frequency distribution was expected since a majority of the participants were STEM persisters, while STEM switchers who probably felt that working in a STEM field would be a waste of their time were few. Indeed, the data analysis showed that Item 1 had the lowest factor loading of .51, which means that it contributed less to the value of STEM fields subscale. However, according to Costello and Osborne (2005), a scale item with a factor loading of .50 or higher is a good item. In addition, Item 1 was the only perceived value of the STEM fields scale item that assessed cost value. Therefore, Item 1 was retained for further analysis.

Reliability test. To determine the internal consistencies or reliabilities of the perceived value of STEM fields and expectations for success in STEM careers subscales items, the Cronbach's alpha coefficients were calculated. The reliability coefficient for the perceived value of STEM fields subscale was .90, while that of the expectations for success in STEM careers subscale was .89 (see Table 3). These results suggested that both the perceived value of STEM fields and expectations for success in STEM careers subscales items had sufficient internal consistency and could thus be used for assessing variables of interest in the current study.

Perceived success in STEM courses scale. Participants' perceptions of success in respect of their current or past STEM courses were assessed using a modified version of Hall et al.'s (2004) PASS (Perceptions of Academic Success Scale). The original PASS consisted of six items measured on a seven-point Likert-type scale (1= Very unsuccessful, 7 = Very successful) that required students to indicate how successful they felt regarding their academic work. Three versions of PASS were included in the current survey—one for STEM switchers, one for STEM persisters, and the other for past students (see survey Q13, Q17, and Q24 respectively). These three versions of the PASS were identical. However, in order to capture STEM switchers' perceived success in their

STEM courses, each of the six items was reworded to include phrases such as “previous STEM major.” An example item from the scale was “How successful did you feel about the grades you got on tests and assignments in your previous STEM major?”

Similarly, each of the six items for STEM switchers was adapted to include phrases such as “current STEM major.” An example item from the scale was “How successful do you feel in achieving the learning goals you set for yourself?” In the same vein, the PASS items for the former STEM major students were adapted to include phrases such as “past STEM major.” An example item from the scale was “How successful did you feel when you were in your past STEM major overall?”

Prior to data analysis (including reliability analysis), responses of STEM switchers, STEM persisters, and past students on the perceived success in STEM courses subscales were merged into a single data set. Higher scores meant high perceived success in STEM courses. A confirmatory factor analysis in SPSS established a single-factor solution for the perceived success in STEM classes scale, with an overall Cronbach alpha of .96. While the Cronbach alpha value was greater than the .90 threshold, which was explained earlier in this section, the decision was made to retain the complete set of scale items since the perceived success in STEM courses scale was adapted from an established measure of Hall et al.’s (2004) PASS.

Factors associated with STEM persistence and attrition. To understand the reasons that college women persist in STEM programs, the online survey participants were presented with 12 statements that relate to factors associated with STEM persistence (see Q18 and Q25 of Appendix B). They were then asked to select any of the factors that they considered were key to their STEM major persistence.

Apart from being allowed to select multiple persistence factors, participants were also given the opportunity to write any other factors (open-ended response) that were not among the 12 persistence factors presented to them on the survey.

The 12 persistence factors were garnered from related literature and studies. The persistence factors included career goals, friends, and the desire to pursue the major (Edzie, 2014), summer internship, involvement in external student clubs and organizations (Johnson, 2012), parents/family (Brandt, 2014; Edzie; Johnson), faculty (Edzie; Johnson), strong academic preparation in math and science and self-confidence (Brandt), and peer teaching/instruction (Watkins & Mazur, 2013). Intrinsic motivation and institutional support and resources were added based upon the personal experiences of the researcher.

Similarly, to understand the reasons that college women switch from STEM programs, the online survey participants were presented with 11 statements that relate to factors associated with STEM attrition. Participants were asked to select any of the factors that they considered were key to their decisions to switch from STEM fields. There was also an aspect of the survey question on STEM attrition factors that required participants to write any other factors (open-ended response) that were not among the 11 attrition factors presented to them on the survey.

The 11 attrition factors were also gleaned from related literature and studies. The attrition factors included lack of role models or mentors (DuBow, 2014; Geisinger & Raman, 2013), feelings of isolation (Geisinger & Raman; Weissmann, 2015), poor quality of teaching (Geisinger & Raman; Seymour & Hewitt, 1997; Watkins & Mazur, 2013), poor performance in the major (Chen, 2013), growing interest in a non-STEM major (Seymour & Hewitt; Watkins & Mazur), loss of interest in the major (Hughes, 2010; Johnson, 2012; Seymour & Hewitt; Watkins & Mazur), major did not allow student to work, negative experiences in STEM classes (Hughes), high financial cost of the major (Johnson), discrimination on the basis of sex, race or ethnicity (Beasley & Fischer, 2012), and too high a workload in STEM classes (Helfand, 2011; Marklein, 2011; Seymour & Hewitt).

Data Analysis: Quantitative Data

The data analysis for the current study was completed in two stages. Stage I data analysis was completed during the quantitative study phase, while Stage II data analysis was conducted in the qualitative study phase, which will be described later in this chapter. Part of the quantitative data analysis was accomplished during the factor analysis, test of normality, and reliability test, which were described earlier. This section describes the remaining part of the quantitative data analysis that was completed during Phase I of the current study. As a reminder, the survey data collected during Phase I were analyzed using SPSS Statistics 24 software. A standard convention level of $p < .05$ was used for evaluating statistical significance of all the quantitative analyses performed in this study. Negative-worded items on the online survey were reverse-coded prior to data analysis. Open-ended questions on the online survey were group-coded by common themes. Table 4 summarizes specific data analysis performed, including the participant groups and variables used to address both the testable and non-testable research questions during the quantitative phase. The following paragraphs describe the quantitative data analysis that was performed per research question.

The first research question was a non-testable research question, which examined the factors most associated with STEM persistence and attrition. Participants' responses to this research question were summarized using descriptive charts.

Like the first research question, question 1a was also a non-testable research question, which sought to examine the characteristics of STEM switchers, with emphasis on background variables such as age of STEM switchers, year of study in which STEM majors were switched, and resident status. The ages of STEM switchers on the survey were recoded into a categorical variable with five levels (18–19, 20–21, 22–23, 24–25, and 26–35). Descriptive tables were used to display the responses of participants to this research question.

Research question 1b examined the STEM majors that participants switched from and the majors that they pursued following their exit from STEM majors. This question was also non-testable; therefore, descriptive tables were used to summarize participants' responses to the research question.

Research question 2 sought to determine whether the perceived value of STEM fields and expectations for success in STEM careers subscales scores differed significantly between STEM persisters and STEM switchers. In this regard, independent samples *t*-tests were used to compare STEM persisters and STEM switchers' mean scores. The STEM major status variable was coded as *1* if students belonged to the STEM persisters group and *2* if the students were STEM switchers.

Table 4. Summary of Data Analyses Performed to Address Current Study's Research Questions.

	Research Variables			
Research Question	Groups Tested	Dependent	Independent	Analysis
1. What factors can account for whether women switch or persist in STEM majors?	NA	NA	NA	Charts
1a. What are the characteristics of college female STEM switchers?	NA	NA	NA	Descriptive table/chart
1b. Which STEM majors are college women likely to switch from and which non-STEM majors are they likely to switch to?	NA	NA	NA	Descriptive tables
2. Do women who persist in STEM majors differ significantly from women who switch STEM majors in terms of their scores on the value of STEM fields and expectations for success in STEM careers subscales?	STEM persisters vs. STEM switchers	VoS, ESSC	STEM major status	Independent samples *t*-tests

Table 4, continued

	Research Variables			
Research Question	Groups Tested	Dependent	Independent	Analysis
3. Is there a significant difference between female STEM persisters and switchers in terms of their perceived success in STEM courses scores?	STEM persisters vs. STEM switchers	PSSC	STEM status	Independent samples *t*-tests
4. Do college women's perceived success in STEM courses and the value that they place on STEM fields predict their expectations for success in STEM careers?	N/A	ESSC	VoS, PSSC	Multiple linear regression

Note. ESSC = Expectations for success in STEM careers; VoS = Value of STEM fields; PSSC = Perceived success in STEM courses.

Research question 3 sought to determine whether the perceived success in STEM courses subscale scores differed significantly between STEM persisters and STEM switchers. Independent samples *t*-tests were used to compare STEM persisters and STEM major switchers' mean scores. The STEM major status variable was coded as *1* if students belonged to the STEM major persisters group and *2* if students were STEM switchers.

The fourth research question sought to determine whether college women's perceived success in STEM courses and the value they placed on STEM fields predicted their expectations for success in STEM careers. To answer this research question, a multiple linear regression was calculated to determine the predictive powers of perceived value of STEM fields and perceived success in STEM courses. The detailed results of all of the data analyses performed are presented in Chapter IV.

Phase II: Qualitative Study

Rationale

The qualitative strand of this mixed methods research study was intended to provide the opportunity for the researcher to follow-up on the quantitative results that needed further exploration. To this end, the focus group interview approach was used to explore the quantitative results—in particular, the reasons that women persist or switch from collegiate STEM programs. While there are several qualitative data collection methods (e.g., one-on-one interview), the focus group interview technique was preferred. This is because "…[a] focus group presents a more natural environment than that of an individual interview, because participants are influencing and influenced by others—just as they are in real life" (Krueger & Casey, 2015, p.7).

Participants

Overall, nine people took part in the focus group interviews. All of the focus group participants also took part in the online survey. Of the nine people who participated in the focus group interviews, four of them were STEM persisters and five were STEM switchers. One participant was an international student, while eight of them identified themselves as domestic students. All of the five STEM switchers were domestic students. In terms of race/ethnicity, there was 1 Black African, 1 Black American, 1 Native American, and 6 Caucasians. The average age of the focus group participants was 23.22 years (SD = 4.76).

Procedures

At the end of the quantitative data collection, the survey data were screened and used to generate a list of participants who indicated a willingness to be contacted for a follow-up focus group study. In other words, Phases I and II of the current study were connected by using the results of the quantitative study to inform the focus group interviews protocol (Creswell & Plano-Clark, 2011). Only participants who took part in the online survey provided their emails; they also gave their consent on the survey to be contacted for follow-up study, and were invited by the researcher via email to participate in the focus group interviews. A total of 156 of the survey participants indicated their willingness to participate in the focus group interviews.

Invitation emails. On September 15, 2016, the researcher contacted the 156 survey participants who consented to take part in the follow-up study via email to solicit their participation in the focus group interviews. The invitation email also included information pertaining to participants' rights, participation incentive, and the location and duration of the focus group interviews. Of the total number of participants who were invited for the follow-up study, only 16 of them responded positively to the invitation email by confirming their willingness to participate in the focus group interviews.

Following the email confirmations, it was discovered that the 16 people who confirmed their participation in the focus group study were made up of eight STEM persisters and eight STEM switchers. Thus, it was decided to organize two focus group sessions—one for persisters and the other for switchers; that is, eight participants per focus group session. As a matter of fact, researchers are divided as to the acceptable number of focus group participants per session. Some researchers recommend a maximum of 8 to 12 people per focus group session (e.g., Stewart & Shamdasani, 2015), whereas others recommend 7 to 8 people per focus group session (see Carey & Asbury, 2016). Those researchers who recommend 8 to 12 people per focus group session maintain that if the group membership is less than 8, it is difficult to generate any meaningful discussion, while a group with membership of more than 12 people is difficult for the moderator to manage. Researchers who recommend 7 to 8 participants per focus group argue that a group membership greater than 7 or 8 is a bit large and difficult for the moderator to manage. These researchers even recommend focus group membership of 3 to 4, particularly if the focus group discussion involves sensitive and complex topics.

Scheduling for the focus group interviews. On September 18, 2016, the researcher sent out two different doodle scheduling surveys (i.e., one for the STEM persisters and the other for the STEM switchers) for individuals to indicate the date and time they would be available for the focus group interviews. Based on the results of the doodle polls, it was necessary to conduct four different focus group sessions, with four participants per session. In other words, two focus group sessions were organized for STEM persisters and two sessions were conducted for STEM switchers.

Focus group interview questions. The construction of the focus group interview questions was guided by the review of related literature and the results of the quantitative study. Two sets of focus group interview questions were created—one for STEM persisters and another for STEM switchers. While the two sets of questions were not the same, there were some similarities between them. The focus group interview questions were mainly open-ended (see Appendix C).

During the focus group interview sessions, the researcher read each question to the group members. The group members would then discuss the question thoroughly before moving on to the next question. Participants of each focus group session were requested to speak one at a time. Participants were also requested to call out their pseudonyms before responding to a question or contributing to the discussion. These measures were taken in order to facilitate smooth discussion and easy identification of each participant's comments during the data transcription process (Carey & Asbury, 2016).

Ensuring confidentiality. The rationale for assigning each focus group participant a pseudonym was to ensure confidentiality and also protect the identity of each participant. Also, there was a statement on the consent form that enjoined participants to keep as confidential all the discussions generated within the focus group sessions. Confidentiality was also maintained by not linking consent forms and the responses of the participants.

First and second focus group meetings. The first and second focus group interviews were held at 2:00 p.m. and 5:00 p.m. respectively on September 26, 2016, for the STEM persisters. The 2:00 p.m. group meeting was attended by three people, although four people were expected to attend. Also, only one person attended the 5:00 p.m. session even though four people were scheduled to attend.

Third and fourth focus group meetings. The third and fourth focus group meetings, which were organized for the STEM switchers, took place on October 3, 2016 at 2:00 p.m. and 5:00 p.m. respectively. During the 2:00 p.m. focus group meeting, while four people were scheduled to attend, only one person attended the meeting. The 5:00

p.m. focus group meeting was better attended because all four participants attended the meeting.

Addressing disparities in focus group interview memberships. Prior to the transcription and analysis of the focus group interview data, the researcher initially decided to remove the focus groups with only one participant from the study. However, consultation with the dissertation committee members led to the inclusion of the focus groups with single participants. The inclusion of these brought the total number of STEM persisters to four, whereas the total number of STEM switchers was five.

Participation incentives. In exchange for their participation, focus group interview participants (only those who consented) were entered into a raffle drawing for a chance to win a $50 amazon.com gift card. Participant number 5 was the winner of the raffle draw. The winner of the gift card received an electronic amazon.com gift card worth $50.00. The winner of the card was determined by randomly generating a number between 1 and 9.

Data Analysis: Qualitative Data

As noted earlier, the focus group interviews were audio-recorded with the permission of participants. The data analysis process was initiated with verbatim transcription of all tape-recorded data from participants (Bailey, 2008; Carey & Asbury, 2016; MacLean, Meyer, & Estable, 2004; Stewart & Shamdasani, 2015). To ensure reliability and validity of the qualitative data, transcripts were double-checked by reviewing drafts while listening to the audio recordings (MacLean et al., 2004). Where necessary, participants' quotes were edited for the purpose of clarity; however, in a situation where editing would change the meaning and/or context of participants' words, no edits were made (Stewart & Shamdasani).

Following Charmaz (2014), a line-by-line coding technique was used to generate initial categories. After that, the coded items were carefully examined in order to identify relationships among categories, similar phrases, and emerging common patterns. The focus group interview data were then organized on the basis of those emerging themes. The conclusions drawn from the group interview data are reported in Chapter IV of this report. They are based on the statements and themes that emerged during the interviews, and supported with direct quotes from the focus group interview transcripts.

The rationale for including verbatim quotations was to provide evidence, give participants a voice, deepen understanding, and enhance readability (Charmaz; Corden & Sainsbury, 2006).

Institutional Review Board Approval

The current study was initiated after submitting the relevant documentation and obtaining approval from the Institutional Review Board (IRB) at the target university. The initial application to conduct the study was submitted to the IRB during fall of 2015. The IRB application was submitted before the topic proposal meeting, because it was a necessary precondition for getting the relevant information from the OIR at the target university. OIR requested an IRB approval letter regarding the study before they released the information needed to complete the topic proposal. Thus, the necessary adjustments were made to the study protocols after the topic proposal meeting, which included expanding the study population to include women in all STEM fields, instead of focusing only on women in technology-related fields.

Chapter Summary

The goal of this chapter was to provide an overview of the research methodology that was used for this current study. A mixed methods research design was employed in this study. Specifically, the explanatory-sequential mixed-methods research design was used to examine the research problem. This current study extended the researcher's initial study on gender differences in college students' perceptions of technology-related jobs in computer science by examining the factors that influence college women to persist or switch from STEM majors, and whether college women who persist in STEM programs differ significantly from those who switch from STEM programs in terms of their perceived value of STEM fields, expectations for STEM careers, and perceived success in STEM courses.

In line with the structure of a mixed methods research design, two types of data collection methods were utilized in this study including a Qualtrics online survey and focus groups interviews. Participants were recruited from current and past students of STEM majors at a large Midwestern research university in the U.S. In all, 356 people participated in the online survey portion of the study. Nine people who were a subset of the online survey sample population took part in the focus group interviews.

The quantitative research variables were assessed using a combination of instruments developed by the researcher and a previously validated instrument. The focus group interviews utilized open-ended questions. The data analysis encompassed two phases. The first phase addressed the statistical and nonstatistical tests performed to answer the research questions. The second phase of the data analysis included a discussion of the data transcription and coding scheme. This chapter also included a discussion of the IRB procedures that were fulfilled before the commencement of the current study. The next chapter presents the findings from both the quantitative and qualitative strands of the current study. The quantitative results are presented before the qualitative findings. In certain situations, however, the quantitative results are supported by findings from the qualitative focus group interviews.

CHAPTER IV

RESULTS

Studies have frequently found that women switch from STEM fields at higher rates than men do (Chen, 2013; Griffith, 2010; Hill et al., 2010). The main purpose of the current study was to examine the factors that influence women to persist in or switch from collegiate STEM programs. The current study also sought to examine whether women who switch from collegiate STEM programs are significantly different from those who persist in STEM programs in terms of the value they place on STEM fields, their perceived success in STEM courses, and their expectations for success in STEM careers.

Integration of the Quantitative and Qualitative Research Strands

Integration of quantitative and qualitative data is recognized as one of the key features of mixed methods research and helps provide a better understanding of the research problem (Creswell & Plano Clark, 2011; Knaggs et al., 2015). As noted earlier, the current study used an explanatory-sequential mixed-methods approach (QUAN→qual=explain results). That is, the quantitative data were first analyzed separately to address the research questions and to identify issues that were necessary for further explanation through qualitative focus group study. Following the qualitative study, the focus group interview data were also analyzed. Finally, the qualitative data were used to support and interpret the quantitative results. Data integration was also achieved by using the quantitative and qualitative findings to make inferences about the reasons that college women persist in or switch out of STEM.

Qualitative Results

The qualitative focus group interview results are presented first because they will help to explain some of the quantitative results that were found, particularly those relating to research questions 1 and 2. In response to the question about the factors that influenced participants to persist in STEM majors (persisters), the data analysis produced eight factors. In response to the question about the factors that contributed to participant attrition from STEM majors (switchers), the data analysis produced six factors. These factors were further distilled down into four major themes that cross both STEM persisters and switchers. Table 5 presents these factors and their associated themes.

Table 5. Qualitative Data Analysis Categories for Factors Associated with STEM Major Persistence and Attrition.

Persistence Factors	Related Themes	Attrition Factors
Support from writing and tutoring centers. Support from faculty and graduate teaching assistants	Academic/ Institutional Support	Poor performance in STEM STEM personnel communication/interpersonal skills Quality of teaching/advising.
Career goals Job/salary opportunities	Career	Nature/working conditions of STEM jobs.

Table 5, continued

Persistence Factors	Related Themes	Attrition Factors
Support from family Influence from female role models in STEM fields	Social Influence	Lack of female role models/mentors
Intrinsic motivation Interest in the major	Psychological	Growing interest in non-STEM major

STEM Major Persistence Themes

The six factors associated with STEM major persistence were categorized into four main themes: *academic/institutional support, career factors, psychological factors,* and *social influence.* The following section describes and provides evidence to support each key STEM persistence theme.

