Evaluating the Impact of Math Self-Efficacy, Math Self-Concept, and Gender on STEM Enrollment and Retention in Postsecondary Education

Marcia Bingham
Brigham Young University

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Evaluating the Impact of Math Self-Efficacy, Math Self-Concept, and Gender on STEM Enrollment and Retention in Postsecondary Education

Marcia Bingham

A dissertation submitted to the faculty of Brigham Young University in partial fulfillment of the requirements for the degree of Doctor of Philosophy

Sterling Hilton, Chair
Julie Crockett
Ross Larson
Richard Sudweeks

Educational Inquiry, Measurement, and Evaluation
Brigham Young University

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ABSTRACT

Evaluating the Impact of Math Self-Efficacy, Math Self-Concept, and Gender on STEM Enrollment and Retention in Postsecondary Education

Marcia Bingham
Educational Inquiry, Measurement, and Evaluation, BYU
Doctor of Philosophy

Low enrollment and high attrition of women in science, technology, engineering, and mathematics (STEM) continues to be an issue for postsecondary institutions. Improvements in representation of women has been seen in some of the agricultural and biological sciences; however, in many of the more math intensive areas such as geosciences, engineering, mathematics/computer science, and physical sciences (GEMP), women continue to be underrepresented leading to underrepresentation in the workforce and further exacerbating gender gaps. Studies suggest the lack of representation is not due to a gap in math ability between men and women, yet underrepresentation remains predominantly within math intensive STEM areas, suggesting something like math self-efficacy (MSE) and math self-concept (MSC) may be impacting enrollment and retention.

The research presented here investigates the link between enrollment in GEMP STEM and retention in STEM with the factors of MSE, MSC, and gender. Structural equation modeling (SEM) with Bayesian estimation is used incorporating additional factors from previous research. Study results indicated that MSE and male were both positive and significant indicators of enrollment in GEMP STEM and retention in STEM. MSC was not a significant indicator of retention in STEM but was shown to be significant for GEMP STEM enrollment; however, it was negatively associated with GEMP STEM when combined with MSE. Several program related factors were also shown to be significant indicators of GEMP STEM enrollment and STEM retention.

This study highlights the importance of MSE and gender for enrollment and retention and should encourage future efforts towards improving MSE as a possible method of increasing representation of women in underrepresented areas of STEM.

Keywords: STEM enrollment, STEM retention, math self-efficacy, math self-concept, gender, structural equation modeling
ACKNOWLEDGMENTS

Any endeavor worth pursuing often takes time, sacrifice, and assistance to accomplish it. My journey has been no different and I would like to thank those that indeed sacrificed on my behalf to help me achieve this goal.

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I’m indebted to Dr. Richard Sudweeks and Dr. Ross Larsen for their ongoing support during my time in the program. They are true experts in their field, and I have been blessed to learn from them. Dr. Sudweeks provided a depth and breadth of knowledge not easily found. Both as program chair and from the many courses taken from him, I was blessed to gain a deeper understanding of difficult topics and received invaluable feedback. Dr. Sudweeks has served our campus community for many years and touched the lives of countless students, of which I am grateful to be a part. Dr. Larsen is a master at SEM and willingly shared his insights on countless occasions making completion of this project possible. His cheerful nature always put students at ease and made challenging courses enjoyable and comprehensible. His devotion to the Gospel of Jesus Christ shines through all he does. So much of what I learned in my program came from the courses taught by these to two scholarly giants. I would not have the foundation I do today without their knowledge and willingness to share that with others.
Thank you also to Dr. Julie Crockett for her invaluable insights as a woman who has both studied and worked in a STEM field. Her experience provided a depth of understanding I would not have discovered on my own and guided much of the initial focus of this study. She has assisted and encouraged so many other women in their own pursuits within STEM and is an outstanding role model and inspiration to future generations of women in STEM.

To my wonderful husband, Evan Bingham, you are my biggest support and my happiness. You have always been an incredible strength and made it possible for me to pursue all I set my mind to. This required a lot of sacrifice on your part, and you willingly gave of your time and provided me the mental and emotional strength to lean on when things got challenging. You always put our family first and help our children see what teamwork really looks like in a marriage. There is no way I could have done this without you! Thank you for your unwavering love and support.

To my beautiful children Sariah, Caide, Bryce, Ellie, and Blake. You will never know what your support meant to me through this process. You were always my biggest cheerleaders and made me feel like I could be both mom and student at the same time. I hope that you will always remember to reach for your dreams and work hard to make them a reality. You have so much potential within you and I am so proud of the good things you all are pursuing. Thank you for your love and patience during this time.

My parents, though not involved in the daily pursuits of this work, set me on this path and paved the way to understand the importance of education and hard work. My in-laws and extended family have loved and strengthened me along the way. Thank you to you all for your endless support and confidence in me.
I would also like to thank Christian Faulconer, Jodi Chowen, and Monte Marshall for allowing me the opportunity to further my education while continuing in my full-time employment. All three are wonderful supervisors and mentors that have helped me learn and grow in a professional capacity and given me the space for professional development that will impact my work for years to come.

Lastly, I dedicate this work to all the women out there who may have at any point doubted their ability to pursue and succeed in a math intensive field. God has a divine mission for each of us and my hope is that this will help to open the door, if only slightly, for others to pursue a path they have an aptitude and passion for. “We call upon our sisters around the world to be brave, to embrace the strength within themselves and realize their full potential” (Yousafzai, 2013, 14:12).
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DESCRIPTION OF RESEARCH AGENDA AND STRUCTURE OF DISSERTATION

This dissertation, *Evaluating the Impact of Math Self-Efficacy, Math Self-Concept, and Gender on STEM Enrollment and Retention in Postsecondary Education*, includes two articles, written in a hybrid format: *Evaluating the Impact of Math Self-Efficacy, Math Self-Concept, Math Saturation, and Gender on STEM Retention in Postsecondary Education* and *Evaluating the Relationship Between GEMP STEM Enrollment and the Factors of Math Self-Efficacy, Math Self-Concept, and Gender in Postsecondary Education*. The hybrid format includes more traditional dissertation requirements as well as the two journal articles mentioned in publication format.

Preliminary pages of this dissertation reflect requirements for submission to the University. The two articles included have been written in accordance with formatting requirements of the journal it will be submitted to. The articles must conform to the style of the *Publication Manual of the American Psychological Association* (7th edition) and include an abstract that is no more than 200 words. The article must be under 35 pages in length including appendices, single-spaced (although they are included here double-spaced to meet formatting requirements for dissertation submission). Text should be in Times New Roman, 12-point font with one-inch margins.

This dissertation contains a list of references for each article. Additionally, it contains a list of references for the dissertation, which includes references for all preliminary pages and appendices. Appendix A contains an extended literature review followed by an extended methodology and results section in Appendix B. Institutional Review Board approval and consent material can be found in Appendix C and Appendix D. Instruments used in this research can be found in Appendix E.
Evaluating the Impact of Math Self-Efficacy, Math Self-Concept, Math Saturation, and Gender on STEM Retention in Postsecondary Education

Marcia Bingham
Dr. Sterling Hilton
Dr. Ross Larsen
Dr. Richard Sudweeks
Dr. Julie Crockett

Brigham Young University
Abstract

Retention of women in Science, Technology, Engineering, and Mathematics (STEM) remains an issue for postsecondary institutions. Women continue to be underrepresented in math intensive areas of STEM and demonstrate lower retention compared to men. This leads to underrepresentation in the STEM workforce and further enforces gender gaps. Studies suggest this is not due to a gap in math ability between men and women, yet underrepresentation remains predominantly within math intensive majors, suggesting something like math self-efficacy (MSE) and math self-concept (MSC) may be impacting retention. This study sought to investigate the link between STEM retention and the factors of MSE, MSC, math saturation of a program, and gender using Bayesian structural equation modeling (SEM) while incorporating additional indicators of retention from previous research. Study results identified MSE and gender as significant indicators of retention along with variables associated with student experience in STEM programs such as research participation, club engagement, and experiences with faculty and male peers. MSC in the presence of MSE and other indicators was not a significant indicator of retention. Ideally the findings of this study will aid in identifying the importance of math self-efficacy as it relates to retention and in turn help to increase representation of women in math intensive STEM fields.

Keywords: STEM retention, math self-efficacy, math self-concept, gender, structural equation modeling, postsecondary education
**Background**

In the United States, women make up less than half of all the degrees awarded in several STEM areas, with some of these areas showing less than 20% of degrees awarded to women and others exhibiting a decline in degrees awarded to women between 1998 and 2018 as can be seen in Figure 1 (Hamrick, 2019). Additionally, although both men and women leave STEM programs, women leave in higher numbers and for different reasons than men (Ackerman et al., 2013; Chen & Soldner, 2013).

**Figure 1**

*Degrees Awarded to Women in STEM Fields*

![Graph showing degrees awarded to women in STEM fields from 1998 to 2018 for different fields such as Agricultural sciences, Biological sciences, Engineering, Computer sciences, Geological Sciences, Mathematics and statistics, and Physical sciences.]

In 1983, Berryman began using the term “pipeline” to describe the entire pathway of women in STEM, from early exposure and interest to education and training, and all the way through to career completion. In 1993, this idea of a STEM pipeline was revisited by Joe Alper and Ann Gibbons in their article titled “The Pipeline is Leaking Women all the Way Along” where they address females’ lack of early exposure to STEM in younger years, low attraction rates to STEM courses and programs, and the loss of women from educational STEM programs and the workforce. The problem of retention in STEM is obviously not isolated to higher education but is certainly one place along the pipeline that needs to be addressed given that many STEM majors see lower representation and higher attrition of women compared to men in STEM.

Not all STEM majors, however, are plagued with low representation of women. Many of the Agricultural and Biological Sciences have national averages at or above 50%. Biology, for example, has had above 50% female representation among graduates since 1996 (Hamrick, 2019). Programs in areas such as geosciences, engineering/economics, mathematics/computer science, and physical sciences tend to be the STEM programs with lower female representation. These programs are also typically considered to be more math intensive (Kahn & Ginther, 2017). This low representation of women in these math intensive areas is worsened by the higher attrition from STEM seen in women compared to men.

**Math Intensity and Math Achievement**

An apparent link between math intensive STEM programs and high attrition seems to suggest that the amount of math involved in a program has an impact on retention. The importance of this relationship has not fully been studied previously. Although many studies have looked at the impact of various aspects of math achievement on attrition in STEM majors,
math intensity of a program has not been measured and used to evaluate its impact on retention in STEM. A true measure of how math intensive a STEM program may be is difficult to determine. Math saturation, defined as the proportion of required coursework in a major that is a mathematics course or requires a mathematics course prerequisite, may begin to address this question and help us understand connections between mathematics and STEM retention.

Math achievement and the perception of achievement affect retention within postsecondary STEM programs. Lang (2008) found that performance in coursework impacts persistence in associated majors. Many of these math intensive majors require completion of calculus as a prerequisite to subsequent coursework. Ellis et al. (2016) found that women were 1.5 times more likely to switch to non-STEM programs after Calculus I. Dabney and Tai (2014) also found that introductory courses that are designed to weed out students are more harmful for underrepresented minorities and women. Tutoring has been found to counteract this with significant impacts on the level of math attained (Robinson, 2007) which can indirectly affect retention by reducing the number who leave due to math achievement and math intensity.

Although math achievement has been shown to impact retention and women leave STEM in higher proportions than their male counterparts, evidence suggests that a gap in math ability between genders either does not exist or is negligible. Gaps in achievement have been closing over the past several decades as women have begun taking more advanced math courses with the gap virtually disappearing (Hyde et al., 2008). Several studies found that males have a small advantage, but the difference tends to be trivial (Friedman-Sokuler & Justman, 2016; Fryer & Levitt, 2010; Pope & Sydnor, 2010; Penner & Paret, 2008). Of additional consideration is that many studies conducted on this topic fail to account for the level of math exposure. We know that women take fewer advanced math courses (Xie & Shaumann, 2003). Despite a lack of
exposure to advanced math courses, evidence suggests that a gap in math ability between genders either does not exist or is negligible. Kahn and Ginther (2017) summarized research related to women in STEM and found that even the largest differences demonstrated are objectively small and have decreased from previous decades.

Math Self-Efficacy and Math Self-Concept

Given this lack of achievement gap, it begs the question, why do we see lower retention rates for women in these math intensive STEM majors? Low math self-concept has been shown to be a significant predictor of women leaving STEM programs (Ackerman et al., 2013). Similarly, students with a high sense of self-efficacy are more likely to persist in STEM and go on to complete a STEM degree (Aryee, 2017).

Math self-concept (MSC) and math self-efficacy (MSE) have many similarities but are defined as two distinct concepts. Academic self-concept has been defined as “one’s perceived competence in a specific domain (often an academic subject) in a normative way (in comparison to peers or the average person) that includes both cognitive and affective evaluations of the self” (Sax et al., 2015). Self-efficacy is defined as, “people’s judgements of their capabilities to organize and execute courses of action required to attain designated types of performances” (Bandura & National Institute of Mental Health, 1986, p. 391). Math self-concept focuses more on perceived identity in mathematics and is based on comparison with peers. MSC may play a role as women compare themselves to men in STEM programs. Math self-efficacy is focused more on perceived ability to execute and master specific requirements related to mathematics. MSC is an individual’s general perceptions of self regarding math whereas MSE is an individuals’ expectations about what they can accomplish regarding math. MSE can be measured based upon an individual’s confidence in performing or completing a task whereas MSC is based
on peer comparisons, normative expectations, and a sense of self. MSC is measured using level of agreement with statements such as “I am quite good at mathematics,” and “I have always done well in mathematics courses.” Although there are differences between the two constructs, they are both concerned with personal perception of competency in regard to math and may impact a women’s decision to enroll or persist in a STEM program.

For more than 40 years, men have consistently rated themselves higher in math self-concept than women (Sax et al., 2015). Even when women scored in the top 10% in the math portion of the SAT, they were far less likely than men with similar scores to report their math ability as “highest 10%” (Sax et al., 2015). Women who leave STEM have significantly lower math self-concept than men and have significantly lower math self-concept than women who persist (Ackerman et al., 2013). Ellis et al. (2016) found that women with above average ability in calculus start and end the term with lower mathematical confidence (math self-concept) than men, suggesting that math self-concept is likely more responsible for attrition rather than ability.

Additional Factors Impact STEM Retention

Many additional factors have been shown to have a positive impact on female retention in STEM. Some examples are research experience (Wilker, 2017), faculty attitudes and support (Blair et al., 2017), increased female representation amongst faculty (Vieyra et al., 2011), and exemplary high school grades (Rask, 2010). Ackerman et al. (2013) found that traditional predictors of academic success such as high school GPA and SAT/ACT scores were also significant predictors of STEM persistence. Mentoring programs have also been beneficial in retaining women and increasing female students’ perception of their ability to succeed within these programs (Cheryan et al., 2011).
Alternatively, certain factors have been shown to negatively impact retention and increase attrition of women in these programs. Psychological factors such as stereotype threat (Beasley & Fischer, 2012), and demographic factors such as being a female first-generation student increase the risk of attrition (Vielma, 2016). Perceptions of male dominance and “unconscious gender bias remains widespread” (Corbett & Hill, 2015) and contributes to a culture that also increases attrition of women in these programs. Ceci et al. (2014) found that attitudes towards STEM are affected by parental and familial influences, often leading to lower propensities towards STEM, despite similar abilities in math.

**Problem Statement**

Despite no inherent difference in ability between men and women, differences in opportunity and representation persist within STEM. With fewer advanced math courses taken, less representation in math intensive STEM programs, and higher attrition both in education and industry, women have access to fewer opportunities in these fields and the higher pay associated with those opportunities. Women leave STEM opportunities in higher numbers than their male counterparts further contributing to the lack of female representation within the STEM field (Chen & Soldner, 2013; Ackerman et al., 2013).

Women make up almost half of the workforce in the United States, but only account for 27% of the STEM workforce (Martinez, A., & Christnacht, 2021). STEM occupations have grown by 79% since 1990 and are projected to continue growing with STEM job growth expected to be between 8% - 31% from 2019 to 2029 for various areas of STEM. Combined, these opportunities translate to nearly 800,000 new positions in STEM areas over a ten-year period (Martinez, A., & Christnacht, 2021).
Adding to the lack of representation of women in the workforce, is the added concern of gender pay gaps. Although gender pay gaps exist in various STEM fields, an additional concern relates to fewer women graduating with degrees in the more math intensive STEM disciplines (Blau & Kahn, 2017; Beede et al., 2011). Graduates of more math intensive programs have been shown to earn more than those in less math-intensive fields (Beede et al., 2011; Weinberger, 1999). With fewer women graduating in math intensive STEM, the majority of female graduates are not even eligible for the higher paying positions found in these areas.

Given the large expectations in STEM job growth over the next 10, it stands to reason that female representation within STEM programs is of great importance to supply diversity in the future workforce, reduce pay gaps between genders, and provide sufficient opportunity for women in all areas of STEM.

Although much has been studied related to women in STEM, there are still significant gaps in the literature. Research has covered topics related to attrition of women in STEM programs; however, very little has focused on the impact of the math intensity or math saturation on retention of women in STEM. Studies have also looked at MSE and MSC separately but have not combined these effects while controlling for the math saturation of a program to see the impact on attrition.

Considering these gaps and the high demand for STEM positions, the need for further investigation becomes apparent. Better understanding of drivers of retention in STEM, particularly for women, are important to address this issue. Math intensive areas of STEM in postsecondary education deal with higher attrition of women after already lower representation in enrollment. Coupled with the lack of evidence regarding any consequential difference in math ability, MSE and MSC along with math saturation emerge as possible indicators of retention.
Further insight into the interplay between gender, math saturation of a program, MSE and MSC, and their impact on STEM retention can provide valuable knowledge to increase female representation.

**Purpose Statement**

This study builds upon previous research with the purpose of examining the relationship between retention in STEM in postsecondary education and the factors of MSE, MSC, math saturation, and gender. It also seeks to synthesize previous research by investigating the impact of these factors together with additional indicators that address previous math experience, parental influence, and program experience. This study will provide administration of higher education institutions with a greater understanding of the relationships that exist between these variables and representation of women in STEM. A deeper understanding of the differential impact across genders can empower leadership to make more informed decisions and design intervention initiatives focused on areas of greatest impact to reduce attrition and subsequently increase representation of women in needed areas within STEM.

**Research Questions**

This study focused on the following research questions:

1. To what extent do math self-efficacy, math self-concept, and math saturation impact retention in STEM programs while controlling for other factors that are associated with retention?
2. To what extent does the relationship between math self-efficacy, math self-concept, math saturation, and retention in STEM programs differ between genders?
Method

Built upon previous literature, a model is presented here that examines the relationship between retention in STEM and the explanatory variables of MSE, MSC, math saturation, and gender. This section describes the study participants, methods, and model. Study participants are described below including information by retention status and gender. The survey used in this study is discussed including descriptions of the previously developed scales for measuring MSE and MSC. The research design and statistical analysis which utilized confirmatory factor analysis (CFA) and structural equation modeling (SEM) is also discussed below. Ethical practices were followed, and approval was obtained by the institutional review board along with participants’ consent prior to administering the survey.

Participants

The sampling frame for this study was made up of 26,096 undergraduate students enrolled in STEM during 2020 or 2021 at a private four-year tier-2 research university in the Western United States. STEM majors included the areas of life sciences, physical sciences, engineering, mathematics, computer science, and the health sciences. Students in the sampling frame fell into one of six categories that could be categorized as retained or not retained as shown in Table 1. Retained students were those who were still enrolled in a STEM major during fall semester 2022 (n = 9494), had graduated from a STEM major by fall 2022 (n = 6951), or were still declared a STEM major during fall 2022 but were on deferment or leave of absence (n = 2901). Students not retained were those who were no longer declared a STEM major and were either enrolled, deferred, or on a leave of absence during fall 2022 (n = 3213); had graduated by fall semester 2022 from a non-STEM major (n = 2092); or those who had left the university completely (n = 1445).
Thirty-five percent of students who were considered retained were selected via random selection and were sent the survey used in this study. Oversampling of students considered not retained was done with 100% of students in this category sent the survey inviting them to participate. This was done to ensure proper representation due to lower numbers in the not retained group and anticipated lower response rates from those not retained. Participation was not obligatory, and responses were collected via elective participation.

The final sample size for this study consisted of 2,121 undergraduate students enrolled in STEM programs in 2020 and 2021. Retained STEM students made up 71.15% of the sample (n = 1,509) while students not retained in STEM made up 28.85% of the sample (n = 612). Although students who did not retain were oversampled, retention rates of students in STEM still somewhat reflected retention rates of the sampling frame (75.80% versus 71.15%) due to lower representation and lower response rates of students who did not retain. Participant characteristics can be seen in Table 2.

Female students made up 44.18% of the sample (n = 937), which represented a little more than the sampling frame with 39.10% of all STEM students being female. First generation students represented 9.05% (n = 192) while underrepresented minority groups made up 13.11% of the sample (n = 278). Class standing of the sample was 4.15% freshman (n = 88), 14.33%
sophomores \((n = 304)\), 19.05\% juniors \((n = 404)\), 26.36\% seniors \((n = 559)\), and 36.12\% graduate students \((n = 766)\). The mean age was 23.65 with a standard deviation of 2.75 and a minimum age of 18 and maximum age of 53.

Attrition rates between males and females differed amongst respondents, with a higher proportion of women that had left STEM compared to their male counterparts. This can be seen below in Figure 2 with 38.04\% of women leaving STEM versus 22.84\% of men.

Table 2

<table>
<thead>
<tr>
<th>Participant Characteristics</th>
<th>n</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Retained</td>
<td>1509</td>
<td>71.15</td>
</tr>
<tr>
<td>Left</td>
<td>612</td>
<td>28.85</td>
</tr>
<tr>
<td>Female</td>
<td>937</td>
<td>44.18</td>
</tr>
<tr>
<td>Male</td>
<td>1184</td>
<td>55.82</td>
</tr>
<tr>
<td>First Generation</td>
<td>192</td>
<td>9.05</td>
</tr>
<tr>
<td>Not First Generation</td>
<td>1929</td>
<td>90.95</td>
</tr>
<tr>
<td>Minority</td>
<td>278</td>
<td>13.11</td>
</tr>
<tr>
<td>White</td>
<td>1843</td>
<td>86.89</td>
</tr>
<tr>
<td>Class Standing</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Freshman</td>
<td>88</td>
<td>4.15</td>
</tr>
<tr>
<td>Sophomore</td>
<td>304</td>
<td>14.33</td>
</tr>
<tr>
<td>Junior</td>
<td>404</td>
<td>19.05</td>
</tr>
<tr>
<td>Senior</td>
<td>559</td>
<td>26.36</td>
</tr>
<tr>
<td>Graduate</td>
<td>766</td>
<td>36.12</td>
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<tr>
<td>Total</td>
<td>2121</td>
<td>100.00</td>
</tr>
<tr>
<td>Mean Age</td>
<td>23.65</td>
<td></td>
</tr>
<tr>
<td>SD Age</td>
<td>2.75</td>
<td></td>
</tr>
<tr>
<td>Age Range</td>
<td>18 – 53</td>
<td></td>
</tr>
</tbody>
</table>
The issue of differences in retention between genders becomes even more apparent when examining STEM majors traditionally considered to be more math intensive as shown in Figure 3. When isolating the more math intensive majors, we can see that 40.85% of women left by fall 2022. This is contrasted with 20.65% of men who were enrolled in a more math intensive major in 2020 or 2021 and left by fall 2022. Fewer men left from math intensive majors than non-math intensive majors and more women left from math intensive majors than non-math intensive majors. This results in an attrition rate for women that is almost twice that of the men. A differential in retention exists between men and women for STEM majors not traditionally considered to be math intensive, but the difference is not as large (6.71% versus 20.20%).
Women were also on average 1.39 years younger than men and had a little higher proportion of underrepresented minorities than men with 83.67% of women classified as white and 87.25% of men classified as white. Men and women had similar proportions of first-generation students as well as similar breakdowns by class standing.