Academic/institutional theme. Academic and institutional support are defined in terms of assistance and services that the focus group interview participants received from the institution that influenced their decision to stay in STEM majors. The factors within the academic and institutional support theme comprised support from the university writing and tutoring centers and support from faculty and graduate teaching assistants.

All the focus group participants recounted the various forms of academic and institutional support that helped them to persist in STEM. For example, Kris talked about the support that she got from GTAs and the university writing center while she was pursuing her bachelor's degree in psychology:

> I got my associate degree about 13 years ago and so when I started my undergraduate program in psychology, I didn't know how to do a lot of things. Fortunately, I had several good graduate teaching assistants (GTAs) that were really helpful. They taught me how to write papers, especially APA style, and doing that type of research. I also received a lot of support from the writing center.

Mercy also said this about the university writing center and her professors:

> English is not my first language, and so I go to the writing center for help whenever I need it. Also, most of my professors have been very helpful to me. They are always willing to help me with my academic problems during their office hours and even after class.

Both Kris and Mercy's comments suggest that the support that students receive from GTAs, faculty, and the university writing center are important academic and institutional factors that influence women to persist in STEM programs.

Career theme. Career factors were defined in terms of the individual's STEM job aspirations, job prospects, and good remuneration. The factors within this theme were *career goals and opportunities* and *good salary*. In response to the question about the factors that influenced their persistence in STEM, focus group participants commonly shared thoughts on how they were influenced by career factors. For example, Mercy commented that she has not given up on her STEM major because she knows she will be likely to get a job after her bachelor's degree in petroleum engineering. "One of the things that has kept me going is, all this hard work is gonna pay off later on, because we have a huge field out there waiting for us, I mean petroleum engineers." Maria expanded on Mercy's comment by highlighting career goals, the financial reward, as well as the job opportunities in her STEM field: "I want to be a psychologist, and I know there are a lot of jobs out there for female psychologists, and they are well-paid, too." These comments, and by extension this theme, suggest that career factors are similar to extrinsic motivation, because participants were influenced to persist in STEM by anticipated external rewards and opportunities.

Social influence theme. This theme was defined by the positive influences on participants that came from parents, relatives, and female role models in STEM, both in academia and industry. The factors within this theme included *support from family* and *influence from female role models in STEM fields*. Focus group participants unanimously expressed strong views about the influences of family and female role models on their STEM major persistence. For example, Maria shared how her uncle, a clinical psychologist, has served as a strong role model for her:

> Psychology has touched my life because my family has gone through a lot of things like clinical psychology and just seeing what it has done for them. My uncle is a clinical psychologist; seeing what he does and the impact he has on people really inspires me to stay with my major….

Mercy also addressed the influences of family and female role models on her STEM major persistence:

> I get a lot of encouragement from my family and friends. I do have a role model too, a very powerful woman from my country; a CEO in one of the biggest oil companies in the world. She is an engineering major. I really look up to her, because she is a powerful woman. Because to achieve all the things that she has

> achieved in life is really an inspiration to me. It tells me that women can also do it.

Maria and Mercy's comments illustrate how close family members and role models can influence female students to persist in STEM majors. These might be considered both extrinsic and intrinsic motivation factors.

Psychological theme. This theme was defined by personal attributes that influenced individuals to persist in STEM majors in the face of difficult, challenging, and stressful situations. The factors within this theme included *interest in the major* and *intrinsic motivation*. When asked to describe and rate the factors that influenced them to persist in their STEM majors, the focus group interview participants used the word "me" and phrases such as "interest," "inner motivation," "intrinsic motivation," "internal drive," and "passion for my field" in their responses. These terms were classified as interest and intrinsic motivation and were labelled as psychological factors because they reflect the individuals' cognitive and affective motivational dispositions. As expected, all of the focus group interview participants felt very strongly that these factors were the most influential of all the STEM persistence factors. For example, Taylor, a Ph.D. student in psychology, remarked that although she gets a lot of encouragement and support from parents and significant others, her intrinsic motivation has been the source of her strength:

> Even though I get support and encouragement from my parents and professors, my internal drive is what is keeping me in the program more than somebody else wanting me to do something …. If I'm to rate the factors that keep me going, intrinsic motivation and passion for my field will be on top. If you don't have the

> intrinsic motivation and you are trying to do your Ph.D., you will definitely stop along the line…. helping people is what I am passionate about.

Sarah, a biology student, also expressed her thoughts on how her passion for medicine and desire to help people have influenced her to persist in her STEM major:

> I think that the biggest influential factor for me will be the passion I have for the field (medicine). I naturally want to help people no matter what I do. And I found that medicine is one of the biggest ways I can help someone…

Taylor and Sarah's comments revealed that they were passionate about their STEM majors because of their desire to help people, which is an intrinsic motivation factor. Further, they believed that they could fulfill those desires best through their chosen STEM majors. Such motivations for choosing STEM majors are consistent with some literature which indicates that women may choose STEM careers because of the desire to help others (Eccles, 2007; Hughes, 2010).

STEM Major Attrition Themes

The STEM major attrition themes were generated in response to the question about the factors that influenced participants (STEM switchers) to switch their STEM majors. The qualitative data analysis produced six categories that relate to factors associated with STEM major attrition: *poor performance in the STEM major, too much workload in STEM classes compared to non-STEM classes, poor quality of teaching in STEM classes, growing interest in non-STEM major, lack of female role models/mentors, nature and working conditions of STEM jobs.*

Interestingly, the attrition categories could also be distilled into four main themes, which are similar to the persistence themes, suggesting that the same factors that influence women to stay in STEM programs could also influence their decision to leave, but in different ways (see Table 5). The STEM attrition themes were: *academic/institutional factors, career factors, psychological factors,* and *social influence.*

Academic and institutional theme. The academic and institutional theme was defined in terms of poor academic performance and negative experiences experienced by the individual in STEM classes. The factors within this theme were *poor performance in the STEM major*, *poor quality of teaching and advising*, and *poor communication and interpersonal skills on the part of faculty and staff in STEM departments*. Three of the five STEM major switchers actually switched to non-STEM majors because of academic and institutional factors. For example, Kim explained why she switched to an English major because of poor performance in her chemical engineering major:

> I wasn't doing so well in chemical engineering, so I switched to English because I think all along I have been running away from it, because English doesn't get a good reputation for future careers. I have always been good in literature, so I decided to pursue that. So for me, it was safer and beneficial option. I have succeeded in my classes way better than I did in chemical engineering…

Kelly also commented that she switched from aviation to English because she struggled in her aviation classes:

> I was actually in commercial aviation major for one year, but it was tremendously difficult for me; very stressful for me a lot of times. I was taking some English classes too and enjoyed it so much more…. I'm naturally a much better writer than I am in math. Although I had enough math skills for flying, it was more

difficult for me than a lot of people around me because math didn't come naturally to me than writing did.

Kim and Kelly's comments suggest that they switched from STEM because their academic performance was poor in their chosen STEM majors. Their comments also suggest that they did not believe they had the necessary aptitude for their chosen majors; rather, they believed they were naturally good at something else (English). It is important to recognize here that academic performance is not just the result of internal factors like aptitude; it is also due to outside factors such as quality of teaching. Kelly perhaps enjoyed the non-STEM major classes (English) better because she was not doing well in her aviation classes. Kim appears to have chosen STEM because she perceived it to have a better career prospect than English, which she preferred from the beginning.

When asked to explain the factors that influenced them to go into chemical engineering and the aviation program in the first place, Kim had this to say:

> I initially chose chemical engineering because I enjoy background work. A lot of STEM-related fields are the background before something is produced, and I enjoy the kind of build-up to that. The high pay for STEM professionals was definitely a core, but also because STEM fields were looking for diversity, and I thought I could help provide that. There are a lot of opportunities for women and women of color, so I thought that a STEM major would be a good place to start.

Three things could be deduced from Kim's motivations for pursuing chemical engineering initially. First, Kim enjoys (has intrinsic value) STEM-related work. Second, she was attracted by the perceived high salary for STEM professionals in her field. Third, she thought she could easily find a STEM job after graduation because of her gender and race. From her earlier comment, Kim is also very good in literature and English. However, she might have thought about motivations for going into STEM without considering her aptitude for STEM or chemical engineering specifically.

While the analysis showed that psychological factors (i.e., intrinsic motivation and interest) were the most influential persistence factors for the STEM major persisters, these were not strong enough to retain Kim in her STEM major even though she also claims to have intrinsic value (enjoyment) for STEM-related work. This finding thus suggests that although psychological factors (e.g., intrinsic motivation) are critical STEM major persistence factors, natural abilities need to be taken into account when one is making the decision to pursue a particular STEM major. This is problematic, however, because the factors of institutional support and prior STEM experiences are intertwined with performance. In other words, while poor aptitude is likely to result in poor performance, not all poor performance can be attributed to poor aptitude, as will be seen in later comments by participants.

Kim struggled in her chemical engineering major not because of lack of interest or intrinsic motivation, but because she may have lacked the aptitude for chemical engineering or was failed by a lack of institutional support (support from faculty, writing and tutoring centers, STEM communication/interpersonal skills, poor quality of teaching and advising). Financial and career motivations were also not strong enough to help Kim persist in her chemical engineering major, suggesting that these two factors appear to be fragile motivations for STEM persisters.

Kelly also explained that she entered her aviation major initially through the encouragement of her mother (social influence). However, like Kim, she also considered the career opportunities and the financial benefits as well before she finally opted for aviation:

> I originally wanted to study English, because that is what I have always been good at. But, I had the interest in traveling and flying a lot. So, after high school I wanted to work for a few years as a flight attendant. When I told my mom about it, she was like "why don't you fly the plane instead?" My mom was very enthusiastic about it, but she never pressured me to do it. So, I decided to study aviation and I did a lot of research into the field. I realized that it is hard to get into the field, but the salary is good and there is a huge pilot shortage right now, and so I thought there would be a lot of jobs out there for me.

Like Kim, career and financial motivations were not enough to help Kelly to persist in her aviation major, nor was the encouragement from her mother. It is possible that Kelly is naturally better at English than she is in the skills needed for being an aviation major. This may explain why she found an aviation major so difficult. On the other hand, academic and institutional support is just as likely to account for her difficulty. For example, while poor communication and interpersonal skills on the part of STEM faculty were not addressed by the survey as attrition factors, these emerged as a theme during the focus group interviews. All the STEM switchers in the focus group interviews commented that professors and administrative staff in non-STEM majors have better communication and interpersonal skills than their counterparts in STEM departments. For example, Kim remarked:

> I wouldn't like to make generalizations about people in STEM, but there is a weird interpersonal relationship among the people in STEM. They are not very

> good at communicating and connecting with people: even faculty, staff, and advisers. Some advisers would meet with me so that we could talk through a paper or exam, but if you express your worry, concerns, they are like, "just study hard; you will be okay." You leave and you're like "you didn't give me any confidence, you didn't tell me how to resolve my problems." So, I have to find a way to get out of the major; I have to figure out how to leave this major without ruining anything (GPA) because no one was helping.

Kelly echoed these sentiments when discussing her former aviation professors:

> For some reason, I have better relationships with my English professors than I had with my aviation professors. My aviation professors didn't interact with me much. And because of that, I was less passionate about aviation, whereas with my English major, I interact a lot more with faculty and I'm learning more.

Judging from the focus group interview participants' comments, poor communication and interpersonal skills on the part of university professors and staff may have a negative impact on student motivation, performance, and persistence. Students may feel dejected and depressed because their concerns are not properly addressed because they do not receive adequate advising or proper guidance, and feel hopeless because they do not get concrete planning and support that they believe would lead to better performance in the long run.

Career factors theme. This theme once again arose as it had for persisters, but with a slightly different emphasis around career flexibility. This was defined by the desire to work in a field with flexible work schedules and stability of work schedules, which would allow students to pursue other noncareer interests. In this study, the STEM switchers (the four participants who switched to non-STEM majors) in the focus group interviews expressed that the nature and work conditions associated with their STEM fields played a part in their decisions to switch to non-STEM majors. Khloe recounted why she switched to a business administration (accounting option) major at the graduate school:

> Just before the oil boom in… my state crashed, I made the decision to leave the oil field because the kind of life style there was rough. You have to work all the time. I worked long hours, 7 days in a week until we were done drilling. As a geologist, I got to take samples and make maps; it was really cool and the pay was really good, too. But, when I first started, my trainer said, "we pay for everything that you miss, but not for the job that you do," and that was true, because I missed everything while I was there. So when I left, I wanted a more stable and flexible career that would enable me to start a family.

Kelly also explained that her decision to switch to being an English major was partly due to the nature and working conditions of the aviation profession:

> I wanted a flexible career, because I have plans to have kids. I felt that aviation wouldn't work for me because aviation is about building more hours to enable you to fly certain planes, especially if you have the goal of becoming a captain. For example, the regional airlines wouldn't hire you until you have accumulated certain number of hours. This situation seems to be difficult for a woman with two or three children. Because childcare cost is so expensive, I would probably stay home with my kids until they started school. And that can take a minimum of 5 years, and you will be missing so many flying hours and experience by staying

home.

Kelly and Khloe's comments suggest that women are not only interested in the good pay that STEM professionals enjoy but that they also want STEM employment that is flexible and reliable enough to allow for other goals, including starting a family (while paternity leave is becoming more common and social mores are changing, women still have primary responsibility for caregiving and the home). Thus, it is not surprising that research shows that women in STEM occupations are significantly more likely to leave their STEM careers than are women in non-STEM professions (Glass, Sassler, Levitte, & Michelmore, 2013). The focus group interview participants' comments and the literature thus suggest that the STEM professions themselves need to change if they want to recruit and retain more women in the STEM workforce.

Social influence theme. This theme was defined by the dearth of women in STEM fields and the low participation of women as faculty in STEM programs, particularly in fields (e.g., physics, computer science) where women are underrepresented. All the STEM switchers in the focus group interviews identified the lack of female role models and mentors as important STEM attrition factors. For example, Khloe shared that:

> In geology, we have all male professors so you don't really have any female role model to go to or look up to. Geology has been very much men's world for a long time. I had a professor telling me that "women in science is a joke. Really, they shouldn't be in science." I kind of lost it a little bit on him.

Another participant, Kelly, also decried the lack of female instructors in the aviation program:

> We go on stage checks and you have to be one-on-one with an instructor. I had four instructors, and they were all males. I didn't think it bothered me so much until I failed one of the stage checks. I had a meeting with the coordinator of the stage checks unit who happened to be a female. The purpose of the meeting was to assess what my weaknesses were and how to fix them. She decided to do my next stage checks. I felt much more comfortable with her, and I didn't realize how much I have been uncomfortable with the male instructors all the time.

Kelly and Khloe's comments echo prior research that suggests that the lack of female role models and mentorship can affect females' performance and persistence in STEM programs. Morganson et al.'s (2015) concept of *links* explains the influence of role models and mentors well. STEM major links have to do with the extent to which a person has ties with other people in STEM fields, including their peers, but also as role models (e.g., female professors and advisers). Adapting this to STEM majors and careers, women may leave the STEM fields because they do not see their peers, do not see professors who look like them to whom they could go for counseling and guidance, and do not see female professors who could serve as role models and a source of inspiration. It may be that women who find themselves in these situations conclude that what they experience in the classroom and school environment might not be so different from what prevails in the STEM workforces. The comment made by one of the STEM persisters (Mercy) accentuates this point:

> If you are in the classroom full of men and one or two other women, it is kind of intimidating, and maybe women will try to avoid that and so they will switch their majors. This is something natural, because you are surrounded by so many men in

> the classroom and you are likely to think that in the field it will be the same and it is actually the same— a lot of men and just a few women.

Thus, one may surmise that only female students who receive good institutional support, have a high aptitude and a high intrinsic motivation for, and have interest in the major can survive and persist in that of kind of academic and work environment.

Psychological theme. The psychological theme was defined by the individuals' cognitive and affective motivational dispositions that influenced their decisions to switch from STEM majors. The main factor within this theme was growing interest in non-STEM majors. Four of the STEM switchers in the focus group interviews indicated that they switched from STEM programs because of growing interest in non-STEM majors. This was the most influential attrition factor for the STEM switchers. For instance, Kourtney said, "I switched from engineering to rehabilitation and human services…. Because I started having interest in it." When probed further to explain why she started having interest in rehabilitation and human services, Kourtney responded by saying that, "I started realizing I wanted to be involved in helping people rather than hands-on side of things." In other words, Kourtney switched her STEM major because she felt that she wanted to help people; perhaps she began to believe that her engineering major was not a field where she could help people, at least not in the way she valued, and that she would prefer to work with people rather than machines. Of course, this could also be seen as a failure of institutional and academic support, in that her faculty and their teaching methods did not convey that engineering can help people, as when bridges connect communities to resources, or when devices can help people regain the ability to walk or save lives in medical settings.

As pointed out earlier, the literature indicates that some women are motivated to choose STEM majors because of a desire to help people (Hughes, 2010). This may explain why there are more women in STEM fields such as psychology and biological and health sciences (Yang & Barth, 2015), where STEM professionals are perceived to be more directly involved in working with and helping people than they are in fields such as physics, computer science, and engineering, for example, where women are underrepresented (Cheryan, Ziegler, Montoya, & Jiang, 2017). In addition to changing the culture of faculty and teaching methods in STEM programs, more public education about STEM fields is needed so that people like Kourtney can see that computer science and engineering may also be about helping people, albeit often in more indirect ways than professions like psychology.

Quantitative Results

The quantitative results are presented by each research question. As stated earlier, these results will be integrated with the qualitative results in this section in order to help interpret and explain the quantitative results.

Research Question 1, Part I: What Factors Can Account for Whether Women Persist in STEM Majors?

To address the first part of research question 1 in relation to persistence, the survey participants were presented with 12 statements that relate to factors associated with STEM major persistence. They were then asked to select any of the factors that they felt played a key role in helping them to persist in their STEM. Thus, participants were allowed to select multiple persistence factors, but not to rank them in terms of importance. Participants were also given the opportunity to write any additional factors that influenced them to persist in STEM (an open-ended response item) which were not among the 12 persistence factors presented to them. Figure 4 summarizes the responses of participants in relation to the factors associated with STEM major persistence.

As can be seen from Figure 4, there were a variety of factors associated with STEM major persistence. However, these factors may be further categorized into four factors, which are similar to the STEM major persistence themes generated in the focus group interviews: *academic/institutional factors*, *career factors*, *social factors*, and *psychological factors*. Each of these four factors has been described below with examples from the survey results and supported with findings from the focus group interviews.

Academic and institutional factors. The examples of the academic and institutional factors were *strong academic preparation in math and science*, *support from faculty and institution*, *involvement in external student clubs and associations, summer internship, and peer teaching/instruction* (see Figure 4). The statistical analysis indicated that *strong academic preparation in math and science* was the most important academic and institutional factor for the survey participants. While the literature indicates that students prefer peer teaching (e.g., Watkins & Mazur, 2013) to traditional teaching methods like lecturing, especially in the teaching of a physics course, peer teaching was among the least cited academic and institutional factors for the survey participants.