**Measures**

Previously developed scales for MSE and MSC were utilized and are discussed below (Betz & Hackett, 1983; Marsh & O’Neill, 1984). A Qualtrics survey was also used to administer the MSE and MSC scales and to gather additional information from respondents and is also discussed.

**Math Self-Efficacy**

To assess mathematics self-efficacy, a subscale from the Mathematics Self-Efficacy Scale (MSES) was used (Betz & Hackett, 1983). The scale was developed to assess self-efficacy...
expectations of late adolescent and college age students in mathematics. The subscale included 16 items that asked students to respond to how confident they were in successfully completing college courses requiring prior knowledge of mathematics. The 16 courses used in the original scale were accounting, advanced calculus, algebra 1, algebra 2, basic college mathematics, biochemistry, business administration, calculus, computer science, economics, geometry, philosophy, physiology, statistics, trigonometry, and zoology. The confidence ratings were on a 9-point scale ranging from 0 (not at all confident) to 8 (completely confident).

Betz and Hackett (1983) reported an internal consistency reliability of .93 for the subscale. The overall reliability was .96 for the full MSE scale. In 1985, Hackett and O’Halloran reported a test-retest reliability for the full scale of .88 and .91 for the courses subscale (cited in Hackett & Betz, 1989). The MSES continues to be frequently used and has been validated as recently as 2022 and was found to have an internal consistency for each subscale of .80 or higher (Morán-Soto & González Peña). The MSES also demonstrated construct validity with a correlation of .66 between the MSES and the prior developed mathematical confidence subscale from the Mathematical Attitude Scales (Fennema & Sherman, 1976).

Math Self-Concept

To assess mathematics self-concept, a mathematics subscale of the Self-Description Questionnaire III (SDQ III) was used (Marsh & O’Neill, 1984). The math subscale consisted of 10 items related to an individual’s sense of self-concept as it pertains to mathematics and included statements such as “I have always done well in mathematics courses” and “I have hesitated to take courses that involve mathematics.” Respondents were asked to rate their level of agreement with each statement on an 8-point scale (1 = definitely false to 8 = definitely true).
SDQ III was validated for use among late adolescent and traditional university age students by Marsh and O’Neill (1984). Several other studies have used exploratory and confirmatory factor analysis to demonstrate construct validity of the scale (Byrne & Shavelson, 1986; Marsh & O’Neill, 1984; Marsh et al., 1986). Barbara M. Byrne (1988) reviewed multiple studies and found, internal consistency reliability coefficients ranging from 0.79 to 0.95 (mean $\alpha = 0.90$; Byrne & Shavelson, 1986; Marsh & O’Neill, 1984; Marsh et al., 1985), and test-retest reliability coefficients ranging from 0.66 to 0.94 (mean $r = 0.86$; Marsh et al., 1986). The academic self-concept facets have also been shown to be moderately correlated with academic outcomes (mean $r = 0.50$; Marsh & O’Neill, 1984).

**Math Saturation**

In an attempt to identify how math intensity impacts STEM retention, a proxy measure of was included called math saturation of a major. A full measure of math intensity would likely need to incorporate a way to account for the level of difficulty as well as the level of saturation; however, accounting for math saturation is a start to begin to account for how math intensity impacts retention.

Math saturation represents the proportion of required coursework in a major that is a mathematics course or requires a mathematics course prerequisite. These can include both direct prerequisites and indirect prerequisites as shown below in Figure 4.
Data were collected from respondents via a Qualtrics survey. The survey contained six sections with items that addressed the following: (a) math self-efficacy, (b) math self-concept, (c) demographics, (d) parental influence, (e) previous math experience, and (f) program experience. The survey took approximately 15 minutes to complete. For MSE and MSC, previously established scales were used (Betz & Hackett, 1983; Marsh & O’Neill, 1984).

Respondents were asked to answer several demographic questions to address their marital status and number of dependents. Participants were also asked the degree to which they struggled to pay for college on a five-point scale (1 = not at all to 5 = a great deal). Additionally, students in the sampling frame often defer for 18 to 24 months for a service mission. To account for this, participants were asked if they had ever deferred for this reason. Survey responses were combined with existing demographic data.

Parental influence items included questions about parental education level and experience studying and working in STEM fields. These were separated by female guardian and male guardian for a total of six items (three for each guardian).

High school math experience was assessed with existing data and items included in the survey. Respondents were asked questions meant to address personal feelings regarding their
experience in mathematics in high school. These questions were not meant to address MSE or MSC and were not tested using factor analysis. They were simply meant to address personal feelings towards taking math such as “I enjoyed my last high school math class,” “I felt confident in my last high school math class,” and “I did well in my last high school math class.” Respondents were asked to rate their level of agreement with each of these statements.

Experience in their major sought to capture information about research participation, club engagement, and whether or not the participant had a mentor or role model in their field of study. Additionally, respondents were asked to rate their male peers, female peers, and faculty in their major on a scale from 0 (negative experience) to 10 (positive experience). Additional variables meant to capture information regarding the participant’s prior experience in mathematics were combined with survey responses such as the number of math credits taken in high school, high school math GPA, and math ACT/SAT score.

**Research Design**

This study used a sample survey coupled with observational data in a cross-sectional design. SEM was implemented to identify relationships between persistence in STEM majors and MSE, MSC, and gender without utilizing random assignment. Random assignment is used in experimental designs to identify causal relationships while controlling for possible confounding variables; however, random assignment is not appropriate or possible with the variables of interest in this study. Due to a lack of random assignment, possible confounding variables may still exist that are not accounted for in the model.

**Statistical Analysis**

Data were collected, reviewed, and cleaned with preliminary analysis done using descriptive statistics and bivariate correlations. Data visualizations of all variables were also
created in Tableau to increase understanding of the underlying data and allow for filtering by
gender and retention status. Logistic regression models were run assessing unadjusted
relationships between variables of interest and the outcome. Confirmatory factor analysis (CFA)
was conducted on both the MSE subscale and the MSC subscale of the SDQ IIIs to ensure the
factor structure of the observed variables in the sample. Model fit for CFAs was determined
using the comparative fit index (CFI), Tucker Lewis Index (TLI), root mean square error of
approximation (RMSEA), and the standardized root mean squared residual (SRMR). Structural
Equation Modeling (SEM) using Bayesian estimation was used to determine final adjusted
relationships between outcome and key explanatory variables. Preliminary analysis was
conducted in SPSS (IBM Corporation, 2021) and Tableau (Tableau, 2022) with CFA and SEM
conducted in Mplus (Statmodel, 2023). Missing data was handled using full information
maximum likelihood (FIML) in the Bayesian estimation process.

Limitations should be considered when using SEM, specifically omitted variable bias can
jeopardize SEM conclusions. Omitted variable bias occurs when a relevant variable is not
included in a model and can lead to bias in parameter estimates, thus threatening the validity of
causal claims. Additional consideration should be given to ensuring model assumptions are
satisfied such as multivariate normality, sufficient sample size, and appropriate handling of
missing data.

Retention Model

The model presented in Figure 5 illustrates the proposed relationships being examined
between STEM retention and MSE, MSC, math saturation, and gender. The model includes both
the measurement models for MSE and MSC as well as the structural components. Variables
addressing demographics, mother’s influence, father’s influence, high school math experience,
and program experience were all included. The final model was assessed with SEM using Bayesian estimation and a logit link to address the extent that MSE, MSC, and math saturation impact retention in STEM programs and the relationship that gender plays. Estimation was done using Mplus following the CFAs conducted on MSE and MSC.

**Results**

CFA results for both MSE and MSC are reported here demonstrating appropriate representation of the constructs. SEM results are also presented addressing model fit and final parameter estimates.

**Confirmatory Factor Analysis of the Measurement Model for Math Self-Efficacy**

The CFA for MSE was run using all 16 courses listed in the original scale; however, model fit did not meet sufficient thresholds (RMSEA = 0.19, SRMR = 0.12, CFI = .63, TLI = 0.57). Five of the original courses (biochemistry, business administration, philosophy, physiology, and zoology) demonstrated low factor loadings relative to the other 11 courses (0.50, 0.45, 0.37, 0.27, and 0.30, respectively) and are not traditionally considered math related courses. All other factor loadings ranged from 0.60 to 0.85 for the 11 other courses. The CFA was rerun using only the 11 courses with factor loadings above 0.60 and with covariances allowed between common courses such as calculus and advanced calculus, algebra I with algebra II, basic math with algebra I and algebra II, accounting with economics, and geometry with trigonometry.
Figure 5

Proposed Model of the Relationship Between STEM Retention and Predictors
Three out of four model fit indices met appropriate thresholds. SRMR was below 0.08 and equaled 0.045, CFI and TLI were both above 0.90 and equaled .95 and 0.93, respectively, and RMSEA was a little above 0.08 and equaled 0.10. Factor loadings were all above 0.60. The final CFA model can be seen in Figure 6. Configural, metric, and scalar measurement invariance was established across genders and McDonald’s omega was used to demonstrate internal consistency reliability ($\omega = 0.75$).

**Figure 6**

*Confirmatory Factor Analysis for Math Self-Efficacy*
Confirmatory Factor Analysis for Math Self-Concept

A CFA for MSC was also conducted using the 10 items from the original scale with covariance between items 1 and 10 and items 6 and 8 (Item 1: “I find many mathematical problems interesting and challenging,” Item 10: “I have never been excited about mathematics,” Item 6: “I have trouble understanding anything that is based upon mathematics,” and Item 8: “I never do well on tests that require mathematical reasoning”). Items 1 and 10 are assumed to be negatively correlated. Fit indices indicated good model fit with three out of the four indices at appropriate thresholds. SRMR was below the 0.08 threshold and equaled 0.04, CFI and TLI were above 0.90 and equaled .95 and 0.93, respectively, and RMSEA was just above the 0.90 threshold and equaled 0.09. Configural, metric, and scalar measurement invariance was established across genders and McDonald’s omega was used to demonstrate internal consistency reliability ($\omega = .92$). The final CFA model can be seen in Figure 7.

Math Achievement Across Genders

Prior to SEM analysis, differences in math achievement levels across genders were examined using math ACT/SAT equivalency scores. No significant difference was found after controlling for exposure to advanced math coursework through an advanced placement calculus designation ($p = .10$).

Model Results

Bayesian estimation using a logit link was used for model estimation in Mplus. Mplus does not currently return fit statistics, log likelihood values, predictive p-values, or the Bayesian Wald test for models that use Bayes estimation with a logit link, so additional modeling was done using the same model structure with maximum likelihood estimation (MLE) to select the appropriate model and address model fit. Additionally, Asparouhov and Muthén (2021) suggest
that model fit can be assessed by comparing model estimated distribution tables with observed distribution tables. An additional suggestion by Muthén was to add parameters individually (Muthén & Muthén, 2023). If added parameters are significant then the more restricted model is not appropriate.

**Figure 7**

*Confirmatory Factor Analysis for Math Self-Concept*
A model with all predictors as in the proposed model found in Figure 5 was compared to a model including an interaction between male and MSC. The less restricted model did not demonstrate an improvement in model fit ($\Delta$deviance = 0.07, 1 df, $p = .79$). A similar model was explored with an interaction between male and MSE. The model failed to converge in Mplus, but preliminary logistic regression analysis suggested the interaction was not significant and so the original model with only main effects was selected. A significant interaction between male and either MSE or MSC would suggest that one of these affects gender differently; however, that was not observed. Various other models were compared using MLE but the optimal model was the model with all main effects included from the originally proposed model found in Figure 5. A comparison of model estimated distribution tables and observed distribution tables was also done and was deemed appropriate for continued analysis. The $r$-squared for STEM retention in the final model was 0.53.

The final model reported was run using Bayesian estimation with a logit link for improved interpretability and to obtain a posterior distribution of possible parameter estimates. Parameter estimates and model results can be seen in Table 3. Significant indicators are designated with an asterisk ($p < .05$).

Of the four primary explanatory variables, MSE, math saturation, and male were significant. For each additional increase in MSE (9-point scale ranging from 0 = not at all confident to 8 = completely confident), study participants were 21\% more likely to be retained in a STEM major ($e^{0.19} = 1.21, p = .00$), indicating that an individual’s self efficacy as it relates to math (and in particular math courses) has a significant impact on their likelihood of persisting in a STEM major. The difference in persistence for an individual with an MSE of one compared to an MSE of nine becomes quite large. In a separate analysis, MSE scores for men and women
were compared. An independent samples $t$-test revealed a significant difference in average MSE scores between those who were retained in STEM compared to those who left. The average MSE score for those who retained in STEM was 7.43 (SD = 1.40) versus 6.79 (SD = 1.60) for those who left.

MSC had shown a positive relationship with retention in preliminary analysis; however, when combined with MSE and other independent variables, it was not a significant indicator of retention in STEM ($e^{-0.16} = 0.85, p = .26$). MSC scores were higher on average for those who retained than those who did not (5.73 vs. 5.43), but were inconsistent across levels of MSE. Those who retained and had lower or median MSE scores had MSC scores that were higher on average than those who left; however, those who retained and had higher MSE scores demonstrated lower MSC scores than those who left. Initial correlations between MSC items and STEM retention were low ($r = 0.02$ to $r = 0.03$) indicating that the change from positive to negative association is likely due to random variation after adjusting for MSE.

Math saturation of a program decreased the likelihood of persistence by 55% ($e^{-0.81} = 0.45, p = .00$), indicating that a 10% increase in math saturation would decrease the likelihood of retention by 5.5%. A one unit change in math saturation (i.e., 100% math saturation compared to 0% math saturation) would decrease the likelihood of retention by 55%.

Males were 2.6 times as likely to persist in STEM than females after controlling for all other variables in the model ($e^{0.95} = 2.58, p = .00$). Average MSE scores for males and females showed a significant difference using a independent samples $t$-test ($p <.001$) with MSE for males at 7.52 (SD = 1.36) and 6.90 (SD = 1.57) for females.
Table 3

Parameter Estimates and Model Results for SEM of STEM Retention

<table>
<thead>
<tr>
<th>Category</th>
<th>Variable</th>
<th>Logistic Estimate</th>
<th>Odds Ratio</th>
<th>Posterior S.D.</th>
<th>P-Value</th>
<th>95% C.I.</th>
<th>Significance</th>
</tr>
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<tbody>
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<td>MSE</td>
<td></td>
<td>0.19</td>
<td>1.21</td>
<td>0.07</td>
<td>0.00</td>
<td>0.07 - 0.32</td>
<td>*</td>
</tr>
<tr>
<td>MSC</td>
<td></td>
<td>-0.16</td>
<td>0.85</td>
<td>0.14</td>
<td>0.26</td>
<td>-0.43 - 0.11</td>
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</tr>
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<td>Math Saturation</td>
<td></td>
<td>-0.81</td>
<td>0.45</td>
<td>0.31</td>
<td>0.01</td>
<td>-1.41 - 0.22</td>
<td>*</td>
</tr>
<tr>
<td>Male</td>
<td></td>
<td>0.95</td>
<td>2.58</td>
<td>0.15</td>
<td>0.00</td>
<td>0.66 - 1.25</td>
<td>*</td>
</tr>
<tr>
<td>Demographics</td>
<td>White</td>
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<td>0.99</td>
<td>0.21</td>
<td>0.98</td>
<td>-0.42 - 0.41</td>
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</tr>
<tr>
<td></td>
<td>International</td>
<td>0.88</td>
<td>2.41</td>
<td>0.44</td>
<td>0.04</td>
<td>0.03 - 1.75</td>
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</tr>
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<td>First Generation</td>
<td>-0.12</td>
<td>0.88</td>
<td>0.30</td>
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<td>-0.70 - 0.46</td>
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<td>Freshman</td>
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<td>-0.04 - 1.25</td>
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<td>Sophomore</td>
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<td>-0.21 - 0.62</td>
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<td>Junior</td>
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<td>1.06</td>
<td>0.18</td>
<td>0.76</td>
<td>-0.28 - 0.42</td>
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</tr>
<tr>
<td></td>
<td>Age</td>
<td>-0.12</td>
<td>0.88</td>
<td>0.03</td>
<td>0.00</td>
<td>-0.19 - 0.06</td>
<td>*</td>
</tr>
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<td></td>
<td>Service Deferment</td>
<td>0.03</td>
<td>1.03</td>
<td>0.17</td>
<td>0.84</td>
<td>-0.32 - 0.35</td>
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<tr>
<td></td>
<td>Struggle to Pay</td>
<td>0.02</td>
<td>1.02</td>
<td>0.06</td>
<td>0.79</td>
<td>-0.10 - 0.13</td>
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<td></td>
<td>Married</td>
<td>1.30</td>
<td>3.67</td>
<td>0.17</td>
<td>0.00</td>
<td>0.97 - 1.63</td>
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</tr>
<tr>
<td></td>
<td>Dependents</td>
<td>-0.08</td>
<td>0.92</td>
<td>0.20</td>
<td>0.71</td>
<td>-0.47 - 0.34</td>
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</tr>
<tr>
<td>Parental Influence</td>
<td>Mother's Education</td>
<td>0.00</td>
<td>1.00</td>
<td>0.06</td>
<td>0.96</td>
<td>-0.12 - 0.13</td>
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<tr>
<td></td>
<td>Mother Studied STEM</td>
<td>0.12</td>
<td>1.13</td>
<td>0.25</td>
<td>0.63</td>
<td>-0.37 - 0.61</td>
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<tr>
<td></td>
<td>Mother Worked in STEM</td>
<td>-0.05</td>
<td>0.95</td>
<td>0.27</td>
<td>0.86</td>
<td>-0.57 - 0.49</td>
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<tr>
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<td>Father's Education</td>
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<td>0.41</td>
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<td>Father Studied STEM</td>
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<td>0.99</td>
<td>0.20</td>
<td>0.96</td>
<td>-0.40 - 0.40</td>
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<tr>
<td></td>
<td>Father Worked in STEM</td>
<td>0.19</td>
<td>1.20</td>
<td>0.18</td>
<td>0.31</td>
<td>-0.18 - 0.53</td>
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<td>High School Math Experience</td>
<td>Math Credits</td>
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<td>1.00</td>
<td>0.09</td>
<td>0.97</td>
<td>-0.18 - 0.17</td>
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<td>Math GPA</td>
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<td>0.90</td>
<td>0.31</td>
<td>0.73</td>
<td>-0.70 - 0.49</td>
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<td></td>
<td>Confident</td>
<td>-0.06</td>
<td>0.95</td>
<td>0.12</td>
<td>0.67</td>
<td>-0.30 - 0.20</td>
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<td></td>
<td>Enjoyed</td>
<td>-0.15</td>
<td>0.86</td>
<td>0.08</td>
<td>0.06</td>
<td>-0.32 - 0.01</td>
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<td></td>
<td>Did Well</td>
<td>0.24</td>
<td>1.28</td>
<td>0.13</td>
<td>0.06</td>
<td>-0.01 - 0.50</td>
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<tr>
<td></td>
<td>AP or Honors</td>
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<td>1.18</td>
<td>0.21</td>
<td>0.41</td>
<td>-0.22 - 0.57</td>
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<tr>
<td></td>
<td>Math ACT/SAT</td>
<td>0.02</td>
<td>1.02</td>
<td>0.02</td>
<td>0.33</td>
<td>-0.02 - 0.06</td>
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<tr>
<td>Major Experience</td>
<td>Research</td>
<td>1.60</td>
<td>4.95</td>
<td>0.20</td>
<td>0.00</td>
<td>1.22 - 2.00</td>
<td>*</td>
</tr>
<tr>
<td></td>
<td>Clubs</td>
<td>1.05</td>
<td>2.86</td>
<td>0.15</td>
<td>0.00</td>
<td>0.76 - 1.35</td>
<td>*</td>
</tr>
<tr>
<td></td>
<td>Mentor</td>
<td>0.20</td>
<td>1.22</td>
<td>0.18</td>
<td>0.28</td>
<td>-0.16 - 0.56</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Role Model</td>
<td>0.26</td>
<td>1.29</td>
<td>0.16</td>
<td>0.10</td>
<td>-0.06 - 0.57</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Faculty Rating</td>
<td>0.16</td>
<td>1.17</td>
<td>0.04</td>
<td>0.00</td>
<td>0.09 - 0.23</td>
<td>*</td>
</tr>
<tr>
<td></td>
<td>Male Peer Rating</td>
<td>0.14</td>
<td>1.15</td>
<td>0.04</td>
<td>0.00</td>
<td>0.06 - 0.21</td>
<td>*</td>
</tr>
<tr>
<td></td>
<td>Female Peer Rating</td>
<td>0.05</td>
<td>1.05</td>
<td>0.04</td>
<td>0.27</td>
<td>-0.04 - 0.14</td>
<td></td>
</tr>
</tbody>
</table>
International participants were significantly more likely to persist in STEM majors ($e^{0.88} = 2.41, p = .04$), 2.4 times as likely than students that were not international. This is not an unexpected outcome given the commitment involved with choosing to study in another country. Age was another significant indicator and participants were 12% less likely to persist in STEM for each additional year in age ($e^{-0.12} = 0.88, p = .00$). Married students were 3.8 times as likely to persist in a STEM major than non-married students ($e^{1.30} = 3.67, p = .00$).

Parental influencing factors of education level and experience studying or working in STEM were not shown to be significant indicators of retention in STEM. These were separated out by female guardian influence and male guardian influence but were not significant for either guardian.

Many of the indicators related to a participants’ major were also significant, namely research participation, club engagement, faculty and male peer ratings, and the math saturation of a major. Students who participated in research were nearly five times as likely to be retained in a STEM major compared to those who did not participate ($e^{1.6} = 4.95, p = .00$). Club engagement increased a participants’ likelihood of persisting by 2.9 times ($e^{1.05} = 2.86, p = .00$). A one point increase in faculty ratings (0 = negative experience to 10 = positive experience) increased the likelihood of retention by 17% ($e^{0.16} = 1.17, p = .00$) and a one point increase in male peer ratings increased the likelihood of retention by 15% ($e^{0.14} = 1.15, p = .00$). By contrast, female peer ratings were not a significant indicator of persistence. This may be due to the sheer number of male encounters versus female encounters given that so many STEM programs are male dominated, or that experiences with male peers are more likely to be associated with program experiences.
Although not significant at the $p < .05$ level, a few variables relating to prior math experiences came close, specifically the variables labeled did well, role model, and enjoyed. Students who indicated higher levels of agreement with the statement, “I did well in my last high school math class” were more likely to persist ($e^{0.24} = 1.28$, $p = .06$) and those who indicated they had a role model in their field of study were more likely to persist ($e^{0.26} = 1.29$, $p = .10$). Students who indicated higher levels of agreement with the statement, “I enjoyed my last high school math class” were less likely to persist ($e^{-0.15} = 0.86$, $p = .06$). This may seem contrary to expected associations with STEM persistence at first glance; however, it may be that this was more circumstantial and may not have translated to their collegiate experience. Students who enjoyed mathematics in high school may have enjoyed feeling successful and be driven into more math-intensive STEM majors, but due to a more challenging environment at a competitive university and a program with more math intensity, this may translate into lower persistence rates; however, the exact reasoning for this negative association is unknown and not pursued further in this study.

It is interesting to note that first generation status and white were not significant indicators for STEM retention. Retention rates for first generation and underrepresented minorities tend to be lower; however, in this study, after controlling for other variables, these were not significant. It is likely that students in these areas are dealing with other factors associated with their first generation and URM status that are somewhat accounted for in other variables included in this model such as parental education level and ability to pay for school.