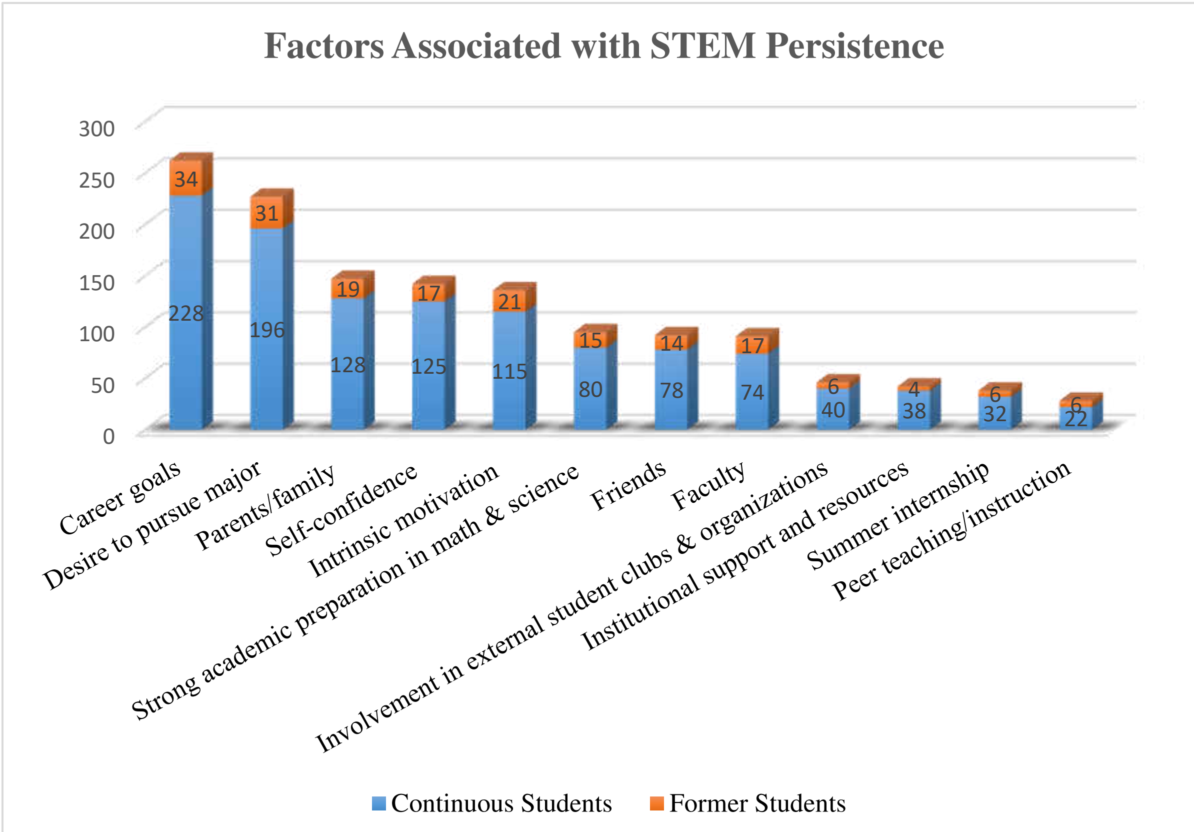


Figure 4. Frequency Distribution of Participants by Factors for Persisting in STEM.

During the focus group interviews, participants alluded to various ways they were influenced by academic and institutional factors in their studies. For example, participants talked about the various support that they received from GTAs, faculty, and the university writing and tutoring centers. For example, Kourtney, a switcher, recounted the support that she received from her professors and the university tutoring center while she was engineering major:

> The math-tutoring center helped me tremendously. Like, I went from a D to an A in my calculus class and I thought that was amazing. A couple of my professors had available office hours for me; they scheduled around in order to help me

outside class, especially whenever I was preparing for a test. I think that was very helpful to me.

While Kourtney later switched her engineering major to rehabilitation and human services because she developed an interest in a career that involves helping people, her remarks underscore the role that the university academic services and faculty/mentoring play in contributing to students' success in collegiate STEM programs, which has implications for retention and design of STEM programs. Previous studies on STEM education have also identified support from faculty (Edzie, 2014; Johnson, 2012) and strong academic preparation especially in math and science (Geisinger & Raman, 2013; Hughes, 2010; Shaw & Barbuti, 2010) as important STEM major persistence factors.

Career factors. Career factors have to do with career goals and all the opportunities that go along with them. Previous research on STEM persistence and attrition has suggested that career goals are important influences on students' decisions to persist (or not) in STEM majors (Edzie, 2014; Geisinger & Raman, 2013). In particular, Edzie (2014) found that career goals were more important in predicting student persistence in a STEM major than was personal interest in the major.

According to the quantitative data analysis, *career goals* appeared to be the single most important STEM persistence factors for the participants in the online survey (see Figure 4). This result was expected because STEM fields are associated with job opportunities and good salaries (Cataldi, Siegel, Shepherd, & Cooney, 2014). It is possible that people might be attracted to STEM careers because of extrinsic rewards. Comments made by the focus group participants highlighted how long-term career goals can influence students to persist in STEM majors. For example, Sarah shared that her dream of becoming a physician in the future has served as an impetus to press on in her STEM major despite some challenges:

> I think there is a lot of versatility in the STEM majors. If you get a psychology major or biology major, you can do so many things with it. There are a lot of possibilities when you go into STEM. I am interested in becoming a physician, and I guess I have to do undergraduate science in order to achieve this goal. I am really intrigued and passionate about the field of medicine. Even though it is hard, it is very interesting.

Taylor also added that her interest in conducting research in clinical psychology and helping people is the reason that she is persisting in her STEM major:

> In my undergrad, I did psychology and zoology just because of pure interest in science, science of people definitely. So, what influenced me to continue with a Ph.D. in clinical psychology was, I think of really being able to conduct research, I mean regular research with people in the field that I am interested in. So, I focused on eating disorders research and treatment. I like both aspects of it—being able to actually see change, but then a big component of what I like about clinical psychology is that the research informs what I do and practice and what I see with clients informs and influences my research. So, they kind of go hand in hand. I just like how I can apply the science aspect of it. Being with people is what I'm passionate about.

Sarah and Taylor's comments suggest that they are both persisting in their respective STEM majors because of their career motivations. They see their majors as means to an end; in this case, their desire to help people. As discussed under STEM persistence themes in the qualitative results section, many women enter STEM fields with the goal and desire to help others (Eccles, 2007; Hughes, 2010).

Social factors. The statistical analysis revealed that influences from parents and family was the third-most important STEM persistence factor for the survey participants (Figure 4). In the focus group interviews, all the participants stressed the importance of family support on their STEM education. They all recounted the various forms of support and encouragement that they received from parents, uncles, and role models. For example, Sarah shared that:

> My parents and siblings have been very supportive. They like my passion to study medicine, and they think that I am capable of achieving that dream. They always make sure that I have all that I need to do well in my education. They call to check on me always. When the going gets tougher, I know there are people out there I can fall on, people who love and care for me.

Given that Sarah has an inner motivation to become a physician, the support and encouragement from her parents and siblings (social persuasion) might offset some of the switching pressures she may encounter in her STEM major. Findings from the current study corroborated previous studies that have identified the influence of social factors such as family (Brandt, 2014; Edzie, 2014; Johnson, 2012) as an important STEM persistence factor.

Psychological factors. The quantitative data analysis suggested that psychological factors (i.e., *desire to pursue the major*) were the second most important STEM persistence factor for the survey participants. Examples of psychological factors also included *self-confidence* and *intrinsic motivation*. The survey item “desire to pursue the major" selected from the results of a previous empirical study may be too ambiguous. This expression could mean many things that helped the participants in the survey to persist in STEM majors. When this survey item (desire to pursue the major) was explored during the focus group interviews, participants indicated that they interpreted the expression to mean "interest in the major," "I have the inner motivation to pursue the major," "I like the major," or "I am passionate about the major." Thus, the interpretation of this factor should be done with caution. In the focus group interviews, all participants said they were influenced to persist in their STEM majors because of interest in the major and intrinsic motivation. For example, one of the STEM persisters (Mercy) said:

> …another reason why I have persisted in this major [petroleum engineering] is, even though it is hard, I am doing something that I like or am interested in, so I have to find fun ways to keep me motivated in the program...The most influential factor is me; that is, my inner motivation.

Maria also said she persisted in her STEM major because of her interest in psychology:

> I guess I stayed with it (psychology) because I am interested in the major. Because, the more I look to the field (psychology) the more I see the research that has been done in the field and the more I keep finding things that make me interested. They keep finding new research and case studies. That is really cool and I want to be a part of that. The most influential factor is the interest I have in making impact in people's lives as a psychologist.

Mercy's comments suggested that she persisted in petroleum engineering because of her interest in and inner motivation for the field, whereas Maria's comments suggested that she persisted in psychology because of her interest and desire to help people. Both intrinsic motivation and interest in helping people are related examples of psychological factors. There appears to be inconsistency between the quantitative and qualitative results in terms of the psychological factors in that the statistical analysis revealed that the majority of the STEM persisters in the online survey were influenced by career factors (career goals), whereas the qualitative analysis indicated that psychological factors were the most influential factors for the STEM persisters. There may be several reasons for this discrepancy.

First, in the online survey, participants were not asked to rate the factors that influenced them to persist in STEM majors. Rather, the survey participants were asked to *indicate* any factors (from the list that was provided) that influenced them to persist in STEM majors. The STEM persisters in the focus group interviews, in contrast, were asked to *rate* the STEM persistence factors. Thus, it is not possible to make a direct comparison between the two.

Furthermore, there were only four STEM persisters in all the focus group interviews, whereas there were two hundred and ninety-seven STEM persisters in the survey. It is possible, therefore, that the results indicate sampling error and that the survey participants (STEM persisters) who did not take part in the focus group interviews differed in some ways from the larger sample.

Research Question 1, Part II: What Factors Can Account for Whether Women Switch STEM Majors?

The second part of research question 1 examined the factors that influenced participants to switch from STEM majors. To address this question, the survey participants were presented with 11 statements that related to factors associated with STEM attrition. Participants were then asked to select any of the factors that they felt were influential in their decision to switch from STEM (again, they were not asked to rate these). Multiple selections were thus allowed. Participants were also given the opportunity to write in any other factors that influenced them to switch from STEM (open-ended response item), which were not among the 11 attrition factors presented to them. Fifty-nine participants responded to the survey item relating to STEM attrition. Of this number, 53 were continuous students (currently enrolled) and 6 were former students (no longer enrolled at the university). The responses of the survey participants are summarized in Figure 5.

The information displayed in Figure 5 indicates that participants in the survey switched from STEM programs because of several factors. These factors have also been categorized into four factors, which are comparable to the STEM major attrition themes: *academic*, *financial*, *lack of role models*, and *psychological factors*. Each of these four factors are described below and accompanied by examples from the survey results and supported with quotes from the focus group interviews.

Psychological factors. Examples of psychological factors that influenced survey participants to switch STEM majors included *growing interest in non-STEM major*, *loss of interest in the STEM major*, and *feelings of isolation because too few peers pursue the STEM major* (Figure 5). The statistical analysis suggested that psychological factors were the most important factors that influenced the survey participants to switch from STEM programs. In particular, *growing interest in non-STEM major* and *loss of interest in the STEM major* were the two most important psychological factors that influenced survey participants to switch (Figure 5).

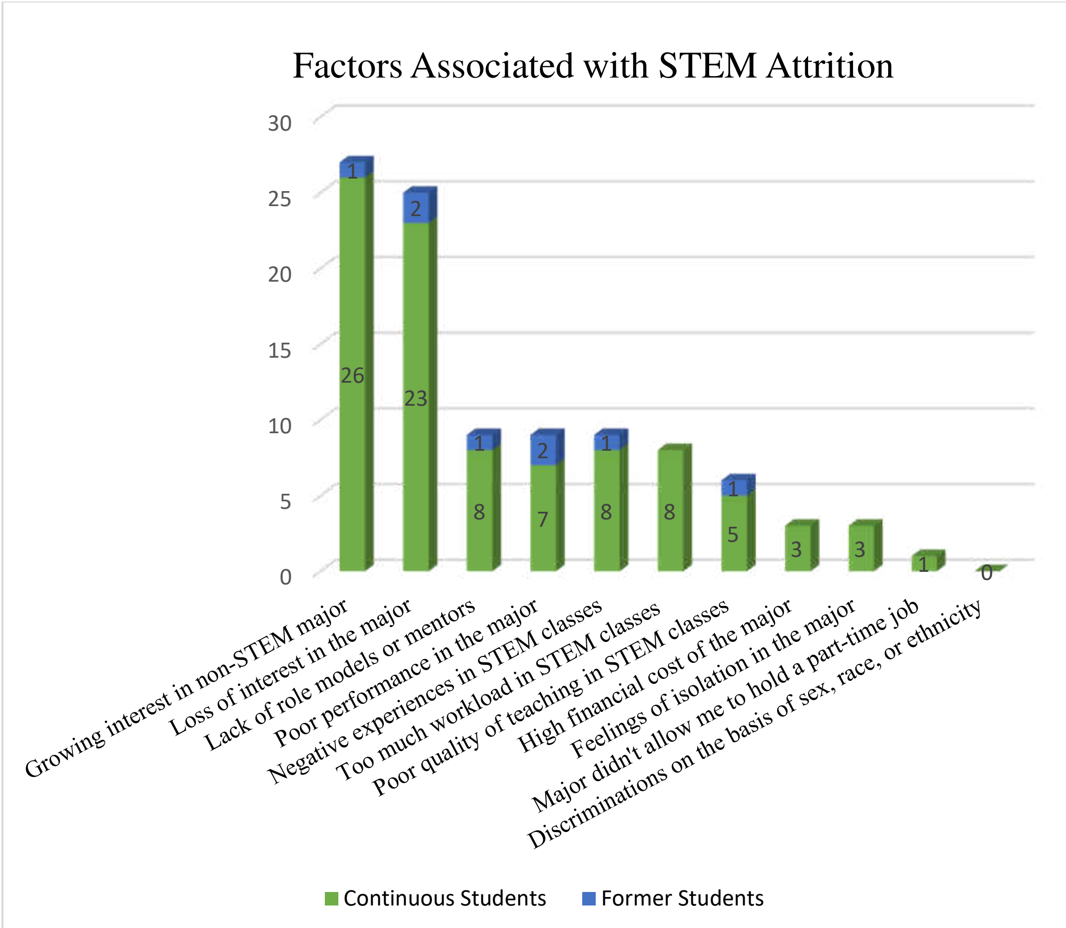


Figure 5. Frequency Distribution of Factors Contributing to STEM Switching Decisions.

The STEM literature does not explain what *growing interest in non-STEM major* and *loss of interest in STEM major* actually mean; therefore, it is important to distinguish between these two STEM attrition factors. Growing interest in non-STEM majors may be triggered by a change in career goals (e.g., wanting a career that involves helping people) or positive experiences such as higher grades in non-STEM classes in relation to STEM classes. As discussed in Chapter II, the literature indicates that grades received in STEM classes viewed in relation to grades in non-STEM classes can be a determining factor as regards the decision to persist in or switch from STEM majors (Ost, 2010; Rask, 2010).

Geisinger and Raman (2013) also note that most students switch STEM majors because they find a more appealing career option in non-STEM majors (Hughes, 2010).

Recall that one of the focus group interview participants, Kourtney, switched from a STEM major because she started developing an interest in a non-STEM major: "I switched from engineering to rehabilitation and human services…. because I started having interest in it (rehabilitation and human services). I started realizing I wanted to be involved in helping people rather than hands-on side of things." Kourtney's comment is an example of growing interest in non-STEM major, triggered by the realization that her engineering major was not about what she wanted to do for a career—helping people.

Loss of interest in STEM may be caused by negative experiences in STEM classes (e.g., poor performance in the STEM major, feelings of isolation because too few peers pursue the STEM major; lack of female role models; poor teaching or interpersonal communication skills of faculty). Recall that Kim and Kelly shared during the focus group interviews that they switched to non-STEM majors because they were performing poorly in their respective STEM majors. Kim remarked, "I wasn't doing so well in chemical engineering. So, I switched to English because I think all along I have been running away from it." Kim's remarks illustrate how poor performance (itself a possible result of academic and institutional factors) in a STEM major can cause a student to lose interest in the major. Mercy, a STEM persister, shared comments that highlight the feeling of isolation in STEM classes which may cause women to lose interest in STEM majors, particularly majors like petroleum engineering which are mostly dominated by men. "If you are in the classroom full of men and one or two other women, it is kind of intimidating and maybe women will try to avoid that and so they will switch their majors."

Lack of role models/mentors. The statistical analysis suggested that the lack of role models was the second most important factor that influenced the survey participants to switch from STEM programs (Figure 5). During the focus group interviews, all the participants stressed the need for having more female faculty and GTAs in STEM departments, particularly in the "hard" sciences like computer science, aviation, physics, and engineering, which are dominated by men. Focus group interview participants like Kelly also suggested that women are more likely to avoid courses dominated by men and taught by male professors because they feel uncomfortable in this kind of class environment:

> Having more female professors in aviation can help to attract and retain more women in the program. If we had more female instructors in the program, that would have been the biggest thing to me. We had one female professor and she made me feel better about getting my pilot license. Like, if we had more female instructors that would encourage more female students to join the program.

Another focus group interview participant (Kim) remarked:

> I believe that female role models can have positive impact on female students in STEM. For example, when you see a female chemical engineering professor, you would want to be like her. When you see a female GTA in your engineering department, you will say 'I can also get there.' I think we need more female role models in STEM programs.

The issue of having more female faculty in STEM programs has been discussed extensively in the STEM literature with mixed findings. Some studies (e.g., Carrell, Page,

& West, 2010; Price, 2010) found no evidence to support the assertion that the presence of female faculty in a STEM major can encourage more female students to enroll and persist in the major. Conversely, other studies (e.g., Bettinger & Long, 2005) have found a link between a higher proportion of female faculty in math and science classes and increased enrollment and persistence of female students in those majors. In spite of these inconsistencies in the literature, it must be said that in order to attract and retain more women in STEM, having more female faculty and GTAs in STEM programs, based on this study, may be an important factor in retaining more female STEM students.

Academic factors. Academic and institutional factors associated with STEM major attrition included *poor performance in the STEM major*, *negative experiences in STEM classes, too much workload in STEM classes as compared to non-STEM classes,* and *poor quality of teaching in STEM classes* (Figure 5). According to the statistical analysis, a majority of the survey participants switched from STEM programs because of academic factors, specifically poor performance. In the focus group interviews, three of the participants who switched from STEM to non-STEM majors shared some of the academic factors that influenced their decisions to switch, including poor performance in STEM majors. For example, Kourtney shared, “I struggled in my engineering classes. It was difficult and I didn’t have the passion for it (engineering).” Indeed, it would be difficult, if not impossible, to see how a student would perform well academically in a course that she or he is not passionate about or has no interest in, especially when she or he is struggling and does not have access to role models and academic support to offset this. Kourtney was among those focus group interview participants (switchers) who entered a STEM field because of financial motivation: “I was interested in high pay and I thought I could get it from the STEM fields." However, it appears that financial motivation was not strong enough to keep her in the engineering program in the absence of other factors that might help her persist, suggesting that among all factors, financial may be a a more "fragile" motivational factor.

The statistical analysis also indicated that the survey participants were influenced to switch (or discouraged from persisting) from STEM programs because of poor quality of teaching. For instance, Kourtney shared that even though she was not passionate about her engineering major she would have persisted because of her financial motivation if she had had better teaching and more faculty guidance:

> I found it hard to understand some of my professors because they were there to dictate notes and it was kind of fast-paced for me because I kind of jumped in late in the year. That was very frustrating for me. I also felt that there wasn't good advisement either in the engineering department. So, it was hard to get direction on where to go next.

It is also possible that Kourtney would have been more passionate about the field had it been taught in a manner that demonstrates the applicability, challenge, and benefits of the major. Similarly, Kim alluded to the fact that she often asked some of her classmates to explain certain basic concepts to her after class because she could not always understand her professors:

> Most of the faculty there (engineering department) aren't actual teachers. They are more like researchers and have worked in the field. So, the teaching methods aren't always best and understanding students' confusions. They lack the

> pedagogical skills, and so you have to run to your classmates to get help, because your professors couldn't really teach you.

Kim and Kourtney's comments suggest the need for institutional support for students, and professional development for (or recruitment of) university professors, especially those who are not trained as teachers. Tutoring is one of the effective ways that students can be supported academically, but it may be insufficient without additional faculty development. Further, there is some evidence that such support needs to be within the context of the major department itself as Kourtney's comments illustrate:

> The math-tutoring center helped me tremendously. Like, I went from a D to an A in my calculus class, and I thought that was amazing. Couple of my professors had available office hours for me; they scheduled around in order to help me outside class especially whenever I was preparing for a test. I think that was very helpful to me.