First generation students had parents with less education and experience studying or working in STEM on average compared to students who were not first generation. Additionally, more first generation students indicated they struggled to pay for college than non first
generation students with only 26.60% of first generation students selecting “not at all” compared to 42.60% of non first generation students when asked to what degree they struggled to pay for college. Parental education by first generation status can be seen in Table 4.

Table 4

*Parental Education and Struggle to Pay Comparison Based on First Generation Status*

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>First Generation</th>
<th>Not First Generation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parental Education</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mother finished bachelor's degree or higher</td>
<td>21.88%</td>
<td>77.70%</td>
</tr>
<tr>
<td>Father finished a bachelor's degree or higher</td>
<td>20.75%</td>
<td>94.97%</td>
</tr>
<tr>
<td>Neither parent studied STEM</td>
<td>80.21%</td>
<td>47.59%</td>
</tr>
<tr>
<td>Neither parent worked in STEM</td>
<td>77.08%</td>
<td>52.14%</td>
</tr>
<tr>
<td>Struggled to Pay</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Not at all</td>
<td>26.60%</td>
<td>42.60%</td>
</tr>
<tr>
<td>A moderate amount or more</td>
<td>39.10%</td>
<td>24.60%</td>
</tr>
</tbody>
</table>

Similarly, underrepresented minority students had parents with less education and experience studying or working in STEM on average compared to white students. These students also indicated they struggled to pay for college more than their white peers as shown in Table 5.

Consideration should be given to the unique circumstances and challenges students in these groups face and how retention can be improved for these students with typically higher levels of attrition.
**Table 5**

*Parental Education and Struggle to Pay Comparison Based on Ethnicity*

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Minority</th>
<th>White</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parental Education</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mother finished bachelor's degree or higher</td>
<td>42.17%</td>
<td>73.50%</td>
</tr>
<tr>
<td>Father finished a bachelor's degree or higher</td>
<td>73.33%</td>
<td>89.07%</td>
</tr>
<tr>
<td>Neither parent studied STEM</td>
<td>58.63%</td>
<td>48.93%</td>
</tr>
<tr>
<td>Neither parent worked in STEM</td>
<td>65.11%</td>
<td>52.56%</td>
</tr>
<tr>
<td>Struggled to Pay</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Not at all</td>
<td>39.40%</td>
<td>49.10%</td>
</tr>
<tr>
<td>A moderate amount or more</td>
<td>41.20%</td>
<td>28.10%</td>
</tr>
</tbody>
</table>

**Discussion**

Model results indicated that MSE, math saturation, and gender were indeed significant predictors of retention in STEM while MSC was not. Additionally, many of the indicators associated with a student’s major were significant such as research participation, club engagement, and ratings of faculty and male peers. Math saturation also exhibited a negative association with retention as math saturation increased. These results shed light on the association between mathematics, gender, and retention in STEM, particularly in those programs that require a considerable amount of math.

Study findings confirmed previous research with males being more likely to persist than their female counterparts (Chen & Soldner, 2013; Ackerman et al., 2013). Women in this study were more likely to leave STEM than men despite any significant difference in achievement levels between genders as measured by math ACT/SAT equivalency scores. This was the case even in the presence of all the other indicators, demonstrating that there continues to be a gender component impacting retention in STEM and demonstrating trends often seen in the literature with more women leaving STEM than their male counterparts. Despite controlling for MSE,
MSC, and math saturation, women left STEM in higher numbers than their male counterparts. This is ameliorated by experience with male peers and faculty, with an increase in persistence seen for each additional increase in positive experience rating with their male peers and faculty.

Women have been shown in previous research to have lower MSE than men (Sax et al., 2015). Similar results were found in the present study with women having significantly lower MSE scores than men. The impact of MSE on retention in STEM was found to have a positive association with retention and was not found to differ between males and females; however, those with lower MSE are still more likely to see lower retention. Given the findings in the present study that lower MSE reduces the likelihood of persisting and women were found to have lower MSE scores on average, it becomes increasingly important to identify ways to address low MSE to increase the likelihood of women retaining in STEM and in turn increase the representation of women in STEM. Studies have been conducted related to increasing self-efficacy and have shown various methods of increasing self-efficacy in students. Positive improvements have been found with cognitive behavior therapy, tutoring and mentoring, professional development for faculty that trains on improving self-efficacy in students, and adoption of early warning systems (Sithole et al., 2017). Research has also shown that positive experiences and prior achievement are likely to improve self-efficacy (Falk, 2015), suggesting that providing resources coupled with positive experiences such as doing well in a mathematics prerequisite course can help to improve retention in later math intensive courses.

There has previously been a lack of research related to math intensity or math saturation of a major and it additionally has not been examined with MSE and MSC as they relate to STEM retention. This study showed that math saturation of a program demonstrated a negative association with STEM persistence. As math saturation of a program increased, retention
decreased. This coupled with the impact of MSE, suggests that greater self-efficacy as it relates to math can likely prepare women to persist in programs with higher math saturation.

MSC alone was previously shown to be a significant and positive predictor of STEM persistence (Ackerman et al., 2013); however, in the current study, in the presence of MSE, MSC was not significant, indicating that retention in STEM is less influenced by an individual’s view of their own identity and more about how they view what they are capable of accomplishing. A student may or may not have a high level of competency in a normative way, but if they have a high sense of self efficacy as it relates to math and believe they can accomplish the associated tasks, they are more likely to persist. In preliminary analysis, MSC alone was found to have a positive and significant association with STEM retention. This changed when combined with MSE and became negative and insignificant. Initial correlations of MSC items with STEM retention were close to zero and the introduction of MSE likely indicates just random variation when the path coefficient and initial correlations of MSC with retention do not have the same sign. Future studies should further investigate MSC and its impact on STEM retention in a longitudinal study as results may differ.

This study combined factors addressing demographics, parental influence, high school math experience, and program experience with the explanatory variables of MSE, MSC, math saturation, and gender to identify indicators of persistence. Contrary to previous research was the importance of high school factors such as grades and ACT/SAT scores (Ackerman et al., 2013; Rask, 2010). The current study showed that these earlier indicators were not significant when examined with experiences in their program and the other explanatory variables. Previous exposure to STEM and other earlier influences may influence enrollment and decisions about STEM majors during initial enrollment, but they were not significant predictors of retention once
students were declared STEM majors. Parental influencing factors were also found to be insignificant; however, it should be noted that omitted variable bias is likely present regarding parental influence. The impact of parental factors likely extends well beyond education level and experience in STEM and other variables not included in the model may impact retention in STEM.

Research participation, club engagement, and positive ratings of faculty and male peers were all positive markers of persistence while math saturation was negatively associated with retention. Mentoring and having a role model were not significant in the present study; however, as mentioned above, research has shown these can be methods of increasing self-efficacy and may have a mediating effect on retention. Additionally, it should be noted that more students in less math intensive majors reported having a mentor than those in more math intensive majors and may affect the impact on retention. Although programs of all math intensity levels in the study provided mentoring opportunities, the frequency of use of the term “mentor” may have influenced association of the term for those in less math intensive programs. It is possible in another study that the impact of having a mentor on STEM retention may be different.

One of the most poignant findings of this study are the variables related to experiences in their major. Previous research related to women in STEM has shown that early exposure to STEM and factors that are present in younger years have a large impact on enrollment in STEM. This often leaves faculty and administrators in higher education asking what they can do to increase representation of women in STEM once they are under their realm of influence within the higher education system. This study has shown that several variables connected to the student experience have a significant impact on whether or not they persist in a STEM major. Wilker (2017) showed that research experience matters and Blair et al. (2017) demonstrated that faculty
attitudes and support can improve retention. Similar findings were found in the present study with research participation and positive faculty ratings having a positive impact on persistence. Additionally, previous research found positive associations with female peers and increased retention for women (Robnett, 2016; Morganson et al., 2010). This study went a step further to investigate how experience with female and male peer ratings separately impact retention for both men and women. It was found that only male ratings were a significant indicator of STEM retention with higher ratings indicating higher retention and the finding was consistent for both males and females.

One of the biggest implications from this study is that there are indicators of STEM retention that higher education faculty and administrators can influence. Programs and interventions can be designed to improve math self-efficacy, involve more students in research and clubs, and identify ways to improve interactions amongst faculty and peers. Early exposure to STEM and earlier indicators of STEM still matter for initial enrollment and should not be neglected; however, there are also additional mediums for influencing retention after students are enrolled in STEM and the focus shifts to retention. Evidence suggests positive associations between increased participation in research, club involvement, improved faculty and peer interactions, and retention in STEM in addition to positive associations between MSE and STEM retention.

**Limitations**

The research presented here provides valuable insights into STEM retention for women; however, a few limitations should be noted as well as recommendations for future research. This study was a cross-sectional study that measured MSE and MSC on one occasion. Enrollment data was used from prior periods (2020 and 2021) but interaction with study participants and
measuring of MSE or MSC did not occur in 2020 or 2021. It should be noted that MSE and MSC were measurements of fall 2022 only and could be different than they may have been in previous years.

It should also be noted that rates of retention were measured based on enrollment in either 2020 or 2021 and again in fall 2022. This may be different than traditional measures of retention that follow a specific cohort through time to determine what retention and attrition looks like. This was also a measure of students leaving STEM and not just leaving the university, as is typically the focus with retention. Study participants may have switched to a non-STEM major but retained with the university.

Additionally, due to the observational nature of the study design, it is possible that omitted variable bias is present. Confounding effects of omitted variables can impact results.

This study also took place during the pandemic and likely impacted retention of some individuals. A follow up study would be beneficial to verify results.

**Recommendations**

This study identified the relationships between STEM retention and MSE, MSC, math saturation, and gender. It also incorporated math saturation which had not been studied previously and synthesized previous research. Given these significant connections between math related factors (MSE and math saturation) and STEM retention, it is recommended that faculty and administrators of postsecondary institutions develop interventions meant to improve self-efficacy in mathematics, particularly for women who have a lower MSE score on average than men. Research related to effective methods of improving self-efficacy have been presented, but further exploration on methods of improvement is recommended.
Math saturation of programs was found to be negatively associated with retention in STEM; however, it is not implied here that it is either practical or beneficial to reduce the math saturation of a program as a means of increasing retention. Instead, increasing MSE as a means of preparing students to persist in math intensive programs is encouraged.

Additionally, it is recommended that a longitudinal study following specific cohorts of students be conducted. MSE and MSC should be measured on multiple occasions to further identify the impact of MSE and MSC along with gender and math saturation on STEM retention.

Conclusion

Retention of women in STEM remains an issue for postsecondary institutions with women still underrepresented in math intensive areas of STEM and attrition rates higher for women than men. Research demonstrates that this gap is not due to a difference in ability in math between men and women, indicating that variables such as math self-efficacy and math self-concept may be impacting retention.

This study sought to investigate the link between MSE, MSC, math saturation, gender, and STEM retention. It also sought to synthesize previous research by incorporating indicators related to parental influence, previous high school experience in math, and experiences connected to their STEM majors.

Study results demonstrated MSE, math saturation, and gender were significant indicators of retention while MSC in the presence of other variables was not. Additionally, indicators associated with student experience in STEM programs such as research participation, club engagement, and experiences with faculty and male peers also impacted STEM retention. The implications of this suggest that the ability to influence retention is available at the postsecondary level. Ideally the findings of this study will provide additional insights for faculty and
administrators in higher education and encourage appropriate measures of intervention to improve math self-efficacy, and in turn, increase retention and representation of women in math intensive STEM fields.
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https://doi.org/10.1037/a0032338


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https://doi.org/10.1111/0019-8676.00134


INTRODUCTION TO ARTICLE 2

The following study *Evaluating the Relationship Between GEMP STEM Enrollment and the Factors of Math Self-Efficacy, Math Self-Concept, and Gender in Postsecondary Education* is an extension of the previous study titled, *The Impact of Math Self-Efficacy, Math Self-Concept, Math Saturation, and Gender on STEM Retention*. The research presented in the two studies is built upon similar concepts, theories, and closely aligned topics. The study below focuses on the same factors presented in the first study but looks instead at their association with enrollment in math intensive STEM majors instead of retention in STEM. Much of the supporting literature and applied methodologies are similar, but the outcome of interest is different, and the study makes a separate contribution to the area of enrollment in math intensive STEM.

Supporting literature provides insights into previous research related to STEM and mathematics; however, the first study provides context focused on retention in STEM whereas the second is supported by research related to enrollment. Similar methodologies are used in both studies. The same survey was utilized with items related to math self-efficacy, math self-concept, parental influence, high school math experience, and program experience. Structural equation modeling with Bayes estimation was used for both studies but with different outcomes of interest.
ARTICLE 2

Evaluating the Relationship Between GEMP STEM Enrollment and the Factors of Math Self-Efficacy, Math Self-Concept, and Gender in Postsecondary Education

Marcia Bingham
Dr. Sterling Hilton
Dr. Ross Larsen
Dr. Richard Sudweeks
Dr. Julie Crockett

Brigham Young University
Abstract

Women continue to be underrepresented in certain areas of science, technology, engineering, and mathematics (STEM), particularly in more math intensive disciplines. These math intensive majors are in the areas of geosciences, engineering, mathematics/computer science, and physical sciences (GEMP). Low representation within these GEMP STEM majors leads to underrepresentation in the STEM workforce, further enforcing gender gaps. Studies suggest this is not due to a gap in math ability between genders, yet underrepresentation remains predominantly within GEMP STEM, suggesting something like math self-efficacy (MSE) and math self-concept (MSC) may be at play. This study sought to investigate the relationship between GEMP STEM enrollment and the factors of MSE, MSC, and gender along with additional factors suggested in previous research. Structural equation modeling (SEM) was used to estimate parameters with Bayesian estimation. Results showed that MSE and being male were significant indicators of GEMP STEM enrollment. MSC was also a significant indicator but demonstrated that non-GEMP STEM students on average had higher levels of MSC than GEMP STEM students. This study highlights the importance of MSE and gender in GEMP STEM enrollment and should encourage future efforts on improving MSE as a method of increasing representation of women in GEMP STEM disciplines.

Keywords: GEMP STEM, enrollment, math self-efficacy, math self-concept, gender, structural equation modeling
Background

In the United States, women make up less than half of all the degrees awarded in several STEM areas, with some of these areas showing less than 20% of degrees awarded to women and others exhibiting a decline in degrees awarded to women between 1998 and 2018 as can be seen in Figure 1 (Hamrick, 2019). Not all STEM majors, however, are plagued with low representation of women. Many of the Agricultural and Biological Sciences have national averages at or above 50%. Biology, for example, has had above 50% female representation among graduates since 1996 (Hamrick, 2021). Programs sometimes referred to as GEMP (Geosciences, Engineering/Economics, Mathematics/Computer Science, and Physical Sciences) tend to be the STEM programs with lower female representation. These GEMP STEM programs are also considered to be more math intensive (Kahn & Ginther, 2017).

Math Achievement Across Genders

Previous studies have explored the connection between mathematics and achievement in mathematics with STEM, with few studies linking mathematics specifically to enrollment in the math intensive GEMP STEM areas. Completing advanced math courses in high school was shown to be a large and significant predictor of pursuing a postsecondary degree in STEM (Wang, 2013; Xie & Shaumann, 2003). Riegle-Crumb et al. (2012) found that high school scores in STEM subjects were correlated with expected enrollment in postsecondary STEM programs. Additionally, several studies have shown that both high school and introductory grades impact choice of major, particularly for STEM and economics majors (Main & Ost, 2014; Ost, 2010; Owen, 2010; Rask, 2010; Stinebrickner & Stinebrickner, 2011). Anaya et al. (2022) found that math achievement was a significant predictor of majoring in STEM with boys benefitting more
from higher levels of math achievement when looking at predictors of majoring specifically in GEMP STEM.

**Figure 1**

*Degrees Awarded to Women in STEM Fields*

<table>
<thead>
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<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>18.6%</td>
<td>20.4%</td>
<td>22.9%</td>
<td>26.9%</td>
<td>43.1%</td>
<td>46.8%</td>
<td>55.3%</td>
<td>56.9%</td>
<td>59.4%</td>
<td>62.8%</td>
<td>61.9%</td>
</tr>
</tbody>
</table>


Girls are less likely to take advanced math and science courses in high school, which in turn affects their enrollment in postsecondary STEM programs (Xie & Shaumann, 2003). With girls taking fewer math classes and enrolling in math intensive STEM majors in lower numbers, the implication may seem to be that perhaps girls are less capable in mathematics; however, research shows this is not the case. Despite fewer courses and low representation of women in math intensive GEMP STEM programs, evidence suggests that a gap in math ability between
genders either does not exist or is negligible. Gaps in achievement have been closing over the past several decades as women have begun taking more advanced math courses with the gap virtually disappearing (Hyde et al., 2008). Several studies found that males have a small advantage, but the difference tends to be trivial (Friedman-Sokuler & Justman, 2016; Fryer & Levitt, 2010; Penner & Paret, 2008; Pope & Sydnor, 2010). Kahn and Ginther (2017) summarized research related to women in GEMP STEM and found that even the largest differences demonstrated are objectively small and have decreased from previous decades.

**Math Self-Efficacy and Math Self-Concept**

Fewer advanced math courses being taken in high school by women despite any sizable difference in ability further perpetuates the gender gap in STEM majors, particularly in GEMP STEM. This persistent gap, despite the lack of difference, suggests that additional factors may be contributing to underrepresentation such as math self-efficacy (MSE) and math self-concept (MSC).

Academic self-concept is defined as “one’s perceived competence in a specific domain (often an academic subject) in a normative way (in comparison to peers or the average person) that includes both cognitive and affective evaluations of the self” (Sax et al., 2015). Self-efficacy has been defined as a, “[person’s] judgement of their [own] capabilities to organize and execute courses of action required to attain designated types of performances” (Bandura & National Institute of Mental Health, 1986, p. 391). Math self-concept focuses more on perceived identity in mathematics and is normative being based on comparison with peers. MSC may play a role as women compare themselves to men in their STEM programs. Math self-efficacy is focused more on perceived ability to complete and master specific requirements involving mathematics. MSC is an individual’s general perceptions of themselves in regards to math whereas MSE is an
individuals’ expectations about what they can accomplish regarding math. MSE can be measured based upon an individual’s confidence in performing or completing a task whereas MSC is based on peer comparisons, normative expectations, and a sense of self. MSC is measured using statements based on level of agreement such as “I am quite good at mathematics,” and “I have always done well in mathematics courses.” Although there are differences between the two constructs, both are concerned with personal perception of competency in regard to math and may impact a women’s decision to enroll in a STEM program.

MSE has been linked to enrollment in STEM (Ackerman et al., 2013; Aryee, 2017; Gurski, 2016). Women often rate their abilities lower on math and science, but higher on critical thinking, problem-solving, and teamwork (Gurski, 2016). Participation in a STEM field was shown to be linked to early development of confidence in math abilities for women (Sakellariou & Fang, 2021). A woman’s self-efficacy can be influenced by stereotypes that STEM is masculine and that women have lower perceived natural talent in these male-dominated fields (Bench et al., 2015; Luong & Knobloch-Westerwick, 2017; Rea, 2015; Shaffer et al., 2013). Additionally, higher levels of self-perceived math ability significantly predict the likelihood of enrolling in GEMP STEM during postsecondary education even after adjusting for achievement (Nix et al., 2015).

MSC begins to develop early and has been positively associated with enrolling in a STEM major for both men and women (Sax et al., 2015); however, women tend to have lower MSC than men. Bieri Buschor et al. (2014) found that students develop a sense of identity associated with STEM from childhood. Gender differences in attitude toward STEM careers begin to manifest as early as kindergarten and increase in subsequent years (Ceci et al., 2014). These early and varied gender attitudes towards STEM translate into women having lower
propensities to major in STEM (Ceci et al., 2014) despite similar abilities in math achievement. Conversely, Bieri Buschor et al.’s study (2014) showed that the majority of women who intended to major in STEM continued on in their intended major two years later. Women tend to rate themselves lower in MSC and even when women scored in the top 10% in the math portion of the SAT, they were far less likely than men with similar scores to report their math ability as “highest 10%” (Sax et al., 2015). Women also tend to be less confident about their ability relative to men (Kamas & Preston, 2012).

Additional Factors Impacting Enrollment

Various influences have been studied regarding their impact on attracting women to STEM programs in higher education. Many of these factors have been shown to have a positive impact by increasing female enrollment. Some examples are increased female representation amongst faculty (Vieyra et al., 2011), research experience (Wilker, 2017), faculty attitudes and support (Blair et al., 2017), early selection of a STEM major, and exemplary high school grades (Rask, 2010). Mentoring programs have also been beneficial in retaining women and increasing female students’ perception of their ability to succeed within these programs (Cheryan et al., 2011). Early exposure to STEM in elementary and middle school has also had a significant impact on attraction to STEM (Bishop, 2015; Valla & Williams, 2015). Additionally, men and women have been found to have a higher probability of working in a STEM field if they have a parent that works in STEM (Cheng et al., 2020).

Problem Statement

Despite no inherent difference in ability between men and women, differences in opportunity and representation persist within STEM. In addition to low enrollment, women leave STEM programs and industry opportunities in higher numbers than their male counterparts.
further contributing to the lack of female representation within STEM (Chen & Soldner, 2013; Ackerman et al., 2013). With fewer advanced math courses taken, less representation in GEMP STEM programs, and higher attrition both in education and industry, women have access to fewer opportunities in GEMP STEM fields and the higher pay associated with those opportunities.

Women make up almost half of the workforce in the United States, but only account for 27% of the STEM workforce (Martinez, A., & Christnacht, 2021). STEM occupations have grown by 79% since 1990 and are projected to continue growing with STEM job growth expected to be between 8% - 31% from 2019 to 2029 for various areas of STEM with larger growth expected in the GEMP STEM areas. Combined, these opportunities translate to nearly 800,000 new positions in STEM areas with much of the opportunities expected to be in GEMP STEM fields (Martinez, A., & Christnacht, 2021).

Adding to the lack of representation of women in the workforce, is the added concern of gender pay gaps. Although gender pay gaps exist within both GEMP and non-GEMP STEM fields, an additional concern relates to fewer women graduating with GEMP STEM degrees (aBlau & Kahn, 2017; Beede et al., 2011). Graduates of more math intensive (GEMP) fields have been shown to earn more than those in less math-intensive fields (Beede et al., 2011; Weinberger, 1999). With fewer women graduating in math intensive GEMP STEM, the majority of female graduates are not even eligible for higher paying GEMP STEM positions.

Given the large expectations in STEM job growth over the next 10 years, particularly in GEMP STEM fields, it stands to reason that female representation within GEMP STEM programs is of great importance to supply diversity in the future workforce, reduce pay gaps between genders, and provide sufficient opportunity for women in all areas of STEM.
Studies related to enrollment in STEM programs have been conducted; however, very little has focused on GEMP STEM and enrollment. A limited amount of research exists related to math intensive STEM majors and retention, but insufficient research exists directly investigating relationships with math intensive STEM enrollment. Studies have also looked at MSE and MSC separately but have not combined these effects and examined their association with enrollment. One contribution of this study is the synthesizing of previous research and expanding on GEMP STEM enrollment by combining MSE, MSC, gender, and additional indicators to see the relationships that exist with GEMP STEM enrollment.