Financial factors. The quantitative analysis suggested that the relative costs of STEM education were among the least cited factors that influenced the survey participants to switch from STEM programs. Examples of financial factors included *high financial costs associated with the STEM major* and *major didn't allow me to hold a part-time job* (see Figure 5). These financial costs may include the cost of tuition and some basic requirements of the STEM major such as the cost of medical certifications, textbooks, lab equipment, and flight costs for aviation students.

While the results of the survey showed that some participants (3 out of 59) switched STEM majors because of the high financial costs associated with their STEM majors, only one participant in the focus group interviews (see below) mentioned this as a

STEM attrition factor. Thus, cost does not seem to be a major reason for switching, at least not in comparison with other factors.

During the focus group interviews, Khloe expressed that when she decided to switch from geology to an MBA at the graduate school, she initially thought about other STEM majors that would be more flexible (e.g., psychology) but she could not pursue that because of a lack of financial support:

> For me, I finished my undergraduate STEM degree, but one reason I didn't pursue more STEM education was due to lack of funding. In some situations, I considered the courses and I applied, but couldn't get funding to pursue the program I was interested in.

Regarding financial factors as a STEM major attrition factor, the literature indicates that STEM students can be expected to pay more for their education than non-STEM students do (American Institutes for Research, 2013; Catalanello, Solochek, & Ackerman, 2012). Given that STEM classes involve a higher workload (as indicated by the survey results and the literature), this might also prevent STEM students from taking on part-time jobs to defray their educational costs. Thus, STEM students who may not be eligible for financial aid, tuition waivers, and scholarships, and whose parents may not be able to afford the high costs of STEM education, may opt for non-STEM majors. Nonetheless, by percentage alone, this does not seem to be a factor that demands the same attention as the others.

Research Question 1a: What Are the Characteristics of College Female STEM Switchers?

Age. Participants were asked to report their ages on the online survey. As pointed out earlier, age-related data for STEM switchers were recoded into categorical variables (see Table 6). The number of participants appearing within each age range has been provided along with the combined total and percentages. As can be seen in Table 6, about 52% of the STEM switchers were between the ages of 18 and 21, approximately 27% were between the ages 22 and 25, and approximately 10% were 26 years or older. Six of the STEM switchers did not disclose their ages on the survey.

The age information summarized in Table 6 suggested that the majority of the STEM switchers were in their early twenties, which is considered traditional college age (National Center for Education Statistics, 2016). Of the five STEM switchers in the focus group interviews, three were between the ages of 19 and 21, one participant was 28, and the other was 33.

Table 6. Frequency Distribution of STEM Switchers by Age.

	Students		
Age Category	Continuous	Former	Combined (*n*=59)
18–19	11	4	15 (25.4%)
20–21	16	–	16 (27.1%)
22–23	9	–	9 (15.3%)
24–25	7	–	7 (11.9%)
26–35	6	–	6 (10.2%)
Missing	6	–	6 (10.2%)

Year study participants switched. One of the goals of the current study was to determine the year of college that participants decided to switch from STEM majors. To achieve this goal, STEM switchers were presented with eight statements on the online survey that relate to the year of study and semester in which they switched from STEM fields. They were then asked to select one of the statements that best described them. Participants were also given the opportunity to indicate if none of the statements presented to them adequately described them. Table 7 gives an overview of the different years and semesters that survey participants switched from STEM programs.

Table 7. Frequency Distribution of Participants by College Year and Semester STEM Majors Were Switched.

College Year/Semester	**Students (*n*=59)**	**%**
First year first semester	12	20.3%
First year second semester	17	28.8%
Second year first semester	7	11.9%
Second year second semester	5	8.4%
Third year first semester	4	6.8%
Third year second semester	2	3.4%
Fourth year first semester	3	5.1%
Fourth year second semester	2	3.4%
Changed to a non-STEM major after undergraduate program	7	11.9%

Figure 6 provides a graphical representation of the information summarized in Table 7. Of the 59 STEM switchers, approximately 50% of them switched from STEM programs during their first year of college. The total number of the participants who switched from STEM during the second year was approximately 20%, whereas the percentage of those who switched from STEM during the third and fourth years was approximately 19%. Seven of the participants commented on the survey that they did not switch from STEM while pursuing their bachelor's degrees but rather did so at the graduate school level.

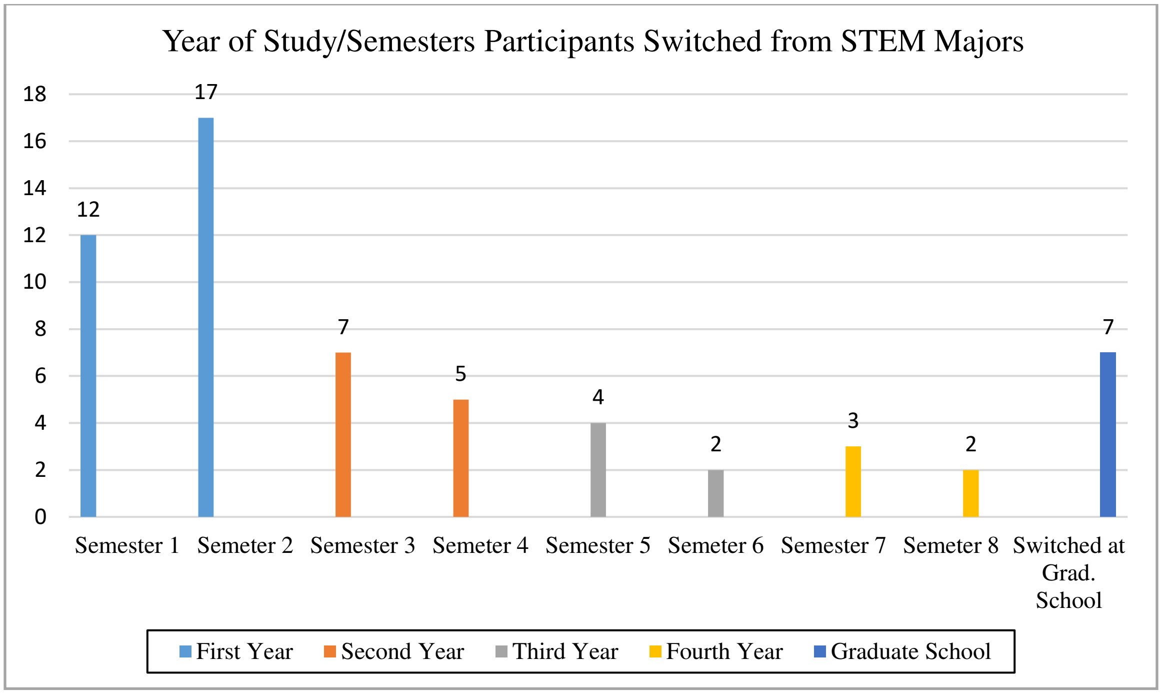


Figure 6. Frequency Distribution of Participants by Year of Study and Semesters in Which Participants Switched from STEM Majors.

The qualitative data analysis indicated that all the focus group interview participants who switched to non-STEM majors persisted beyond the first year of college. One switched during second year, first semester; two switched during the second year, second semester; and one switched at the graduate school level. One focus group interview participant also indicated that she switched from a STEM major to a different STEM major at the graduate school. Overall, the quantitative results suggest that most students who switch from STEM programs do so during their first year of college. This result suggests the need to focus retention efforts at first-year college STEM students.

Resident status. It has been suggested that international students are more likely to persist in STEM majors throughout their college life than are their domestic student counterparts (Newlon, 2013). To find out whether this was the case with the domestic and international students in this sample population, participants were asked to indicate on the survey whether they were international or domestic students. The survey results revealed that all of the 59 STEM switchers were domestic students. Therefore, it was not possible to answer this question with this study.

Research Question 1b. Which STEM Majors Are Women Likely to Switch from and Which Non-STEM Majors Are They Likely to Switch to?

Another objective of the current study was to find out what academic majors STEM switchers decided to pursue after leaving the STEM majors they had chosen initially. To answer this question, survey participants who had indicated they switched from a STEM major were asked to list their previous STEM major. Appendix G displays the STEM majors that participants switched from vis-à-vis the academic majors that they switched to.

The quantitative data analysis revealed that biology and psychology were the most frequently reported STEM majors that participants switched from (see Table 8). This result is somewhat puzzling, since poor performance in the major was frequently mentioned by the focus group participants, and because one might expect that more switchers would leave majors like computer science, chemistry, engineering, and mathematics, which are often considered to be among the hardest STEM majors. The current study's data analysis indicated that about 30% of the total survey participants were biology and psychology majors (see Table 2). Thus, the result may indicate a sampling error and should therefore be interpreted with caution.

The quantitative data analysis also suggested that education, counseling, criminal justice, and business were the most frequently reported academic destination majors for

STEM switchers (see Table 9). The frequency of the rest of the reported academic majors of STEM switchers was between 1 and 3, with a mode of 1.

Table 8. Frequency Count of STEM Majors That Participants Left (Switched From).

Major Switched From	Total (n = 59)	Percent (%)
Biology	10	16.95
Psychology	9	15.25
Forensic Science	6	10.16
Nursing	4	6.80
Chemical Engineering	3	5.08
Chemistry	3	5.08
Commercial Aviation	2	3.39
Computer Science	2	3.39
Pre-Medicine	2	3.39
Air Traffic Control	1	1.69
Atmospheric Science	1	1.69
Aviation	1	1.69
Biomedical Engineering	1	1.69
Geology	1	1.69
Geography Information Science	1	1.69
Graphic Design Technology	1	1.69
Information Systems	1	1.69
Mechanical Engineering	1	1.69

Table 8, continued

Major Switched From	Total (*n* = 59)	Percent (%)
Meteorology	1	1.69
Occupational Therapy	1	1.69
Petroleum Engineering	1	1.69
Pre-Optometry	1	1.69
Missing	5	8.47

Table 9. Frequency Count of Majors into Which Participants Switched.

Major Switched Into	Total (*n* = 59)	Percent (%)
Education	12	20.33
Business	5	8.47
Counseling	5	8.47
Criminal Justice	5	8.47
Psychology	4	6.78
English and Communications	3	5.08
Nursing	3	5.08
Marketing and Communications	2	3.39
Social Work	2	3.39
Entrepreneurship	1	1.69
General Studies	1	1.69

Table 9, continued

Major Switched Into	Total (*n* = 59)	Percent (%)
History	1	1.69
Human Resources	1	1.69
International Studies	1	1.69
Investments	1	1.69
Law	1	1.69
MBA	1	1.69
Occupational Therapy	1	1.69
Rehabilitation and Human Services	1	1.69
Sociology	1	1.69
Spanish	1	1.69
Women Studies	1	1.69
Missing	5	8.47

To follow up on the quantitative results, the focus group interview participants were asked to indicate their current majors as well as the STEM majors from which they switched. Table 10 summarizes the responses of the STEM switchers who participated in the focus group interviews. The qualitative data analysis indicated that four of the participants switched from physical sciences (i.e., aviation, chemical engineering, geology, and mechanical engineering) to non-STEM majors (i.e., English, MBA, and rehabilitation and human services). Only one participant switched from a STEM (psychology) to another STEM major (counseling). However, both the previous STEM and the destination majors were in the social sciences domain.

Table 10. STEM Majors That Focus Group Participants Switched from and the Other Majors That They Switched Into.

Participant	Academic Majors	
	Switched from	*Switched to*
Kelley	Aviation	English
Khloe	Geology	MBA
Kim	Chemical Engineering	English
Kourtney	Mechanical Engineering	Rehabilitation and Human Services
Kris	Psychology	Counseling

When examining the participants who switched from STEM to other majors in the quantitative data, there did not appear to be any meaningful patterns about which majors participants switched to. That is, it is not the case that most biology majors switched mostly to education (see Appendix G). However, the quantitative data generally suggested that participants tended to switch from a people-oriented major (e.g., biology) to another people-oriented major (e.g., education; see Tables 8 and 9). The qualitative data also suggested that the focus group interview participants tended to switch from a non-people-oriented STEM major to a people-oriented major (see Table 10).

Research Question 2: Do Women Who Persist in STEM Majors Differ Significantly from Women Who Switch STEM Majors in Terms of Their Scores on the Value of STEM Fields and Expectations for Success in STEM Careers Subscales?

It was hypothesized that the expectations for success that the individuals hold about STEM careers and the value that they place on the STEM fields could affect their persistence in STEM programs. Therefore, the second research question examined two null hypotheses (H) and two alternative hypotheses (H_A) using independent samples *t*-tests to determine whether value of STEM fields and expectations for success in STEM careers subscale scores differed significantly between STEM persisters and switchers. Regarding the first hypothesis (H_1), participants were asked a series of questions relating to value of STEM fields, for example, “I find STEM related jobs very interesting” on a 5-point Likert-type scale anchored by “Strongly Agree” (5) and “Strongly Disagree” (1).

H_1: There is no significant difference between STEM persisters and STEM switchers in terms of their scores on the value of STEM fields subscale.

H_{A1}: STEM persisters will have significantly higher scores on the value of STEM fields subscale than do STEM switchers.

The *t*-test indicated that scores on the value of STEM fields subscale were significantly higher for STEM persisters than for STEM switchers (see Table 11). In other words, STEM persisters tended to “agree” or “strongly agree” that they value STEM fields (M = 34.81, SD =4.52), while STEM switchers tended to “disagree” or “strongly disagree” with statements on the survey relating to the value of STEM fields (M = 29.64, SD =4.27). Thus, the null hypothesis that there is no difference in value of STEM fields scores between STEM persisters and switchers was rejected. Cohen’s effect size value (Cohen, 1988) suggested a very large practical significance (d =1.55). What these statistical results mean specifically in terms of the value of STEM fields subscale items is that STEM persisters “agreed” or “strongly agreed” that STEM-related jobs are very interesting (interest value) and that working in a STEM field is worth their time (cost value), while STEM switchers “disagreed” or “strongly disagreed” that STEM-related jobs are very interesting and that working in a STEM field is worth their time.

Table 11. Group Differences Between STEM Persisters and Switchers on Value of STEM Fields and Expectations for Success in STEM Careers Subscales.

	Persisters		Switchers						Cohen's
Variable	*M*	*SD*	*M*	*SD*	Mean diff.	*df*	*t*	*p*	*d*
Value of STEM Fields	34.81	4.52	27.34	5.10	7.47	353	11.35	<.001	1.55
Expectations for Success	29.64	4.27	25.02	4.94	4.62	353	7.39	<.001	1.00

Note. *N=356* (297 STEM major persisters, 59 STEM major switchers).

The qualitative data analysis also suggested that STEM persisters and switchers in the focus group interviews were different in terms of the value they placed on the STEM fields. For example, all of the STEM persisters in the focus group interviews said they had intrinsic value for STEM fields, while STEM switchers indicated that they enjoyed (interest value) non-STEM majors much more. Also, STEM switchers in the focus group interviews expressed that they were not willing to sacrifice noncareer/personal goals for STEM careers (cost value), which are perceived to be unfavorable for those who want to start families, for example. This was not an expressed concern for the STEM persisters.

Participants were also asked a series of questions about their expectations for success in STEM careers such as “I would be able to succeed in a STEM field as well as most other people,” also on a 5-point Likert-type scale. Hypothesis two (H_2) was tested to address the questions about expectations for success in STEM careers.

H_2: There is no significant difference between STEM persisters and STEM switchers in terms of their scores on the expectations for success in STEM careers subscale.

H_{A2}: STEM persisters will have significantly higher scores on the expectations for success in STEM careers subscale than do STEM switchers.

The *t*-test indicated that scores on the expectations for success in STEM careers subscale were significantly higher for STEM persisters than for STEM switchers (see Table 11). In other words, STEM persisters tended to "agree" or "strongly agree" that they would be successful in STEM careers (M = 29.64, SD = 4.27), while STEM switchers tended to "disagree" or "strongly disagree" that they would be successful in STEM careers (M = 25.02, SD = 4.94). Therefore, the null hypothesis that there is no difference in expectations for success in STEM careers scores between STEM persisters and STEM switchers was rejected. Furthermore, Cohen's effect size value suggested a very large practical significance (Cohen d = 1.00).

Research Question 3: Is There a Significant Difference Between Female STEM Persisters and Switchers in Terms of Their Scores on the Perceived Success in STEM Courses Subscale?

It was hypothesized that STEM persisters and switchers were not significantly different in terms of how they perceived success in STEM courses (see H_3 below). To examine this, participants were asked a series of 7-point Likert-type questions about their perceived success in STEM courses, questions such as "How successful do you feel in gaining new knowledge and understanding from your courses?" anchored by "Very Successful (7) and "Very Unsuccessful" (1) (see Online Survey, Appendix B).

H_3: There is no significant difference between STEM persisters and STEM switchers in terms of their scores on the perceived success in STEM courses subscale.

The *t*-test analysis indicated that scores on the perceived success in STEM courses subscale were significantly higher for STEM persisters than for STEM switchers. That is, STEM persisters felt “successful” or “very successful” about their STEM courses (M = 33.56, SD = 8.09), while STEM switchers felt “very unsuccessful” or “unsuccessful” about their STEM courses (M = 29.56, SD = 8.51).

Table 12. Group Differences between STEM Persisters and Switchers on the Perceived Success in STEM Courses Subscale Scores.

	Persisters		Switchers						Cohen’s
Variable	*M*	*SD*	*M*	*SD*	Mean diff.	*df*	*t*	*p*	*d*
Perceived Success in STEM courses	33.56	8.09	29.56	8.51	4.00	352	3.44	= .001	0.48

Note. $N=356$ (297 STEM major persisters; 59 STEM major switchers).

Cohen’s effect size value suggested a small- to medium-size practical significance (d = .48). Therefore, the null hypothesis that there is no difference in perceived success in STEM course scores between STEM persisters and STEM switchers was rejected.

In terms of specific items on the perceived success in STEM courses subscale, these results indicate that STEM persisters tended to feel “more successful” or “very successful” about the grades that they got on tests and assignments, in achieving the learning goals that they set for themselves, and in gaining new knowledge and understanding from their STEM courses. STEM switchers tended to feel “very unsuccessful” or “unsuccessful” about the grades that they got on tests and assignments, in achieving the learning goals that they set for themselves, and in gaining new knowledge and understanding from their STEM courses. Furthermore, the quantitative results indicated that poor performance in STEM majors was one of the factors that influenced switchers to leave the STEM pipeline (see Figure 5). Also, all three of the STEM switchers (undergraduate students) in the focus group interviews indicated that they switched to non-STEM majors because of poor performance in STEM classes.

Research Question 4: Do College Women’s Perceived Success in STEM Courses and the Value They Place on STEM Fields Predict Their Expectations for Success in STEM Careers?

It was presumed that value of STEM fields and perceived success in STEM courses predict expectations for success in STEM careers. Therefore, the following hypothesis was formulated in relation to research question 4.

> H_4: The level of expectations for success in STEM careers is not affected by the value that college women place on STEM fields or their perceived success in STEM courses.

To address research question 4, a multiple linear regression was calculated to predict expectations for success in STEM careers based on value of STEM fields and perceived success in STEM courses. A significant regression equation was found $F(2, 351) = 256.72$, $p < .001$, with a resultant model $R = .77$ ($R^2 = .59$). The multiple linear regression analysis suggested that both value and perceived success in STEM courses predict expectations for success in STEM careers. Value of STEM fields, not surprisingly, was the best predictor of expectations for success in STEM careers ($\beta = .72$, $p < .001$); while perceived success in STEM courses had relatively low predictive power ($\beta = .13$, $p < .001$). Therefore, the null hypothesis that the level of expectations for success in STEM careers is not affected by the value that college women place on STEM fields or their perceived success in STEM courses was rejected. The multiple linear regression results suggest that the perceived success in STEM courses and the VIES instrument are significantly related. Thus, these instruments could be used together and as subscales to examine student attitudes prior to enrollment in STEM programs as well as how those values and expectations change (or not) during students' STEM studies. The knowledge obtained from these assessments could lead to interventions that may help to recruit or retain people in STEM programs (see further discussion in Chapter V).

CHAPTER V

DISCUSSION

The STEM literature indicates that women are consistently underrepresented in STEM fields (Beede et al., 2011; Espinosa, 2015; Sáinz, 2011). One of the theories that has been advanced to explain this is that academically well-prepared female students who graduate from high school and who choose to pursue a STEM major at the college level often switch from these majors to non-STEM majors during their college career (Chen, 2015; Hill et al., 2010) because of many factors. This has caused U.S. policymakers and researchers to call for reducing STEM attrition in college (Chen). Their contention is that retaining more students in collegiate STEM programs is a fast, cost-effective way to increase the supply of STEM professionals (Chen; Ehrenberg, 2010).

The purpose of this study was to examine factors that may influence women to persist in or to switch from collegiate STEM majors. This study also sought to examine whether STEM persisters and switchers were different in terms of how they valued STEM fields, their expectations for success in STEM careers, and their perceived success in STEM courses, which has largely been ignored in the literature. The expectancy-value theory was adopted as the theoretical framework for the current study as it addresses individuals' educational and vocational choices.

Factors Associated with STEM Major Attrition and Persistence

The quantitative results from this study indicated that the majority of the persisters were influenced by career goals (career factors) to stay in STEM programs (see Figure 4). This might suggest that career goals should be a primary focus of STEM retention in college. However, one of the limitations of the current study was that the survey participants were not asked to *rate* the factors that influenced their persistence in STEM programs in terms of importance; rather, they were asked to indicate *all* the factors that influenced their persistence in STEM programs. Thus, the fact that the majority of the STEM persisters selected career goals as a factor that influenced their persistence in STEM does not necessarily mean that they considered career goals as the most *influential* factor—just the most *common* factor. These results are consistent with other STEM literature. Edzie's (2014) study on women in collegiate STEM programs is a case in point. When asked in a survey (n = 279) to *rate* the important factors that kept them motivated in their STEM majors despite the challenges that they faced, the majority of women rated career goals as the most influential persistence factor. Thus, evidence from the current study supports that of Edzie's study, suggesting that career goals are important STEM persistence factors.

In contrast, all of the four STEM persisters in the focus group interviews rated intrinsic motivation as the *most* influential persistence factor. This is consistent with literature on motivation, and it is tempting to conclude that it is at least as important as career factors. However, it is difficult to draw any conclusions related to this finding because of the limited sample size (4 participants). Career factors could be seen as extrinsic motivation, which could be less robust than intrinsic motivation in terms of persistence, but this study data allow no conclusions to be drawn in this regard.

The quantitative results suggest further that the majority of the switchers left

STEM for non-STEM programs because of interest-related factors, which could also be seen as intrinsic motivation (see Figure 5). These interest-related factors, in part, were linked to career factors as indicated by the findings from the qualitative study. For example, four participants in the focus group interviews who switched to non-STEM majors said that one of the reasons that they lost interest in STEM majors was because they wanted to pursue more people-oriented, flexible careers. Thus, career goals that contributed to persistence in STEM majors were not the same as the factors that influenced STEM switchers to leave. Career factors can be further broken down into extrinsic (salary, job prospects) and intrinsic (quality of life; enjoyment), and future research should strive to disaggregate intrinsic and extrinsic career factors. Taken together, the analyses of both the STEM persistence and attrition factors in this study suggest that career and psychological factors are key factors to consider when planning strategies to retain more women in collegiate STEM programs. This is further discussed later in this chapter.

Characteristics of College Female STEM Switchers

The quantitative results showed that about half of the STEM major switchers left STEM for other majors during the first year, and that overall, two-thirds left STEM majors within the first 2 years (see Figure 6). This result supports the existing literature, which indicates that college STEM major attrition often occurs in the first or second year (Brandt, 2014; Griffith, 2010; Price, 2010; Watkins & Mazur, 2013).

It is therefore not surprising that a majority of the participants switched their STEM majors during the first year of college. According to Brandt (2014), female students' decision to persist or leave STEM majors is often based on their experiences during the first year, which often reflects the overall grades that they obtain. Most STEM programs have initial prerequisite courses that are often seen as a way to “weed out” students. These courses in the first year (e.g., Chemistry 1 and Calculus 1) are considerably more difficult and are intended to cut out unmotivated or unprepared students from the STEM programs (Geisinger & Raman, 2013; Newlon, 2013). Thus, students’ overall performance in first-year classes often determines their persistence in STEM programs (Brandt). Further, results in this study also indicated that lack of academic support and female role models, factors that could help overcome problems experienced in the first year, were important reasons for switching.

The results of the current and previous studies thus suggest that the first year is critical in terms of retaining women in STEM programs. Thus, it is important for educators in STEM departments who wish to retain more women in STEM majors to focus on first-year female students, especially those who may be struggling, by investigating their learning needs and providing counseling and academic support.

STEM Programs That Switchers Left, and the Programs They Entered

Based upon the information summarized in Appendix G, two groups of STEM switchers can be identified. The first group are participants who entered STEM fields and later switched to non-STEM fields, while the second group are participants who entered STEM fields and later switched to other STEM fields. The latter group are important to recognize because early intervention could help save them tuition and time and free up spaces in STEM classes for other students, but they are not as relevant to the leaky pipeline problem. The former group is critical in addressing this problem, however.

It can be seen from the information displayed in Appendix G that participants who switched from STEM to non-STEM fields generally switched to education and business majors, while participants who switched from STEM to other STEM fields generally entered health-related fields (e.g., nursing) and psychology majors.

The quantitative results further revealed that biology and psychology were the most frequently reported *past* STEM majors (i.e., majors that switchers switched *from*; see Table 8). Biology and psychology were also the two most popular majors reported by participants, so this perhaps explains why they were the most frequently left majors as well (see Table 2). This finding also supports the STEM literature that women are often more attracted to biology/life sciences than to the hard sciences (National Science Board, 2012), whereas men tend to choose STEM careers where they perceive they will make new discoveries and become famous and make more money (Hughes, 2010). Therefore, it was more statistically likely that the majority of the STEM switchers in this study would come from biology and psychology majors. This also suggests that intrinsic career factors (e.g., being in the helping sciences) may not be enough on their own to overcome other factors that cause students to switch majors.

The quantitative results further suggested that education was the most frequently reported academic destination major for STEM switchers (Table 9). Overall, the quantitative data suggested that a majority of the participants switched from the "helping" sciences to non-STEM majors where future careers also involve working with and helping people (see Appendix G). In a related study conducted by Chen (2013), education appeared to be one of the least popular destinations for STEM leavers. However, unlike the current study, which focused on female students in bachelor's and graduate STEM programs, Chen's sample consisted of male and female students in bachelor's and associate degree programs. Furthermore, Chen's study findings were reported in aggregate; therefore, it is not possible to know the fields that the female participants entered after switching from STEM programs.

Implications of Findings for Expectancy-Value Theory and VIES

This section discusses both the quantitative and qualitative findings in light of Eccles' et al. (1983) expectancy-value model. Specifically, this section addresses how the findings from this study substantiated the key components of the expectancy-value model: expectations for success and the subjective task value (attainment, intrinsic, utility, cost, financial). The basic assumption of the expectancy-value model as it pertains to this study is that individuals appear to consider their expectations for success in STEM careers as well as the value they attach to the STEM fields and then decide whether to persist or leave STEM majors.

All 356 participants in this study entered college with the intention to pursue a STEM major. However, through their college experiences (e.g., performance in STEM classes; academic and institutional support), they began to reflect on their expectancy for success and the value they attached to the STEM fields and made the choice to persist or leave their STEM majors. The reasons for this were many and varied but, as reported earlier, the STEM persisters' scores on the perceived value of STEM fields and expectations for success in STEM careers subscales were significantly higher than the scores of the STEM switchers. This suggests that the persisters had higher expectations for success in STEM careers and placed higher value on STEM fields than did those who switched.

Subjective Task Value

The subjective task value is one of the key components of Eccles et al.'s (1983) expectancy-value model. The quantitative results revealed that the scores of STEM switchers were significantly lower than scores of the persisters on the value of STEM fields subscale, suggesting that the STEM switchers placed lower value on STEM fields than did STEM persisters. Each of the components of the subjective task value is discussed below in relation to the study findings.

Attainment value. Recall that attainment value has to do with the personal importance that a person attaches to a given task, because doing well in that task will affirm her personal or social identity. The STEM persisters had a higher attainment value for STEM fields than the switchers did because it fit with their social identity and/or desired career. Maria, one of the focus group participants, commented on why she had persisted in her STEM major:

> Psychology has touched my life because my family has gone through a lot of things like clinical psychology and just seeing what it has done for them. My uncle is a clinical psychologist; seeing what he does and the impact he has on people really inspires.

Maria attaches a personal importance to psychology major because of her family history and connection with the field; therefore, she is also working hard to become a clinical psychologist in order to preserve her social identity. Sarah, another focus group participant, also has a high attainment value for her STEM field because she attaches personal importance to helping people and she thinks she can achieve that goal through her STEM field (medicine). She commented, "I naturally want to help people no matter what I do…I found that medicine is one of the biggest ways I can help someone." This finding could suggest that recruiting should focus on those who want to enter STEM for personal reasons rather than financial reasons.

Intrinsic (interest) value. Intrinsic value refers to the enjoyment that the study participants derived from taking STEM classes. Thus, an important question to ask is: did persisters and switchers enjoy STEM classes equally? Judging from the quantitative results and responses of the focus group participants, the answer might be no. Psychological factors, including personal interest in STEM fields, emerged as important factors for STEM persistence. Interestingly, psychological factors such as *growing interest in non-STEM majors* and *loss of interest in STEM majors* also emerged as important factors for STEM major attrition. Thus, one can infer from the study findings that STEM major persisters had high interest value for STEM classes, and therefore enjoyed STEM classes much more than the switchers. Conversely, STEM major switchers had high interest value for non-STEM classes and therefore enjoyed STEM classes less.

Quotations from the focus group participants provide additional support for these assertions. Kelly (switcher) noted, "I was a commercial aviation major for one year…though I like flying, I didn't like it as much as everyone around me liked it. I was taking a class in English too and became more interested in it." Kourtney (switcher) also said, "I switched from engineering to rehabilitation and human services…because I started having interest in it."

Comments from the persisters also confirm their high interest value for STEM fields. Mercy (persister) shared, "…another reason why I have persisted in this major (petroleum engineering) is, even though it is hard, I am doing something that I like or interested in." Taylor (persister) also commented, "If I'm to rate the factors that keep me going, intrinsic motivation and passion for my field (psychology) will be on top."

Utility value. The perceived value of STEM fields is influenced by its short or long-term utility (Eccles, 2005; Eccles et al., 1983). Research indicates that students' perceptions of the usefulness of a STEM major are closely linked to their intentions to persist or leave that major (Eccles et al.). According to the quantitative results, career goals were the single most important factor that influenced the STEM persisters to continue their STEM majors (see Figure 4). In this case, the perceived value of STEM fields was high for the persisters because their STEM majors fit with their personal goals and long-term career aspirations. One of the focus group participants' (Sarah) comments explains the utility value construct much better: "I am interested in becoming a physician and I guess I have to do undergraduate science in order to achieve this goal." The value of science in this case is high for Sarah because of its long-term utility. That is, for Sarah, science courses are a means to an end, rather than an end itself (Eccles, 2005).

For the STEM switchers, it was a change in personal and career goals that influenced them to switch majors. As the quantitative results indicated (see Figure 5), the majority of the switchers indicated that they lost interest in STEM majors and started to develop interest in non-STEM majors. In some cases, their STEM majors no longer fit with their long-term career and personal goals; therefore, it was imperative for them to switch to non-STEM majors that fit with their future goals. Consequently, the perceived value of STEM fields for these switchers was decreased by their loss of interest in STEM majors and their growing interest in non-STEM majors. Kourtney's remarks support this point: "I switched from engineering to rehabilitation and human services…because I started having interest in it. I started realizing I wanted to be involved in helping people rather than the hands-on side of things." Given that Kourtney's long-term goals became an integral part of her identity and needs, a major that fulfilled these goals has a high utility value for her (Eccles, 2005). In other cases, of course, some switchers might have persisted if they had not experienced other factors such as a lack of role models and academic or institutional support in the form of communication skills and teaching quality, so it is important not to overgeneralize from any one factor.

Cost value. The value of STEM fields to an individual is also influenced by the perceived cost and benefit of the major. The variables that may be associated with the cost of a STEM major or career include the amount of effort needed to succeed, the loss of time that could be used to engage in other valued activities, and the psychological cost of failure (Eccles et al., 1983). As they were involved in their STEM classes, the STEM major persisters and switchers appear to have weighed the perceived costs and benefits of their majors and future careers, which helped to guide their decision to persist or leave the STEM fields. For the switchers, the costs associated with their STEM majors and careers were the poor performance in the major, the long working hours for STEM professionals, the cost of STEM education, too much workload in STEM classes, the feelings of isolation in STEM classes, and the negative experiences in STEM classes.

While the STEM persisters also weighed the perceived costs described above, they were nevertheless willing to persist. Understanding why these two populations differed in their decisions is, of course, complicated. The interaction of multiple factors is impossible to understand fully, but it is clear that to persisters, the benefits outweighed the associated costs. These benefits included extrinsic motivations such as career opportunities and good salary and intrinsic motivations such as interest/enjoyment of the STEM major. As Mercy said, "…even though it is hard, I am doing something that I like or interested in… all of this hard work is going to pay off later on, because we have a huge field out there waiting for us...” Thus, the perceived value of STEM fields for the persisters appears to have been increased by their enjoyment of their STEM majors and job prospects. In contrast, for switchers the value of STEM fields appears to have been decreased by the perceived costs associated with their STEM majors.

Financial value. The financial value of a task-related choice has to do with all the financial rewards associated with a choice. For STEM majors, this can include scholarships and tuition waivers, or a potential good salary. These financial rewards may be viewed as extrinsic characteristics (Hagemeier & Murawski, 2014).

In the focus group interviews, all of the participants (persisters and switchers) indicated that they were attracted to STEM majors because of the high remuneration for STEM workers. This finding suggests that both persisters and switchers had high financial value for STEM fields. For example, when asked why she decided to pursue a STEM major, Kim (switcher) said “…the high pay for STEM professionals was definitely a core.” Kelly (switcher) also commented that “I did a lot of research into my STEM field. I realized that it is hard to get into the field, but the salary is good and there is a huge shortage of personnel right now,” echoing Mercy’s quote earlier in the previous section. However, one may ask why STEM switchers like Kim and Kelly left their chemical engineering and aviation majors respectively, despite high perceived financial value, while Mercy has persisted in her petroleum engineering major. One answer could be that the subjective task value alone is insufficient to influence students to persist in the STEM fields in the presence of other factors. Perhaps students normally weigh all the subjective task value components (e.g., attainment, interest, utility, and perceived cost values) in their decision to persist or leave the STEM fields. Future research could examine the weighting and interaction of these factors via regression and critical path analyses, for example.

Expectations for Success in STEM Careers

Another key component of the Eccles et al. (1983) expectancy-value model is expectations for success. The result of the non-testable research question 1 suggested that poor performance in STEM majors was one of the factors that influenced STEM switchers (both survey and focus group participants) to leave the STEM fields. The result of this non-testable research question was corroborated by the statistical analyses. That is, the scores of STEM major switchers were significantly lower than those of the persisters on the expectations for success in STEM careers subscale, suggesting that the STEM switchers felt that their poor performance in STEM majors was an indication that they might not be successful in STEM careers. It is important to remember that poor performance (and thus, expectations for success) could be the result of the interaction of multiple factors. While this could include a lack of academic preparation or even aptitude, it also includes explicit and implicit messages and bias against women in STEM, a lack of support, poor teaching quality, and misconceptions about what kind of STEM career is possible.

Participants' expectations for success in STEM careers also appears to be affected by their perceived success in STEM courses and the value that they place on STEM fields. In other words, participants weighed their success in STEM courses and the value they placed on STEM fields and arrived at the decision to persist or leave the STEM fields. For STEM persisters, their low perceived success might predict future success in

STEM careers, and that it was better for them to leave their STEM majors now. One possible explanation is that the STEM switchers held lower self-efficacy beliefs about STEM careers than did STEM persisters. The STEM switchers' low perceived value of the STEM fields might also affect their persistence in STEM careers.

Implications for Recruiting and Retaining More Women in STEM Programs

The following recommendations are based on the findings of this current study and the knowledge and understanding obtained from the relevant literature. Although this study focused on women in collegiate STEM programs, the recommendations provided here may be useful for school counselors and administrators, teachers, and policymakers involved in precollege and college education.

Our goal should be to understand what factors encourage people to switch and what interventions can be generated to intervene at key moments to recruit and retain those who would otherwise be STEM switchers. Because there are so many factors described in the previous sections for both persisters and switchers, it may be helpful to consider what the typical STEM "switcher" looks like before discussing potential implications for change. To this end, a composite sketch of a switcher is presented below that combines the quantitative and qualitative data discussed previously in a manner that may make it easier to see how all these factors conspire to limit the number of females who pursue and persist in STEM majors and careers. While no single person would likely exhibit all the characteristics presented in this character sketch, "Hannah" represents a combination of the most significant factors for female STEM switchers. Her story will be revisited after the implications to see how the recommendations for intervention could change the experiences of women like Hannah.

Composite Character

Hannah is a 19-year-old first-generation college student. She studied math, science, physics, biology, and chemistry in middle and high school and obtained good grades in all these subjects. While Hannah was very good in STEM subjects at the precollege level, she did not have an interest in pursuing a career in a STEM field. She wanted a career in librarianship because she is good in English and has an interest in working with people. Hannah has heard from her peers that the STEM professions are populated with “nerds” and “geeks.” She has also seen TV shows like the “Big Bang Theory,” in which female scientists such as Sheldon are portrayed as unpopular and unattractive. However, her parents told her that because she was good at science, she could get a good career if she were to pursue a STEM profession.

Following the advice of her parents, Hannah decided to pursue chemical engineering at Empress College. In her first semester, she took classes in calculus and biology. There was only one other female student in her calculus class. She also decided to take an English literature course just for sheer interest.

Hannah did well in her biology and chemistry classes but found calculus very hard because she had not studied it as much in middle and high school. She invested a lot of time studying calculus as a result, at the expense of extracurricular activities that she enjoys. The instructor lectured from a textbook in every class, and Hannah assumed he did so because everyone in the class should be “smart enough” to learn from the book by itself, so she at first asked for help from her classmates, most of whom were male.

One day, Hannah approached her calculus instructor after class and asked him if he could provide some help after class so that she would be able to follow the class lecture. Her professor told her that “women in science is a joke.” Hannah was shocked and depressed, and later angry; she was good in science, just not in calculus (yet!). She did not report the issue to the school authorities, however, because she was afraid that the professor might retaliate. At the end of the first semester, Hannah's grades reflected her struggles with this course. Even though she had managed to get a B-, it had come at the expense of literally all her free time and she'd even had to quit her part-time job. In contrast, she'd gotten an A in English and her instructor was fantastic; she found herself more and more drawn to her first choice of career and decided to switch to an English major at the start of the second semester.

Thus, it is clear from the above scenario that Hannah's decision to switch from her STEM major was not only because she found calculus difficult. Rather, if she had found calculus exciting and satisfying and if she had found institutional support, role models, and mentors, she might have persisted in her major. This kind of attrition of students like Hannah in STEM programs could be prevented if the right kinds of interventions are implemented at the right times.

Academic and Institutional Interventions

Findings from this study showed that support from faculty, GTAs, and college writing and tutoring centers; quality of faculty teaching, and exposure to role models all play key roles in STEM students' performance and, therefore, retention, which has implications for college administrators looking to recruit and retain more women into STEM fields:

1. Recruit more faculty and GTAs with good teaching skills, and train existing faculty to be good teachers with the knowledge and skills to advise and mentor students in general, and women specifically.

2. Provide more qualified staff for writing and tutoring centers and encourage STEM major student, to patronize these centers. Consider specific tutoring and support centers for each discipline and make corresponding efforts to assign GTAs and faculty (especially women) in those programs to provide support in these centers.