**Purpose Statement**

Building upon previous research, this study seeks to examine the relationship between GEMP STEM enrollment and the factors of MSE, MSC, and gender. Additional demographics and factors such as parental influence, previous math experience in high school, and experience within their major are included. The study is not meant to be predictive, but rather is focused on reporting on observed relationships of indicators with GEMP STEM enrollment. This study will provide administration of higher education institutions with a greater understanding of the associations that exist between these variables and GEMP STEM enrollment, with particular focus on the three explanatory variables. A deeper understanding of what is associated with enrollment of women within the various math intensive STEM disciplines can empower leadership to make more informed decisions and design initiatives focused on increasing enrollment of women in needed areas within GEMP STEM.
Research Questions or Research Hypotheses

This study focused on the following research questions:

1. To what extent is math self-efficacy and math self-concept associated with enrollment in GEMP STEM programs while controlling for other factors that are associated with enrollment?

2. To what extent does the relationship between math self-efficacy and math self-concept and enrollment in GEMP STEM programs differ between genders?

Method

This section describes study participants, methods, and the proposed model that examines the relationships between GEMP STEM enrollment and MSE, MSC, and gender. Participants are described together as well as separately by gender and GEMP STEM status. The survey used in this study is described including information for the two previously developed scales for MSE and MSC (Betz & Hackett, 1983; Marsh & O’Neill, 1984). The research design and statistical analysis which utilized confirmatory factor analysis and structural equation modeling is also discussed below. Ethical practices were followed, and approval was obtained by the institutional review board along with participants’ consent prior to administering the survey.

Participants

The sampling frame for this study was made up of 12,051 undergraduate students enrolled in STEM during fall semester 2022 at a private four-year tier-2 research university in the Western United States. Thirty-five percent of students in the sampling frame were selected via random selection and were sent the survey used in this study. Participation was not obligatory, and responses were collected via elective participation.
The final sample consisted of 1,159 undergraduate students enrolled in STEM programs in fall 2022. Characteristics of the sample can be seen below in Table 1. GEMP STEM students made up 59.53% (n = 690) of the sample. Female students made up 41.67% of the sample (n = 483) with 9.06% first generation students (n = 105) and 15.53% minority students (n = 180). Class standing of the sample was 22.95% freshman, 21.05% sophomores, 24.42% juniors, and 31.58% seniors. The mean age was 21.62 (SD = 2.27) with a minimum age of 17 and a maximum age of 48.

Table 1

Participant Characteristics (All Respondents and GEMP Versus Non-GEMP STEM Comparison)

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>All Respondents</th>
<th>GEMP STEM</th>
<th>Non-GEMP STEM</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n</td>
<td>%</td>
<td>n</td>
</tr>
<tr>
<td>GEMP STEM</td>
<td>690</td>
<td>59.53</td>
<td>690</td>
</tr>
<tr>
<td>Non-GEMP STEM</td>
<td>469</td>
<td>40.47</td>
<td>-</td>
</tr>
<tr>
<td>Female</td>
<td>483</td>
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<td>Male</td>
<td>676</td>
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<td>First Generation</td>
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<td>9.06</td>
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<tr>
<td>Not First Generation</td>
<td>1054</td>
<td>90.94</td>
<td>637</td>
</tr>
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<td>Minority</td>
<td>180</td>
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<tr>
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<td>573</td>
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<tr>
<td>Class Standing</td>
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<tr>
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<td>266</td>
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<td>Sophomore</td>
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<td>Junior</td>
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<td>Senior</td>
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<td>Mean Age</td>
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<td>SD Age</td>
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<td>Age Range</td>
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<td></td>
<td>17 - 28</td>
</tr>
</tbody>
</table>
Comparing GEMP STEM students to non-GEMP STEM students, only 30.29% of GEMP STEM students were female while 58.42% of non-GEMP STEM students were female. Non-GEMP STEM students had a higher percentage of first-generation students (11.09%) compared to GEMP STEM students (7.68%) while GEMP STEM had a higher percentage of minority students with 83.04% of students classified as white versus 86.57% for non-GEMP STEM students. The class standing breakdown was fairly similar across GEMP and non-GEMP STEM students. GEMP STEM students were on average 0.27 years older than non-GEMP STEM students.

**Measures**

Previously developed scales for MSE and MSC were utilized and are discussed below (Betz & Hackett, 1983; Marsh & O’Neill, 1984). A Qualtrics survey was also used to administer the MSE and MSC scales and to gather information regarding demographics, parental influence, high school math experience, and experience in their program.

**Math Self-Efficacy**

To assess mathematics self-efficacy, a subscale from the Mathematics Self-Efficacy Scale (MSES) was used (Betz & Hackett, 1983). The scale was developed to assess self-efficacy expectations of late adolescent and college age students in mathematics. The subscale included 16 items that asked students to respond to how confident they were in successfully completing college courses requiring prior knowledge of mathematics. The 16 courses used in the original scale were accounting, advanced calculus, algebra 1, algebra 2, basic college mathematics, biochemistry, business administration, calculus, computer science, economics, geometry, philosophy, physiology, statistics, trigonometry, and zoology. The confidence ratings were on a 9-point scale ranging from 0 to eight (0 = not at all confident to 8 = completely confident).
Hackett and Betz (1989) reported an internal consistency reliability of .93 for the subscale. The overall reliability was .96 for the full MSE scale. In 1985, Hackett and O’Halloran reported a test-retest reliability for the full scale of .88 and .91 for the courses subscale (cited in Hackett & Betz, 1989). The MSES continues to be frequently used and has been validated as recently as 2022 and was found to have an internal consistency for each subscale of .80 or higher (Morán-Soto & González Peña). The MSE scale also demonstrated construct validity with a correlation of .66 between the MSE scale and the prior developed mathematical confidence subscale from the Mathematical Attitude Scales (Fennema & Sherman, 1976).

**Math Self-Concept**

To assess mathematics self-concept, a mathematics subscale of the Self-Description Questionnaire III (SDQ III) was used (Marsh & O’Neill, 1984). The math subscale consisted of 10 items related to an individual’s sense of self-concept as it pertains to mathematics and included statements such as “I have always done well in mathematics courses” and “I have hesitated to take courses that involve mathematics.” Respondents were asked to rate their level of agreement with each statement on an 8-point scale (1 = definitely false to 8 = definitely true).

SDQ III was validated for use among late adolescent and traditional university age students by Marsh and O’Neill (1984). Several other studies have used exploratory and confirmatory factor analysis to demonstrate construct validity (Byrne & Shavelson, 1986; Marsh et al., 1986; Marsh & O'Neill, 1984). Barbara M. Byrne (1988) reviewed multiple studies and found internal consistency reliability coefficients that ranged from .79 to .95 (mean $\alpha = .90$; Byrne & Shavelson, 1986; Marsh et al., 1986; Marsh & O'Neill, 1984), and test-retest reliability coefficients ranging from .66 to .94 (mean $r = .86$; Marsh et al., 1986). The academic self-
concept facets have also been shown to be highly correlated with academic outcomes (mean $r = .50$; Marsh & O’Neill, 1984).

**Survey**

Data was collected from respondents via a Qualtrics survey. The survey contained six sections with items that addressed math self-efficacy, math self-concept, demographics, parental influence, previous math experience, and program experience. The survey took approximately 15 minutes to complete. For MSE and MSC, the scales mentioned above were used and included in the survey (Betz & Hackett, 1983; Marsh & O’Neill, 1984).

Respondents were asked to answer several demographic questions to address their marital status and number of dependents. Participants were also asked the degree to which they struggled to pay for college on a five-point scale (1 = not at all to 5 = a great deal). Additionally, students in the sampling frame often defer for 18 to 24 months for a service mission. To account for this, participants were asked if they had ever deferred for this reason. Survey responses were combined with existing demographic data.

Parental influence items included questions about parental education level and experience studying and working in STEM fields. These were separated by female guardian and male guardian for a total of six items (three for each guardian).

High school math experience was assessed with existing data and items included in the survey. Respondents were asked questions meant to address personal feelings regarding their experience in mathematics in high school. These questions were not meant to address MSE or MSC and were not tested using factor analysis. They were simply meant to address personal feelings towards taking math such as “I enjoyed my last high school math class,” “I felt
confident in my last high school math class,” and “I did well in my last high school math class.” Respondents were asked to rate their level of agreement with each of these statements.

Experience in their major sought to capture information about research participation, club engagement, and whether or not the participant had a mentor or role model in their field of study. Additionally, respondents were asked to rate their male peers, female peers, and faculty in their major on a scale from 0 (negative experience) to 10 (positive experience). Additional variables meant to capture information regarding the participant’s prior experience in mathematics were combined with survey responses such as the number of math credits taken in high school, high school math GPA, and math ACT/SAT score.

Research Design

A sample survey with observational data in a cross-sectional design was used for this study. SEM was implemented to identify existing relationships between GEMP STEM enrollment and the factors of MSE, MSC, and gender without utilizing random assignment. Random assignment was not appropriate or possible in this study. Possible confounding variables may still exist that are not accounted for in the model.

Statistical Analysis

Initial analysis was conducted on data collected from the survey. Preliminary analysis included descriptive statistics of all variables along with bivariate correlations and visualizations. Logistic regression models were run assessing unadjusted relationships between variables of interest and the outcome. Confirmatory factor analysis (CFA) was conducted on both the MSE subscale and the MSC subscale of the SDQ III to ensure the factor structure of the observed variables in the sample. Model fit for CFAs was determined using the comparative fit index (CFI), Tucker Lewis Index (TLI), root mean square error of approximation (RMSEA), and the
standardized root mean squared residual (SRMR). Structural Equation Modeling (SEM) using Bayesian estimation was used to determine final adjusted relationships between outcomes and key explanatory variables. Preliminary analysis was conducted in SPSS (IBM Corporation, 2021) and Tableau (Tableau, 2022) with CFA and SEM conducted in Mplus (Statmodel, 2023). Missing data was handled using full information maximum likelihood (FIML) in the Bayesian estimation process.

Limitations should be considered. Omitted variable bias is a concern when using SEM and can threaten conclusions drawn. Omitted variable bias can lead to bias in parameter estimates by omitting relevant variables from the model that can lead to inaccurate conclusions. Additionally, consideration should be given to ensuring model assumptions are satisfied such as multivariate normality, sufficient sample size, and appropriate handling of missing data.

**GEMP STEM Enrollment Model**

The model presented in Figure 2 illustrates the associations proposed in this study between GEMP STEM enrollment and MSE, MSC, gender, and variables related to demographics, parental influence, high school math experience, and experience in their major. The proposed model was estimated using structural equation modeling (SEM) with Bayesian estimation and a logit link to account for the dichotomous outcome variable of GEMP STEM. Analysis was conducted to address model fit using log likelihood and comparison of model estimated distributions with observed distributions. Components of the model include measurement models for MSE and MSC (analyzed using confirmatory factor analysis as mentioned above) and structural components.
Figure 2

Proposed Model of the Relationship Between GEMP STEM Enrollment and Predictors
Results

CFA results for both MSE and MSC are below to confirm the factor structure of the observed variables. This is followed by SEM model results addressing model fit and parameter estimates.

Confirmatory Factor Analysis for Math Self-Efficacy

A CFA was run for MSE using the 16 courses from the original scale. The model results indicated poor model fit and did not meet recommended thresholds of RMSEA and SRMR below 0.08 and CFI and TLI above 0.90 (RMSEA = 0.20, SRMR = 0.14, CFI = .61, TLI = 0.54). Five of the original courses demonstrated poor factor loadings (biochemistry = 0.45, business administration = 0.45, philosophy = 0.38, physiology = 0.20, and zoology = 0.23). Although these courses were included in the original scale, they are often not considered to be math related courses. For the 11 other courses factor loadings ranged from 0.57 to 0.81. The CFA was run again without the five courses that exhibited poor factor loadings and with covariances allowed between courses with higher correlation such as advanced calculus with calculus, algebra I with algebra II, accounting with economics, and geometry with trigonometry. Three of the four fit indices indicated good model fit (SRMR = 0.05, CFI = .95, TLI = 0.93, and RMSEA = 0.10). Factor loadings were all above 0.58 and ranged up to 0.82. The final model and standardized factor loadings can be seen in Figure 3. Configural, metric, and scalar measurement invariance was established across genders and McDonald’s omega was used to demonstrate internal consistency reliability ($\omega = .76$).