More Female Faculty as Role Models

The current study and previous research indicate that female role models in STEM programs can be effective in recruiting and retaining more women in those STEM programs. According to Drury et al. (2011), the presence of more female professors in STEM departments benefits female STEM students because it can give them a sense of belonging in STEM. One of the focus group interview participants (Kourtney) commented that having more female professors, especially in traditionally male-dominated STEM fields like engineering, can encourage more female students to enter the program: “We have quite a bit of female students in engineering and so having more female professors in the engineering department will be really a big help and will also attract more women to engineering major.” However, recruiting more female professors into STEM programs poses its own challenge. In order to produce more female professors, we need to be able to recruit and retain more female students in STEM programs who will then graduate and become university professors—a kind of Catch-22.

Thus, to increase the participation and retention of more women in STEM fields, it is suggested that:

1. STEM departments should work with their universities to recruit female professors into STEM programs, recognizing that competitive salaries (equity) will be required to achieve diversity goals. Since this is a limited pool to draw

from, it is likely that industry will be a key resource pool, which make it even more likely that higher salaries will be required.

2. The university should invest more into training all professors to become good teachers, mentors and advisers, especially for those who come from industry and do not necessarily have good teaching experience or skills.
3. Invest more in the success of all STEM faculty and change the culture of STEM departments. Women in STEM departments are as likely to leak out of the pipeline as are students and professionals in industry, and for many of the same reasons. Recruiting more women into STEM departments without changing the culture to ensure their success will fail in the long run.

Build "First-Year Experiences" Orientation and Support Structures for Female STEM Students

Research has shown that first-year seminars have a positive impact on student persistence overall (Porter & Swing, 2006), especially when they focus on success skills and orientation to support structures on campus. Because the findings from this study and other related studies have indicated that most female STEM attrition occurs in the first year, it is recommended that STEM departments should consider first-year seminars for STEM students that are designed to address pressures to switch that women in STEM majors face. An initial seminar should be organized at the start of the program, while the other seminar should take place soon after grades have been submitted for the first-semester coursework. Based on the findings of this study, these seminars should focus on the following:

First seminar:

1. Invite individuals from the student success center to give talks on study and time management skills to help students prepare for the increased workload of "weed-out" courses and to overcome challenges with teaching quality and interpersonal communication skills of STEM faculty. Share and connect students with resources such as support groups and advising that is targeted and specific, preferably led by women as well as men.
2. As part of this seminar, consider targeted break-out sessions for women in STEM where appropriate. Invite female students (e.g., fourth-year students) from different STEM majors to share their experiences on how to be a successful STEM student. This could help to address the lack of female role models and students in STEM programs by showing that success is possible even when confronting other challenging factors and by showing that STEM majors can be about more than what they might seem to be from introductory classes (e.g., helping people).
3. As part of these seminars or other programming, invite female STEM professionals from academia and industry to serve as guest speakers. These guest speakers could talk about the successes they have achieved in STEM fields as women, the career opportunities for women in STEM fields, as well as some of the challenges women in STEM fields face and how to overcome them.
4. The VIES instrument (i.e., the value of STEM fields and expectations for success in STEM careers subscales) could be administered to participants prior to or during this first year in order to see if and how this changes over time and to better understand when interventions might be needed and with whom. The

expectations for success in STEM careers subscale could also be used to identify students with low self-efficacy in STEM careers and to follow up with them.

Second seminar:

1. Prior to the second seminar, the perceived success in STEM courses instrument and the VIES could be administered during the mid-semester exams week. Scores on the value of STEM fields could be used to identify those whose values for STEM fields may be changing over time because of exposure to the STEM curriculum. To illustrate this point, assume a student scored high on interest value but low on cost value during the first seminar. Assume further that the same student scored low on interest value but high on cost value in the second seminar. Clearly, this is an indication that this student is losing interest in STEM and may be more likely to switch at the end of the first year unless the reasons for his or her loss of interest in the STEM program is investigated and the appropriate intervention measures are put in place, if relevant.
2. A second goal of administering the VIES instrument is for program evaluation, to identify, for example, students who may be responding to positive STEM experiences as a result of modifications to STEM programs. If the program is functioning as designed, for example, it might be expected that most female students' scores on interest value, utility value, and expectations for success in STEM careers are high because the STEM department decided to hire more female professors and to provide more major-related advising and support. Trends and issues that arise from comparison between test results should also be used to create and inform what happens in this second seminar.

3. After the second semester, efforts should be made to identify students who have been successful in navigating the pressures they have seen (e.g., through the interventions and support structures generated and shared during the first seminar) and provide opportunities for students to share their learning experiences in STEM, including their successes and difficulties during the first semester.

Change Early STEM Experiences So That Students Develop Intrinsic Value for STEM Fields

The results of the quantitative study showed that women who are more likely to switch from STEM programs have lower interest value for STEM fields than do those who are more likely to persist in STEM programs. Findings from the focus group interviews also suggested that the women who entered STEM programs with intrinsic motivations for STEM careers and majors persisted at a higher rate than those who entered STEM with other motivations. At first glance, this might suggest that we should strive to recruit more women into STEM who are intrinsically motivated toward STEM. However, this would only reach those who are already more likely to persist. In reality, we must reach those who *could* be intrinsically motivated by STEM activities but who have not experienced high-quality STEM courses that provide the full pictures of STEM fields. This requires changing early STEM experiences to reflect the full range of STEM career activities and their relation to society (e.g., how they help people) and to make those experiences relevant and applied in the classroom (e.g., engagement). It also suggests that we should continue this process during the college years as well. The following suggestions may be helpful in accomplishing these goals:

1. Create partnerships with STEM field occupations. These partnerships should involve the schools or STEM companies hosting workshops, all-day events or job

fairs. During these events, companies should showcase the full range and impact of the work they do. Women in STEM careers should be a prominent part of these activities, and both female students and their parents/guardians should be encouraged to attend these events and ask questions about job/internship opportunities, financial benefits, and challenges in working in STEM fields.

2. Teachers and professors should endeavor to integrate meaningful, applied STEM lessons and labs that emphasize not just the processes of STEM but their application to real-world problems that students care about solving. They should also organize STEM field trips for students in STEM programs. These STEM field trips should be well planned and integrated into the coursework, for example, planning a trip to an oil field for students in petroleum engineering.
3. School teachers should continue to expose girls and young women to relevant STEM applications like coding, robotics, and science Web quests. Active participation (Renninger & Hidi, 2016) in STEM-related activities can spark girls' interest in STEM, but equal emphasis should be placed on both the science and the application to real problems that help society.

STEM Professions Need to Change the Culture and Nature of STEM Careers

While this study looked only at college students in STEM majors, interventions at this level that are not replicated in some fashion in the industry will be unlikely to solve the problem of underrepresentation of women in STEM professions; it does little good to provide more women STEM graduates if those graduates then enter an inhospitable world with the same problems as collegiate STEM programs! Findings from this study and the literature suggest that women are concerned about the nature and working conditions of STEM occupations. Workplace and organizational culture are important factors in retaining women in STEM fields. Similarly, certain work conditions such as inflexible schedules and long weekly work hours (Glass et al., 2013) may also be a deterrent. Flexibility of careers in allowing for life goals was also a factor mentioned by the participants in this study. Thus, it is suggested that:

1. STEM organizations need to make accommodations for men and women who wish to balance work and family life. Both paid maternity and paternity leave will allow more women to remain in STEM careers, as they continue to bear the primary responsibility for the home and children even in two-income families and, subsequently, often feel pressure to give up their careers to attend to their families. Reentering the STEM professions also continues to be a challenge for those who are out for any length of time, suggesting that there is tremendous room for improvement in the policies and culture of the STEM professions themselves.
2. The top executives of organizations for women (e.g., American Association of University Women and National Center for Women and Information Technology) should continue to lobby and negotiate favorable working conditions for STEM occupations and equity of pay and advancement. While this study looked only at factors for retaining women in collegiate STEM programs, there are clear implications for STEM fields as well.

Better Representation of Women in STEM Fields in the Media

The literature and the current study suggest that women in STEM fields are concerned about the way they are portrayed in the media. One of the American TV shows which has been criticized for the way women in science are portrayed on the show is “The Big Bang Theory” (Pollack, 2013). This TV show was also cited by focus group interview participants as one of the reasons that girls and women do not want to enter STEM fields. In “The Big Bang Theory” TV show, two of the scientists on the show are women and are portrayed as unattractive, dowdy, and social misfits, whereas a character who is an actress is portrayed as attractive and popular (Pollack, 2013). These types of portrayals of women in science perpetuate stereotypes that discourage many young women from entering the STEM fields. A quotation from one of the STEM persisters (Maria) illustrates the need for a better representation of women in STEM in the media:

> I think representation is so important. We do see women in each STEM field in the media, but one example that comes to mind is the Big Bang Theory. You see, Penny, she is the attractive and funny one, and the one all the men want to date. She is cute and wants to be an actress, I think. Meanwhile, the smart women like Bernadette, a microbiologist, and Amy, a neurobiologist and some crazy other woman scientist are not idolized. Amy is cocky and funny, but she is not attractive. The show implies that “smart women are not attractive; attractive women are not smart.” There is the need for a better representation of women in STEM in the media. It is not true that either you are smart or pretty. If you are pretty and smart, you are just like unobtainable unicorn. They say ‘wow you are so rare.’ I think a good part of it has to do with representation. Teach the little girls that you can be both beautiful and smart, and even if you are smart and not beautiful, it doesn’t matter.

This problem is too large to be addressed with a single recommendation and is beyond the scope of this study, of course, but representations of women in STEM remain a consistent factor that influences both retention and recruitment of women into the STEM professions.

Summary and Conclusion

Based on the findings discussed above, it can be concluded that the current study provides strong support for the continuous use of Eccles' et al. (1983) expectancy-value model of achievement-related choices for future research on STEM persistence and attrition. In particular, this study found evidence to support the key components of the expectancy-value model: expectations for success and the subjective task value (attainment, interest, utility, and perceived cost).

It could also be inferred from the findings of this study that one of the ways to minimize STEM attrition and maximize persistence rates is to focus on addressing the reasons for low expectations for success (self-efficacy beliefs) and low value for STEM fields. As the results of this study suggest, the women who were more likely to persist in STEM majors were those who placed a higher value on STEM fields and had higher expectations for success in STEM careers. Women with high utility value (career goals) for STEM fields were more likely to persist, while women with low intrinsic value for STEM careers (loss of interest in STEM) were more likely to switch. Creating experiences that result in more women (and men) with these beliefs is therefore a critical goal, and the VIES instrument can be helpful in understanding and promoting these efforts.

Revisiting the Composite Character

The following section revisits Hannah to see how her experiences would have been different if the above recommendations were implemented when she started the chemical engineering program.

Hannah is a 19-year-old first-generation college student. She did well in STEM subjects such as math, science, physics, biology, and chemistry in middle and high school. Hannah's favorite show stars a girl like her who is popular at school and who is great at science, which she uses to help solve local problems in her community, and Hannah and her friends watch the show every week. Still, Hannah is not certain that science is the right career for her, even though her parents seem sure.

Hannah decides to pursue a hard science major (chemical engineering) at Empress College, which she will be attending with one of her friends from school, who is also pursuing a STEM major. In her first semester, she takes classes in calculus, biology, and chemistry toward her chemical engineering major. She also decides to take a class in English just for sheer interest. Although there were a few other women in her STEM classes, including her friend, the vast majority of students are men.

Before they started actual classes during the first semester, Hannah and her friend attend a 2-week seminar for first-year STEM students. During the seminar, the organizers from the various STEM departments invite people from the student success center to talk about time management and study skills which will help students to be adequately prepared for their first STEM courses, which historically have high attrition rates. Female students from different STEM majors share their experiences on how to navigate through the challenges of "weed-out" courses in the first year and Hannah is relieved to see that other women have been successful despite having heard how "it's mostly men" who major in Chemistry. A chemist from a major pharmaceutical company also spoke to the group about how her work has helped to create new drugs to treat Parkinson's disease, which her mother has. Other professionals in STEM fields (academia and industry) were also invited to share their success stories and to talk about the different career paths and opportunities in STEM fields.

After the seminar and upon careful examinations of her responses to the individual items on the VIES, the STEM program coordinator of her STEM department discovered that Hannah's scores on the utility (career goals) and cost values (relative cost value item was reverse-coded) were high, suggesting that she strongly agreed to statements on the VIES that working in a STEM career would help her to fulfill her career aspirations, and that working in a STEM field would not be a waste of her time. These results suggested that Hannah had high career motivation. However, Hannah's overall mean score on the expectations for success in STEM careers subscale was just a little above 3.0, suggesting that she neither agreed nor disagreed to the statements about whether she would be successful in a STEM career.

At the beginning of the semester in which Hannah started her program at Empress College, the chemical engineering department employed two female professors and two female GTAs because they read from the current study that female faculty role models benefit women in STEM programs. These female professors happened to be the instructors for two of the classes (Calculus I and Chemistry I) that Hannah registered for during her first semester in the engineering program. The department also had recently created a tutoring center for students in the chemical engineering department and encouraged the students in the department to make use of this center and to also visit the college writing center for academic writing assistance. In fact, the female professors and the GTAs who were newly employed in the department spent time at the tutoring center to help students to understand basic chemical engineering concepts and to address any academic-related concerns that students might have. Hannah also enjoyed her professors' teaching methods, especially the group work and peer teaching, which were the result of a faculty development program to help improve teaching methods.

The *perceived success in STEM courses* and the *VIES* instrument were administered to all students in STEM programs during the mid-semester exams week, with the view to identifying those who may be responding to positive STEM experiences or otherwise.

During Hannah's second semester of her first year of college, the STEM program coordinators at Empress College organized a second seminar. The purpose of the second seminar was to discuss the students' experiences in the various STEM programs during the first semester. Based on the results of the VIES and perceived success instruments, two groups of students were identified— students who were showing signs of *switching pressures* such as low *interest* and *utility* values and high *cost* value and students with high *interest, attainment, and utility* values.

The survey data showed that Hannah was among the group of students whose scores on the *perceived success in STEM courses* and *VIES* subscales were very high. Thus, early STEM experiences and interventions helped Hannah realize that chemical engineering could be a rewarding career; one she believed she could be successful in. The first-semester examination results also indicated that Hannah was one of the best students in her Calculus I, Biology I, and Chemistry I classes, most likely because of the high use she made of the support centers and availability of faculty outside of class. While she continued to take and enjoy English classes, she continued on in her chosen STEM major and was able to graduate with her BS in Chemistry in 4 years. She is now looking for jobs in chemical engineering, but has not ruled out graduate education.

While the two composite sketches of Hannah reflect a diverse set of circumstances that no single person is likely to experience, they are nonetheless illustrative of the factors that influence women to consider STEM fields and to either persist or switch out of STEM majors. As such, Hannah's experiences serve to illustrate the issues we face in attempting to address the leaky pipeline problem in STEM education.

Limitations

Limitations are weaknesses in a research study, which in most cases are out of the control of the researcher (Simon, 2011). The results of the current study should be interpreted with caution for several reasons. First, the online survey was administered in the summer, when most students were on break. Thus, it is possible that some students were not checking their school email accounts at the time the survey was administered and, therefore, did not respond to the survey. This explains the reason why the survey response rate was relatively low. Thus, the ability to generalize the findings from the study to the sampling frame is limited. Second, the female participants of the current study were drawn from a single institution; therefore, the findings from the study may not necessarily be applicable to female students from other institutions.

Third, the survey items relating to STEM major persistence and attrition factors were not examined in terms of importance (e.g., using a Likert-type scale). Survey participants were only asked to select the factors that they felt influenced them to persist or switch from STEM majors, not to indicate which were most important. Thus, it was impossible to rank the factors based on the responses of the participants. The mere fact that most students selected a particular factor did not necessarily mean they regarded it as the most influential factor, and the fact that a factor was most common in the population similarly does not imply importance, just prevalence. The researcher tried to address this limitation through the qualitative study by asking the focus group interview participants to rank the factors that influenced them to persist or switch from STEM majors.

In addition, the focus group interviews were conducted face-to-face at the target university's campus. Therefore, while individuals who were out-of-state or off-campus participated in the online survey, they could not attend the face-to-face focus group interviews. The opinions of such individuals could have added some richness to the focus group data. Finally, there were some limitations in respect to the focus group interview membership. In one of the focus group sessions organized for the STEM major persisters, although four people were scheduled, only one person attended. Likewise, only one person (instead of four) attended one of the focus group sessions organized for STEM major switchers. While the responses of all the focus group interview participants were included in the focus group data, the lack of equality among the group membership undermined the richness of data that the focus group discussion could generate.

Future Research

To have more statistical power, future research would benefit from a larger and more diverse sample population. To this end, future research is encouraged to include students from other universities.

Owing to the fact that this study used a relatively small sample, the distribution of students by major did not allow for meaningful statistical analysis of the rates of switching by STEM majors. Therefore, future research should examine the rates of switching by STEM majors to determine if students have the tendency to switch from a particular STEM major at higher rates than other STEM majors. This is likely to reflect local programs and conditions but could still be an important tool for institutional intervention. Such research could indicate where educators need to focus retention and recruitment efforts.

The value of STEM fields subscale consisted of eight items that tested each aspect of the subjective task value as a whole. Future research should augment the number of items of the value of STEM fields subscale to as many as 20 items. Five items per each component would allow them to potentially function as subscales to be analyzed and compared. Analyzing the key components of the subjective task value separately would help to determine the component that students value most or less. The financial value component should also be tested as well.

Finally, this research should be seen as addressing only one of three key areas in the leaky-pipeline metaphor for women in STEM. Future research should focus on exploring the reasons why women enter the STEM fields in the first place (recruiting) and on the reasons they persist in STEM fields and the factors that influence them to do so. This will help to compare the reasons that STEM persisters and switchers enter STEM fields and what factors motivate them to persist or not persist in STEM majors and careers.

APPENDICES

Appendix A

Initial Study Paper and Pencil Survey

The purpose of this survey is to ask college students about their perceptions regarding the computer technology field. The data will be used for educational purposes only. Participation is voluntary and your responses shall be kept anonymous. You are free to end your participation at any time without any penalty. The survey should take about 5-10 minutes to complete. Thank you for participating.

Please tick one:

Male ______

Female_______

What is your age in years?

____

Is English your first language? Please check one.

Yes ☐

No ☐

Are you an international student? Please check one.

Yes ☐

No ☐

What type of program are you in? Please check one.

☐ Undergraduate

☐ Masters

☐ Doctoral

☐ Other (Please specify)__________________

In what department is your current program? (e.g. Teaching and Learning)

____

How many years are you into your current program?_______

Following is a set of items that refers to a variety of issues related to how people perceive computer technology field/jobs (e.g. Computer Hardware &Software Development, Database Administration, Web Development, etc.). Please rate each of the statements below by circling the appropriate option that best describes you.

VALUE OF COMPUTER TECHNOLOGY FIELDS

Please rate each of the statements below by ticking the appropriate option that best describes you.	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
Working in a computer technology field would be a waste of my time					
I would take a course in computer technology even if it were not required					
I find computer technology related jobs very interesting					
I don't think working as a computer technology person would help me achieve my professional aspirations					
Computer technology is an important field to me					
I would enjoy working in a computer technology field					
I would rather do something else than take on a computer technology job					

INTEREST IN A DEGREE IN COMPUTER TECHNOLOGY

Please rate each of the statements below by ticking the appropriate option that best describes you.	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
I am not interested in a degree in computer technology					
Computer technology would be a good college major for me					
Computer technology classes are boring					
Being in a computer technology class would be fun for me					
The idea of being in a computer technology class excites me					
I would enjoy taking computer technology courses					
I dislike computer technology courses					

EXPECTATIONS FOR SUCCESS IN COMPUTER TECHNOLOGY FILEDS

Please rate each of the statements below by ticking the appropriate option that best describes you.	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
I feel I have what it takes to succeed as a computer technology professional					
I would certainly feel useless on a computer technology related job					
I feel I have a number of good qualities to be successful in the field of computer technology					
I do not think I can make an impact if I take on a computer technology job					
I feel I would have something to be proud of as a computer technology practitioner					
I do not think I will succeed in the computer technology field					
I would be able to succeed in a computer technology field as well as most other people					
I do not think I can achieve anything meaningful as a computer technology professional					

Appendix B

Current Study: Online Survey

STUDY INTRODUCTION & INFORMED CONSENT   Block Options

QA

TITLE:
Examining the Reasons that Female Students Leave or Persist in Collegiate Science, Technology, Engineering, and Math (STEM) majors: A Mixed Methods Study.

Principal Investigator: Joseph Appianing
Phone # 701-885-2079
Department: Teaching and Learning
Academic Advisor: Dr. Richard Van ECK , 701-777-3528

A person who is to participate in the research must give his or her informed consent to such participation. This consent must be based on an understanding of the nature and risks of the research. This document provides information that is important for this understanding. Research projects include only subjects who choose to take part. Please take your time in making your decision as to whether to participate. If you have questions at any time, please ask.

As a student in (or previously) STEM-related major at UND, you are invited to participate in a study dealing with the reasons that students leave or persist in collegiate STEM majors. Your participation in the survey will last approximately 5-10 minutes.

Although this study involves no more than "minimal risk" such as emotional, psychological or discomfort that one may often experience when being subjected to questioning, some participants may feel somewhat uncomfortable or upset in answering questions pertaining to their experiences in particular majors. Should you become upset at any point in the study, you may stop at any time or choose not to answer the question(s). If you would like to talk to someone about your feelings concerning this study, you may contact UND's Counseling Center at 777-2127.

You will not be paid for participating in the study. But, as a way to thank you for your participation, you will be given the opportunity at the end of the survey to decide if you wish to be included in a random drawing for a chance to win an Amazon gift card worth $50.00.

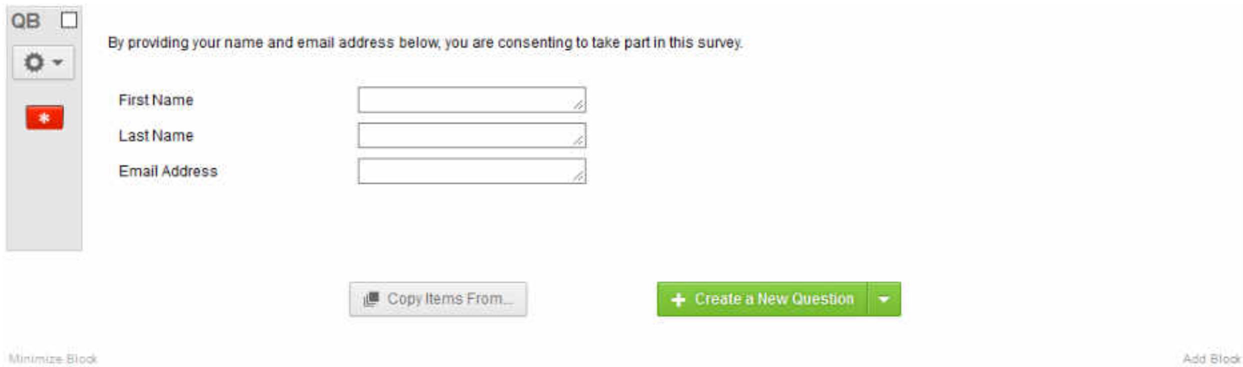
You may not necessarily benefit directly from participating in this study. However, it is hoped that in future other people might benefit from this study because findings from the study will help society to gain a better understanding of why some women may decide to drop from STEM-related majors to non-STEM majors, and why some may choose to persist in STEM majors.

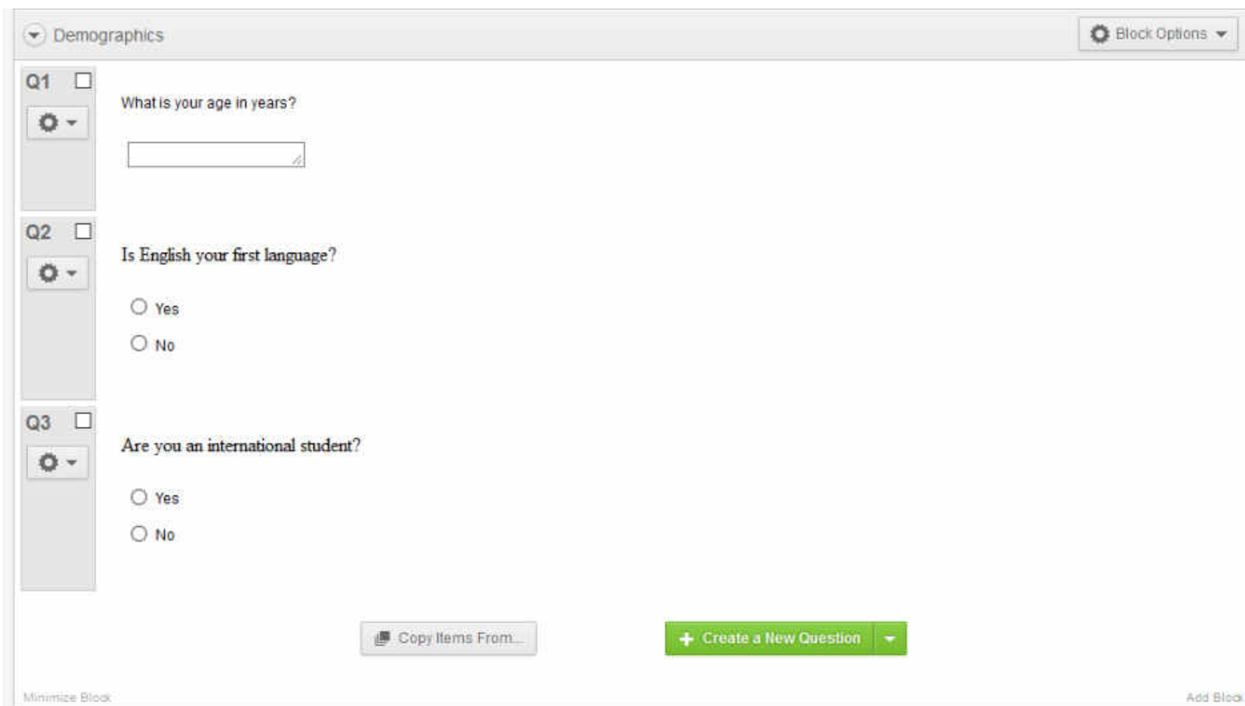
Your participation in this study is voluntary. You may choose not to participate or you may discontinue your participation at any time without penalty or loss of benefits to which you are otherwise entitled. Your decision whether or not to participate will not affect your current or future relations with the University of North Dakota.

The records of this study will be kept private to the extent permitted by law. Your study record may be reviewed by Government agencies, the UND Research Development and Compliance office, and the University of North Dakota Institutional Review Board. To ensure that your responses remain anonymous and confidential, any information that is obtained in this study, which can be identified with you such as your name or email address, will not be used in data analysis or any final reports. Only the principal investigator and academic advisor will have access to the data. After the data is analyzed, the principal investigator will destroy all data in his possession. Only the academic advisor will keep his copy of the data for at least 3 years as required by the Institutional Review Board, after which time he will destroy the data.

If you have any other questions, concerns, or complaints about this study please contact the principal investigator Joseph Appianing at (701) 885-2079 or the academic advisor at 701-777-3528. If you have questions regarding your rights as a research participant, or if you have any concerns or complaints about the research, you may contact the University of North Dakota Institutional Review Board at (701) 777-4279.

You must be 18 years of age or older to participate in this study.


QB
By providing your name and email address below, you are consenting to take part in this survey.
First Name
Last Name
Email Address
Copy Items From...
Create a New Question
Minimize Block
Add Block


Demographics
Block Options
Q1
What is your age in years?
Q2
Is English your first language?
Yes
No
Q3
Are you an international student?
Yes
No
Copy Items From...
Create a New Question
Minimize Block
Add Block

Education- Participants at UND

Block Options

Q4

Are you currently enrolled at UND?

- Yes
- No

If No Is Selected, Then Skip To What was your last major while you we... Skip Logic

Q5

What type of program are you currently enrolled in?

- Undergraduate
- Masters
- Doctoral
- Other (please specify

Q6

How many years are you into your current program?

Q7

What is your CURRENT major at UND?

Q8

How would you classify your CURRENT major? (e.g., Computer Science major falls under Technology; Biology major falls under Science, etc).

- Science
- Technology
- Engineering
- Math
- Not in any STEM-related major at the moment

If Science Is Selected, Then Skip To Rate the following statements in rela... Skip Logic

If Technology Is Selected, Then Skip To Rate the following statements in rela... Skip Logic

If Engineering Is Selected, Then Skip To Rate the following statements in rela... Skip Logic

If Math Is Selected, Then Skip To Rate the following statements in rela... Skip Logic

Q9

What was your previous STEM major?

Q10

How would you classify your previous STEM major? (e.g., Computer Science major falls under Technology; Biology major falls under Science, etc).

- Science
- Technology
- Engineering
- Math

Q11

When did you SWITCH your previous STEM major?

- First year first semester
- First year second semester
- Second year first semester
- Second year second semester
- Third year first semester
- Third year second semester
- Fourth year first semester
- Fourth year second semester
- Other (Please specific)

Q12

Why did you SWITCH your previous STEM major? Select all that apply.

- Poor performance in the major
- High financial cost associated with the major
- Lack of role models and mentors
- Feelings of isolation because too few peers pursue the major
- Discriminations on the basis of sex, race, or ethnicty
- Major didn't allow me to hold a part-time job
- Loss of interest in the major
- Growing interest in non-STEM majors
- Poor quality of teaching in STEM classes
- Too much workload in STEM classes as compared to non-STEM classes
- Negative experiences in STEM classes
- Other (please specify)

Q13

Rate the following statements in relation to the STEM major that you switched FROM.
How **SUCCESSFUL** did you feel...

	Very unsuccessful	Unsuccessful	somewhat unsuccessful	Undecided	Somewhat successful	Succesful	Very successful
...when you were in your previous STEM major overall?	○	○	○	○	○	○	○
...about the grades you got on tests and assignments in your previous STEM major?	○	○	○	○	○	○	○
...in achieving the learning goals you set for yourself in your STEM major?	○	○	○	○	○	○	○
...Knowing that you made an honest effort to make progress during the year in your STEM major?	○	○	○	○	○	○	○
...in doing all the work, meeting deadlines, keeping up with the reading, studying, etc. in your STEM major?	○	○	○	○	○	○	○
...in gaining new knowledge and understanding from your STEM major courses?	○	○	○	○	○	○	○

Q14

Have you had any other majors besides the two you have described already?

- ○ Yes
- ○ No

Q15

If yes, what was the other major you had?

Q16

How would you classify that other major?

- ○ Science
- ○ Technology
- ○ Engineering
- ○ Math
- ○ Other

If **Science** Is **Selected**, Then Skip To **End of Block** — Skip Logic

If **Technology** Is **Selected**, Then Skip To **End of Block** — Skip Logic

If **Engineering** Is **Selected**, Then Skip To **End of Block** — Skip Logic

If **Math** Is **Selected**, Then Skip To **End of Block** — Skip Logic

If **Other** Is **Selected**, Then Skip To **End of Block** — Skip Logic

Q17

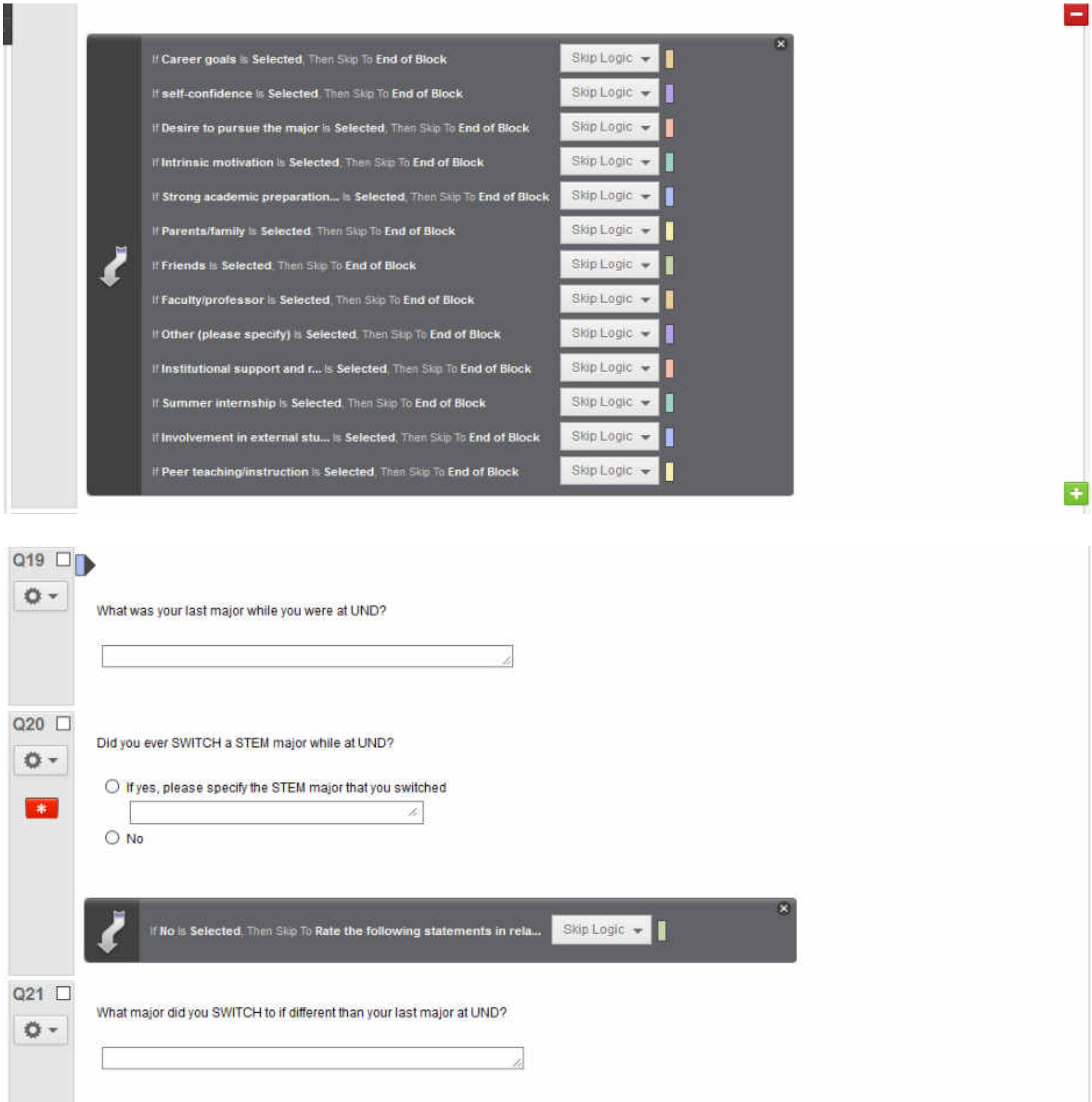
Rate the following statements in relation to your current STEM major.
How **SUCCESSFUL** do you feel...

	Very unsuccessful	Unsuccessful	somewhat unsuccessful	Undecided	Somewhat successful	Succesful	Very successful
... in your current major overall?	○	○	○	○	○	○	○
...about the grades you got on tests and assignments in your current major?	○	○	○	○	○	○	○
...in achieving the learning goals you set for yourself?	○	○	○	○	○	○	○
...when it comes to Knowing that you made an honest effort to make progress during the year?	○	○	○	○	○	○	○
...in doing all the work, meeting deadlines, keeping up with the reading, studying, etc.?	○	○	○	○	○	○	○
...in gaining new knowledge and understanding from your courses?	○	○	○	○	○	○	○

Q18

Which of the following factors have influenced you to PERSIST in your current major? Select all that apply.

- ☐ Career goals
- ☐ self-confidence
- ☐ Desire to pursue the major
- ☐ Intrinsic motivation
- ☐ Strong academic preparation in math and science
- ☐ Parents/family
- ☐ Friends
- ☐ Faculty/professor
- ☐ Institutional support and resources
- ☐ Summer internship
- ☐ Involvement in external student clubs & organizations
- ☐ Peer teaching/instruction
- ☐ Other (please specify)


If Career goals Is Selected, Then Skip To End of Block
If self-confidence Is Selected, Then Skip To End of Block
If Desire to pursue the major Is Selected, Then Skip To End of Block
If Intrinsic motivation Is Selected, Then Skip To End of Block
If Strong academic preparation... Is Selected, Then Skip To End of Block
If Parents/family Is Selected, Then Skip To End of Block
If Friends Is Selected, Then Skip To End of Block
If Faculty/professor Is Selected, Then Skip To End of Block
If Other (please specify) Is Selected, Then Skip To End of Block
If Institutional support and r... Is Selected, Then Skip To End of Block
If Summer internship Is Selected, Then Skip To End of Block
If Involvement in external stu... Is Selected, Then Skip To End of Block
If Peer teaching/instruction Is Selected, Then Skip To End of Block
Skip Logic
Q19
What was your last major while you were at UND?
Q20
Did you ever SWITCH a STEM major while at UND?
If yes, please specify the STEM major that you switched
No
If No Is Selected, Then Skip To Rate the following statements in rela...
Skip Logic
Q21
What major did you SWITCH to if different than your last major at UND?

Q22

When did you SWITCH the major?

- ○ First year first semester
- ○ First year second semester
- ○ Second year first semester
- ○ Second year second semester
- ○ Third year first semester
- ○ Third year second semester
- ○ Fourth year first semester
- ○ Fourth year second semester
- ○ Other (Please specific)

Q23

Why did you SWITCH your STEM major while you were at UND? Select all that apply.

- ☐ Poor performance in the major
- ☐ High financial cost associated with the major
- ☐ Lack of role models and mentors
- ☐ Feelings of isolation because too few peers pursue the major
- ☐ Discriminations on the basis of sex, race, or ethnicty
- ☐ Major didn't allow me to hold a part-time job
- ☐ Loss of interest in the major
- ☐ Growing interest in non-STEM majors
- ☐ Poor quality of teaching in STEM classes
- ☐ Too much workload in STEM classes as compared to non-STEM classes
- ☐ Negative experiences in STEM classes
- ☐ Other (please specify)

Q24

Rate the following statements in relation to the STEM major you pursued while at UND.
How **SUCCESSFUL** did you feel...

	Very unsuccessful	Unsuccessful	somewhat unsuccessful	Undecided	Somewhat successful	Succesful	Very successful
...when you were in your major overall?	○	○	○	○	○	○	○
...about the grades you got on tests and assignments in your previous major?	○	○	○	○	○	○	○
...in achieving the learning goals you set for yourself?	○	○	○	○	○	○	○
...Knowing that you made an honest effort to make progress during the year?	○	○	○	○	○	○	○
...in doing all the work, meeting deadlines, keeping up with the reading, studying, etc.?	○	○	○	○	○	○	○
...in gaining new knowledge and understanding from your courses?	○	○	○	○	○	○	○

Q25

Display This Question:
If Did you ever SWITCH a STEM major while at UND? **No** Is **Selected** Edit

Which of the following factors influenced you to PERSIST in the STEM major that you pursued while at UND? Select all that apply.

- ☐ Career goals
- ☐ self-confidence
- ☐ Desire to pursue the major
- ☐ Intrinsic motivation
- ☐ Strong academic preparation in math and science
- ☐ Parents/family
- ☐ Friends
- ☐ Faculty/professor
- ☐ Institutional support and resources
- ☐ Summer internship
- ☐ Involvement in external student clubs & organizations
- ☐ Peer teaching/instruction
- ☐ Other (please specify)

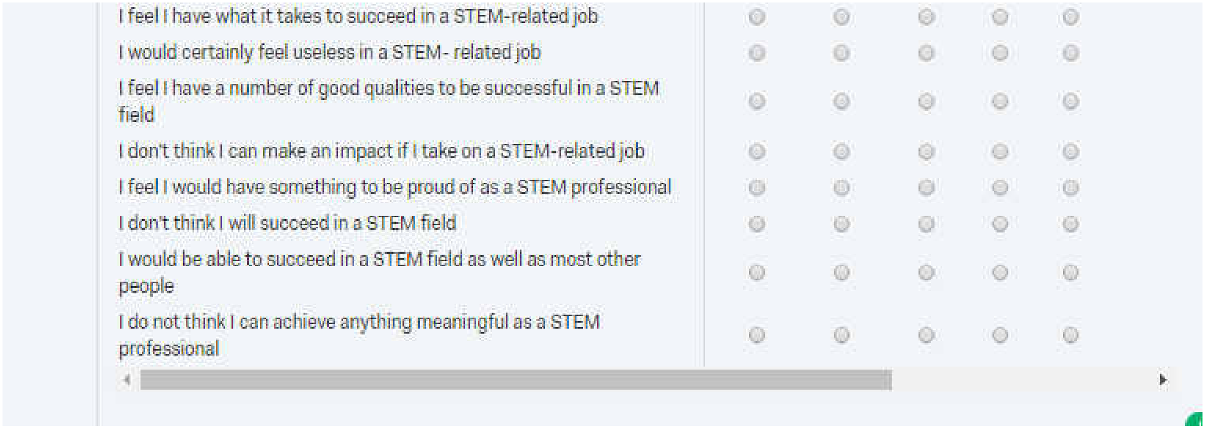
VIES SubScales for ALL Participants

Block Options

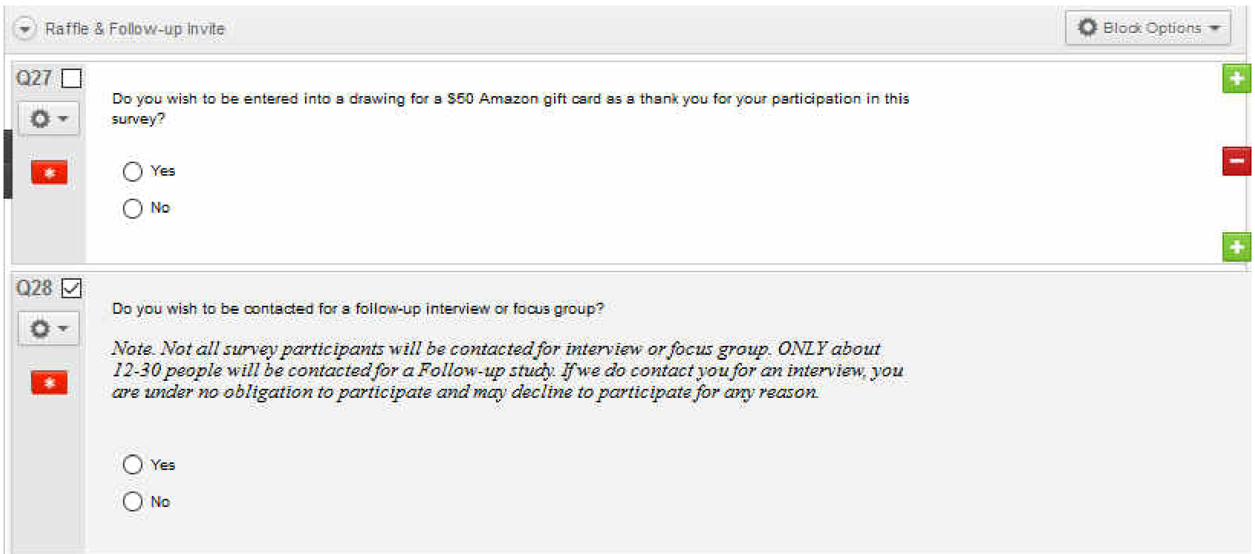
Q26

Please rate each of the statements below by ticking the appropriate option that best describes your attitudes or beliefs about STEM (Scie

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
Working in a STEM field would be a waste of my time	○	○	○	○	○
I would take a course in STEM even if it were not required	○	○	○	○	○
I find STEM-related jobs very interesting	○	○	○	○	○
I don't think working in a STEM field would help me achieve my professional aspirations	○	○	○	○	○
STEM is an important field for me	○	○	○	○	○
I would enjoy working in a STEM field	○	○	○	○	○
I would rather do something else than take on a STEM-related job	○	○	○	○	○
I am not interested in a degree in STEM	○	○	○	○	○
STEM is a good college major for me	○	○	○	○	○
STEM classes are boring	○	○	○	○	○
Being in a STEM class would be fun for me	○	○	○	○	○
The idea of being in a STEM class excites me	○	○	○	○	○
I would enjoy taking STEM courses	○	○	○	○	○
I dislike STEM courses	○	○	○	○	○



I feel I have what it takes to succeed in a STEM-related job					
I would certainly feel useless in a STEM- related job					
I feel I have a number of good qualities to be successful in a STEM field					
I don't think I can make an impact if I take on a STEM-related job					
I feel I would have something to be proud of as a STEM professional					
I don't think I will succeed in a STEM field					
I would be able to succeed in a STEM field as well as most other people					
I do not think I can achieve anything meaningful as a STEM professional					



Raffle & Follow-up Invite

Block Options

Q27

Do you wish to be entered into a drawing for a $50 Amazon gift card as a thank you for your participation in this survey?

Yes

No

Q28

Do you wish to be contacted for a follow-up interview or focus group?

Note. Not all survey participants will be contacted for interview or focus group. ONLY about 12-30 people will be contacted for a Follow-up study. If we do contact you for an interview, you are under no obligation to participate and may decline to participate for any reason.

Yes

No

Adapted from:

Appianing, J., & Van Eck, R. N. (2015). Gender Differences in College Students' Perceptions of Technology-Related Jobs in Computer Science. *International Journal of Gender, Science and Technology*, *7*(1), 28-56.

Appendix C

Phase II Qualitative Study: Focus Group Questions

Focus Group Questions---For Women Who Switched STEM Majors

1. What kind of impact do you think STEM education has on the U.S. economy?
2. What factor(s) influenced you to enroll in your previous STEM major?
3. Tell us what your current major is and why you switched from a STEM to a non-STEM major?
4. Of all the reasons that you switched from a STEM to a non-STEM major, what was the most influential reason and why?
5. Can you share some experiences you had while enrolled in a STEM major?

    (a) Positive experiences

    (b) Negative experiences

6. Can you think of any factor(s) that most contributed to your academic performance in your previous STEM major?
7. Would you recommend your previous STEM major to a relation or friend? Why or why not?
8. What do you think can be done to attract and retain more women in your previous STEM major?

Focus Group Questions ---For women currently in STEM Majors

1. What kind of impact do you think STEM education has on the U.S. economy?
2. What is your current major?
    a. Why do you think students are attracted to your STEM major?
    b. What factor(s) influenced you to enroll in your current STEM major?
3. Have you ever considered switching your current STEM major?

a. If yes, at what year in college did this idea occur?

b. What was the probable cause(s)?

4. a. What factors have influenced you to persist in your current STEM major?

b. Of all the factors that influenced you to persist in your current STEM major, what was the most influential factor and why?

5. Would you recommend your current STEM major to a relation or friend? Why or why not?

6. What do you think can be done to attract and retain more women in your current STEM major?

Appendix D

Perceived Success (Academic) — For STEM Major Switchers

Rate the following statements in relation to the STEM major that you switched FROM.

> 1 = Very unsuccessful, 2 = Unsuccessful, 3 = Somewhat unsuccessful, 4 = Undecided, 5 = Somewhat successful, 6 = Successful, 7 = Very successful

How SUCCESSFUL did you feel...

Name	**Items**
perceivedsucc1	...when you were in your previous STEM major overall?
Perceivedsucc2	…about the grades you got on tests and assignments in your previous STEM major?
Perceivedsucc3	…in achieving the learning goals you set for yourself in your previous STEM major?
Perceivedsucc4	…Knowing that you made an honest effort to make progress during the year in your previous STEM major?
Perceivedsucc5	…in doing all the work, meeting deadlines, keeping up with the reading and studying in your previous STEM major?
Perceivedsucc6	…in gaining new knowledge and understanding from your previous STEM major courses?

Adapted from:
Hall, N. C., Hladkyj, S., Perry, R. P., & Ruthig, J. C. (2004). The role of attributional retraining and elaborative learning in college students' academic development. *Journal of Social Psychology, 144*(6), 591-612. doi: 10.3200/SOCP.144.6.591-612

Perceived Success (Academic) — For STEM Major Persisters

Rate the following statements in relation to the STEM major that you switched FROM.

> 1 = Very unsuccessful, 2 = Unsuccessful, 3 = Somewhat unsuccessful, 4 = Undecided, 5 = Somewhat successful, 6 = Successful, 7 = Very successful

How SUCCESSFUL do you feel...

Name	**Items**
perceivedsucc1	... in your current STEM major overall?

Perceivedsucc2	…about the grades you got on tests and assignments in your current STEM major?
Perceivedsucc3	…in achieving the learning goals you set for yourself in your current STEM major?
Perceivedsucc4	…when it comes to Knowing that you made an honest effort to make progress during the year in your current STEM major?
Perceivedsucc5	…in doing all the work, meeting deadlines, keeping up with the reading and studying in your current STEM major?
Perceivedsucc6	…in gaining new knowledge and understanding from your current STEM major courses?

Adapted from:

Hall, N. C., Hladkyj, S., Perry, R. P., & Ruthig, J. C. (2004). The role of attributional retraining and elaborative learning in college students' academic development. *Journal of Social Psychology, 144*(6), 591-612. doi: 10.3200/SOCP.144.6.591-612

Perceived Success (Academic) — For Past STEM Major Students

Rate the following statements in relation to the STEM major that you switched FROM.

> 1 = Very unsuccessful, 2 = Unsuccessful, 3 = Somewhat unsuccessful, 4 = Undecided, 5 = Somewhat successful, 6 = Successful, 7 = Very successful

How SUCCESSFUL did you feel...

Name	**Items**
perceivedsucc1	...when you were in your major past STEM major overall?
Perceivedsucc2	…about the grades you got on tests and assignments in your past STEM major?
Perceivedsucc3	…in achieving the learning goals you set for yourself in your past STEM major?
Perceivedsucc4	…Knowing that you made an honest effort to make progress during the year in your past STEM major?
Perceivedsucc5	…in doing all the work, meeting deadlines, keeping up with the reading and studying in your past STEM major?
Perceivedsucc6	…in gaining new knowledge and understanding from your past STEM major courses?

Adapted from:

Hall, N. C., Hladkyj, S., Perry, R. P., & Ruthig, J. C. (2004). The role of attributional retraining and elaborative learning in college students' academic development. *Journal of Social Psychology, 144*(6), 591-612. doi: 10.3200/SOCP.144.6.591-612

Appendix E

List of STEM-Related Majors Used in this Study

Major	**Undergraduate or Graduate or Both**
Aerospace Sciences	Graduate
Air Traffic Control	Undergraduate
Airport Management	Undergraduate
Anthropology	Undergraduate
Applied Economics	Graduate
Atmospheric Sciences	Both
Aviation	Graduate
Aviation Management	Undergraduate
Biology	Both
Biomedical Sciences	Both
Chemical Engineering	Both
Chemistry	Both
Civil Engineering	Both
Commercial Aviation	Undergraduate
Communication Science and Disorders	Both
Computer Science	Undergraduate
Clinical Psychology	Graduate
Counseling	Graduate
Counseling Psychology	Graduate
Earth System Science and Policy	Both

Appendix E cont.

Major	**Undergraduate or Graduate or Both**
Electrical Engineering	Both
Energy Engineering	Both
Energy Systems Engineering	Graduate
Engineering	Both
Environmental Engineering	Undergraduate
Environmental Geoscience	Undergraduate
Forensic Psychology	Both
Forensic Science	Undergraduate
Geography	Both
Geological Engineering	Both
Geology	Both
Geographic Information Science	Undergraduate
Graphic Design Technology	Undergraduate
Industrial Technology	Undergraduate
Information Systems	Undergraduate
Applied Economics	Graduate
Mathematics	Both
Mechanical Engineering	Both
Medicine	Medicine
Nursing	Both

Appendix E cont.

Major	**Undergraduate or Graduate or Both**
Occupational Therapy	Both
Petroleum Engineering	Both
Physics	Both
Pre-Unmanned Aircraft Sys Operator	Undergraduate
Psychology	Both
Scientific Computing	Graduate
Space Studies	Graduate
Technology	Graduate

Source: Office of Institutional Research, 2016, Target University.

Appendix F

Consent Form for Focus Group Participation

[redacted]

CONSENT TO PARTICIPATE IN RESEARCH

TITLE: Using the expectancy-value theory to understand why women persist or leave collegiate STEM programs: A mixed methods study

PROJECT DIRECTOR: Joseph Appianing

PHONE # [redacted]

DEPARTMENT: Teaching and Learning

STATEMENT OF RESEARCH

A person who is to participate in the research must give his or her informed consent to such participation. This consent must be based on an understanding of the nature and risks of the research. This document provides information that is important for this understanding. Research projects include only subjects who choose to take part. Please, take your time in making your decision as to whether to participate. If you have questions at any time, please ask.

WHAT IS THE PURPOSE OF THIS STUDY?

You are invited to be in a research study dealing with the attitudes of women toward STEM majors and careers and the reasons that women leave or persist in collegiate STEM majors.

HOW MANY PEOPLE WILL PARTICIPATE?

Approximately 12-30 people will take part in this qualitative study. But, for your session, you will participate in a focus group consisting of three or four other female participants.

HOW LONG WILL I BE IN THIS STUDY?

Your participation in this focus group will last about 30-60 minutes.

WHAT WILL HAPPEN DURING THIS STUDY?

You will answer some questions relating to your past and/ or current experiences in a STEM major at [redacted]. With your permission, your responses will be tape-recorded (including note-taking) for analysis later. You will be assigned a pseudonym to protect your identity.

WHAT ARE THE RISKS OF THE STUDY?

The study involves no more than "minimal risk" such as emotional, psychological or discomfort that some individuals may often experience when responding to questions in a group setting. For example, some questions may be of a sensitive nature to you, and you may therefore become upset as a result. However, such risks are not viewed as being in excess of "minimal risk."

If, however, you become upset by questions, you may stop at any time or choose not to answer a question. If you would like to talk to someone about your feelings about this study, you are encouraged to contact [redacted] Counseling Center on [redacted]

WHAT ARE THE BENEFITS OF THIS STUDY?

You may not necessarily benefit directly from participating in this study. However, it is hoped that in future other people might benefit from this study; because findings from the study will help society to gain a better understanding of why women may leave or persist in college STEM majors.

WILL IT COST ME ANYTHING TO BE IN THIS STUDY?

You will not incur any costs for being in this research study.

WILL I BE PAID FOR PARTICIPATING?

You will not be paid for taken part in this research study. However, you may choose to have your email address entered into a raffle draw for a chance to win an Amazon gift card worth $50.00. A sheet will be provided at the end of the focus group discussion for participants to sign up for the raffle draw. This sheet will not be linked with the consent forms signed by participants and the focus group data.

WHO IS FUNDING THE STUDY?

The [redacted] and the principal investigator are receiving no payments from other agencies, organizations, or companies to conduct this study.

CONFIDENTIALITY

The records of this study will be kept private to the extent permitted by law. In any report about this study that might be published, you will not be identified. Your study record may be reviewed by Government agencies, the [redacted] office, and the [redacted] Institutional Review Board. Any information that is obtained in this study and that can be identified with you will remain confidential and will be disclosed only with your permission or as required by law. Also, any issues that will be discussed during the focus group session should be kept as confidential by group participants.

Confidentiality will be maintained by means of not linking consent forms and responses. Responses to focus group questions will be coded according to the pseudonyms given to participants. The principal investigator and academic adviser will have access to all audio recordings for transcription, analysis and educational purposes. Participants will also have the right to review or edit the records. As a backup plan, both the principal investigator and academic adviser will keep copies of audio recordings and notes taken from the focus groups discussions while the study is underway. However, at the end of the study, the principal investigator will delete all audio recordings and notes in his possession so that there will be no traces. In order to comply with IRB policy, the academic adviser will keep copies of both the audio recordings and/ or discussion notes (on a password protected computer) as well as the consent forms (in securely locked cabinet) in his office for a minimum of 3 years after the end of the study. If a report or article will be written, the study results would be described in a summarized manner so that no particular participant will be identified.

IS THIS STUDY VOLUNTARY?

Your participation is voluntary. You may choose not to participate or you may discontinue your participation at any time without penalty or loss of benefits to which you are otherwise entitled. Your decision whether or not to participate will not affect your current or future relations with the [redacted]

You will be informed by the research investigator of this study of any significant new findings that develop during the study, which may influence your willingness to continue to participate in the study.

CONTACTS AND QUESTIONS?

The researchers conducting this study are Joseph Appianing and Dr. Van Eck. You may ask any questions you have now. If you later have questions, concerns, or complaints about the research, please contact Joseph Appianing at [redacted] and Dr. Van Eck at [redacted].
If you have questions regarding your rights as a research subject, you may contact The

[redacted] Institutional Review Board at [redacted]

- You may also call this number about any problems, complaints, or concerns you have about this research study.
- You may also call this number if you cannot reach research staff, or you wish to talk with someone who is independent of the research team.

[redacted] General information about being a research subject can be found by clicking "Information for Research Participants" on the web site: [redacted]

I give consent to be audiotaped during this study.

Please initial: ____ Yes ____ No

I give consent for my quotes to be used in the research; however, I <u>will not</u> be identified.

Please initial: ____ Yes ____ No

Your signature indicates that this research study has been explained to you, that your questions have been answered, and that you agree to take part in this study. You will receive a copy of this form.

Subjects Name: ____

____________________________________ ____________________

Signature of Subject Date

I have discussed the above points with the subject or, where appropriate, with the subject's legally authorized representative.

____________________________________ ____________________

Signature of Person Who Obtained Consent Date

Appendix G

Previous STEM Majors and Destination Majors for STEM Major Switchers

Majors	
Switched From	***Switched To***
Atmospheric Science	Education: Music
Aviation	Social work
Biology	Nursing
Biology	Occupational Therapy
Biology	Women and Gender Studies
Biology	History/Political Science
Biology	Managerial Finance and Accounting
Biology	Spanish
Biology	Psychology
Biology	Education: Curriculum and Instruction
Biology	Education: Elementary
Biology	Education: Early Childhood
Biomedical engineering	Rehabilitation and Human Services
Chemical Engineering	International Studies, German
Chemical Engineering	English
Chemical engineering	Occupational therapy
Chemistry	Accounting
Chemistry	Psychology

Appendix G cont.

Majors	
Switched From	***Switched To***
Commercial Aviation	English/Communications
Commercial aviation	College Business and Public Admin
Computer Science	Criminal Justice
Computer science	Marketing and Communication
Electrical engineering	Education: Higher Education
Forensic science	Criminal Justice
Forensic Science	Criminal Justice
Forensic Science	Nursing
Forensic science	Education: Elementary and Middle School
Forensic science	Criminal Justice
Forensic Science	Criminal Justice
Geology	MBA
Geographic Information Science	Educational Foundations and Research
Graphic Design Technology	Education: Elementary
Info Sys and Business Communication	Accountancy
Mechanical Engineering	Psychology and Pre-Physical Therapy
Geography	Communications
Nursing	Nursing-Family Nurse Practitioner track
Nursing	Social work
Nursing	Education: Special Education (Elementary)
Occupational Therapy	Human Resources

Appendix G cont.

Majors	
Switched From	***Switched To***
Petroleum Engineering	Investments
Pre medicine & forensic science	Education: Elementary & Early Childhood
Pre-med	Nursing
Pre-Optometry	Entrepreneurship
Psychology	Counseling
Psychology	Education: M.S. in Special Education
Psychology	Counseling
Psychology	Sociology
Psychology	Counseling Psychology
Psychology	General Studies and Minor in Psychology
Psychology	Forensic Psychology
Psychology	Social Work
psychology	Law
Speech-Language Pathology	Psychology
-	Psychology and Criminal Justice
-	Counseling Psychology
-	Psychology and Sociology
-	Counseling
-	Psychology and Criminal Justice

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