Confirmatory Factor Analysis for Math Self-Concept

A CFA for MSC was run with the 10 original items and no error covariances. The model results demonstrated appropriate fit with only two out of the four fit indices (RMSEA = 0.12,
SRMR = 0.05, CFI = .92, and TLI = 0.90). The model was rerun allowing covariances between a few items that were highly correlated. Items 1 and 10 and items 6 and 8 were allowed to covary. Items one and 10 were assumed to be negatively correlated. (Item 1: “I find many mathematical problems interesting and challenging,” Item 10: “I have never been excited about mathematics,” Item 6: “I have trouble understanding anything that is based upon mathematics,” and Item 8: “I never do well on tests that require mathematical reasoning”). Three out of the four fit indices met appropriate thresholds with the fourth relatively close (RMSEA = 0.08, SRMR = 0.03, CFI = .96, and TLI = 0.95). The final model can be seen with standardized factor loadings in Figure 4. Configural, metric, and scalar measurement invariance was established across genders and McDonald’s omega was used to demonstrate internal consistency reliability (ω = .93).
Figure 3

Confirmatory Factor Analysis for Math Self-Efficacy
Math Achievement Across Genders

Prior to SEM analysis, differences in math achievement levels across genders were examined using math ACT/SAT equivalency scores. No significant difference was found after controlling for exposure to advanced math coursework through an advanced placement calculus designation ($p = .35$).
Model Results

Bayesian estimation using a logit link was used for model estimation in Mplus. Mplus does not currently return fit statistics, log likelihood values, predictive p-values, or the Bayesian Wald test for models that use Bayes estimation with a logit link, so additional modeling was done using the same model structure with maximum likelihood estimation (MLE) to select the appropriate model and address model fit. Additionally, Asparouhov and Muthén (2021) suggest that model fit can be assessed by comparing model estimated distribution tables with observed distribution tables. An additional suggestion was to add parameters individually (Asparouhov & Muthén, 2021). If added parameters are significant then the more restricted model is not appropriate.

The proposed model as shown in Figure 2 was estimated using MLE and compared to a model with the added interaction of male by MSC to identify gender effects. The less restricted model did not demonstrate a significant improvement in model fit over the restricted model (Δdeviance = 0.03, 1 df, \( p = .82 \)). An additional model with the interaction of male by MSE was also compared to the original model and did not demonstrate a significant improvement in model fit (Δdeviance = 0.03, 1 df, \( p = .82 \)). A significant interaction between male and either MSE or MSC would suggest that one of these affects gender differently; however, that was not observed. Additionally, a comparison of model estimated distribution tables and observed distribution tables was conducted and the model was deemed appropriate for continued analysis. The r-squared for GEMP STEM enrollment in the final model was .51.

Bayesian estimation with a logit link was used to estimate the final model. Bayesian estimation was used to obtain a posterior distribution of parameter estimates and for improved
interpretability. Model results can be seen below in Table 2 with significant parameter estimates ($p < .05$) denoted with an asterisk.

Examining model results, it can be seen that all three of the main explanatory variables (MSE, MSC, and gender) were significant. For every additional point in MSE, participants were 2.2 times as likely to be enrolled in a GEMP STEM major ($e^{0.81} = 2.24, p = .00$). The average MSE score for GEMP STEM participants was 7.73 (SD = 1.01) versus 6.60 for non-GEMP STEM participants (SD = 1.55) with a significant difference between the two groups ($p < .001$).

MSC was a significant indicator of GEMP STEM enrollment; however, it indicated that participants were less likely to be enrolled in a GEMP STEM major than their non-GEMP STEM counterparts for each additional point increase in MSC (44% less likely, $e^{-0.59} = .56, p = .00$). The average MSC score for GEMP STEM students was 5.98 (SD = 1.18) and the average for non-GEMP STEM students was 5.27 (SD = 1.41). An independent samples t-test showed a significant difference in means between the two groups ($p < .001$). This negative association with GEMP STEM enrollment was contrary to preliminary analysis that showed that MSC had a positive relationship with being enrolled in GEMP STEM. When adjusted for MSE, the relationship became negative. Stratifying respondents into three groups by MSE and examining MSC levels showed that for those with low MSE ($\leq 7$), non-GEMP students had on average higher MSC than GEMP STEM students (5.58 compared to 5.07), while the reverse was true for those with high MSE. In the high MSE range ($> 8$) GEMP STEM students had on average higher MSC than non-GEMP STEM students (6.50 compared to 6.45). The middle range of MSE saw comparable averages across GEMP and non-GEMP STEM students. Interactions with MSE and MSC as well as an interaction between low MSE and MSC were examined and found to be
insignificant and did not indicate significant improvements in model fit ($\Delta$deviance MSE*MSC = 0.03, 1 df, $p = .80$; $\Delta$deviance low MSE*MSC = 0.05, 1 df, $p = .79$).

Table 2

Parameter Estimates and Model Results for SEM of GEMP STEM Enrollment

<table>
<thead>
<tr>
<th>Category</th>
<th>Variable</th>
<th>Estimate</th>
<th>Odds Ratio</th>
<th>S.D.</th>
<th>P-Value</th>
<th>95% C.I.</th>
<th>Significance</th>
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</thead>
<tbody>
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<td></td>
<td></td>
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<td>Logistic</td>
<td>Posterior</td>
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<td></td>
<td></td>
<td></td>
<td>Odds Ratio</td>
<td>S.D.</td>
<td>P-Value</td>
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<td>Upper 2.5%</td>
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Gender differences were of interest in this study and the variable male was highly significant and showed that males students were nearly three times as likely to be enrolled in a GEMP STEM major as compared to females. \((e^{1.08} = 2.93, p = .00)\). Even after controlling for all other variables in the model, gender was still a significant predictor of being enrolled in a more math intensive major, indicating a gender effect continues to be present.

In addition to the three main explanatory variables, several demographic variables were also significant indicators of GEMP STEM enrollment. International students were 14 times more likely to be enrolled in a GEMP STEM major \((e^{2.64} = 14.027, p = .00)\). Age was also significant with participants being 28% more likely to be enrolled in GEMP STEM for each additional year in age. On average GEMP STEM students were slightly older than non-GEMP STEM with a slightly wider dispersion. The average age of GEMP STEM students was 21.72 (SD = 2.45) while the average age for non-GEMP STEM students was 21.47 (SD = 1.96). First generation status was significant \((p < .001)\) and demonstrated that first generation students were 68% less likely to be enrolled in a GEMP STEM major \((e^{-1.13} = 0.323)\). Married students were also significantly less likely to be enrolled in GEMP STEM (41% less likely, \(p = .01, e^{-0.528} = 0.59\)). Class standing was also included in the model and showed that freshman were almost four times as likely to be enrolled in GEMP STEM compared to seniors \((e^{1.33} = 3.79, p < .001)\).

Parental influence was included in the model in the form of level of education of each parent as well as if they studied or worked in a STEM field. Of these, only a father’s education level (male parental guardian’s education level) was a significant indicator of GEMP STEM enrollment. For each additional year of education of the male guardian, the participant was 23% less likely to be enrolled in GEMP STEM \((e^{-0.26} = 0.77, p < .001)\). A higher percentage of GEMP STEM participants had fathers with a bachelor’s degree or higher (90.72% vs. 88.27%);
however, a higher percentage of non-GEMP STEM participants had fathers with doctoral or professional degrees (31.34% vs. 19.86%). The indicators of “studied STEM” and “worked in STEM” were not significant predictors.

Math ACT (or SAT equivalent) score was significant and showed that for every additional point increase in math ACT/SAT score, participants were 13% more likely to be enrolled in a GEMP STEM major ($e^{0.12} = 1.13, p < .001$). It is important to point out that the score used was the math sub score for the ACT/SAT and not the composite score.

A couple variables connected to their major experience were also significant. If a student had a mentor in their field of study, they were 35% less likely to be enrolled in a GEMP STEM major ($e^{-0.43} = 0.651, p = .02$). Students that were non-GEMP STEM were more likely to have a mentor with 36.46% of non-GEMP STEM students indicating they had a mentor compared to only 27.83% of GEMP STEM students. It is worth noting that although programs within both GEMP STEM and non-GEMP STEM engage in research mentorships, learning mentorships, and peer mentoring, programs in the non-GEMP STEM area use the term mentor more frequently and may contribute to more non-GEMP STEM students identifying the support provided as mentors. Faculty ratings were also significant and showed non-GEMP STEM students with higher positive ratings for faculty than their GEMP STEM counterparts. For each additional increase in rating for faculty, participants were 24% less likely to be enrolled in GEMP STEM ($e^{-0.27} = 0.76, p < .001$). The average faculty rating for GEMP STEM students was 8.03 (SD = 1.76) while non-GEMP STEM students averaged 8.39 (SD = 1.68).

Although not significant at the $p < .05$ level, a few variables came close, specifically the variables of enjoyed, female peer rating, and defer for service. For each additional point increase in level of agreement with the statement “I enjoyed my last high school math class,” participants
were 22% more likely to be enrolled in GEMP STEM ($e^{0.20} = 1.23$, $p = 0.05$). Female peer ratings were close to the 0.05 level as well and showed that for each additional increase in female peer rating ($0 = \text{negative experience to } 10 = \text{positive experience}$), students were 14% more likely to be enrolled in GEMP STEM ($e^{0.13} = 1.14$, $p = .06$). Additionally, students who deferred for service were 40% less likely to be enrolled in a GEMP STEM major ($e^{-0.51} = 0.60$, $p = .05$).

It is interesting to consider the variables that were not significant in the model. Minority students tend to be underrepresented in STEM in general; however, ethnicity was not a significant predictor of being enrolled in GEMP STEM after controlling for other variables in the model. Students in GEMP STEM or non-GEMP STEM were not more likely to participate in research or engage in club activity. There was also no significant difference between male peer ratings for GEMP STEM and non-GEMP STEM students. Lastly, many of the high school variables (number of math credits taken in high school, high school math GPA, etc.) were not significant with the exception of the math ACT/SAT scores.

**Discussion**

Findings indicated that all three of the primary explanatory variables (MSE, MSC, and male) were significant. MSE and male were positively associated with GEMP STEM, demonstrating that students with higher MSE were more likely to be enrolled in GEMP STEM as were male students compared to female students. MSC, however, was negatively associated with GEMP STEM enrollment. Additionally, international students and older students were more likely to be enrolled in GEMP STEM as were freshman relative to seniors. First generation and married students were less likely to be enrolled in GEMP STEM. Non-GEMP STEM students were more likely to select they had a mentor and had on average higher faculty ratings than GEMP STEM students. They also had a higher proportion of their male guardians with
professional or doctorate degrees. Lastly, most of the high school related indicators were not significant predictors of GEMP STEM enrollment with the exception of math ACT/SAT scores.

This study confirmed previous research demonstrating that more math intensive GEMP STEM programs tend to have lower female representation (Kahn & Ginther, 2017) and showed that MSE is significantly connected to GEMP STEM enrollment. Participants with a higher MSE were more likely to be enrolled in GEMP STEM. Even after controlling for other variables, gender continued to be a significant indicator without any significant difference in math achievement between genders. Research shows women tend to have lower MSE despite similar achievement levels (Sax et al., 2015). The present study had similar findings with women having significantly lower MSE than men. Given lower MSE in women and the relationship seen with enrollment in GEMP STEM, suggests that focusing on increasing MSE will likely have an impact on increasing representation of women in GEMP STEM.

MSC exhibited a negative association with GEMP STEM enrollment. Previous research demonstrated that MSC was a positive indicator of enrollment in STEM (Ackerman et al., 2013); however, in the present study this was not the case. MSC alone was found to have a positive and significant association with GEMP STEM enrollment in preliminary analysis. This changed when combined with MSE and became negative, although still significant. Stratifying results by MSE showed inconsistent levels of MSC between GEMP and non-GEMP students across the various levels of MSE and interactions between MSE and MSC were not significant. MSC is normative in nature and involves comparison to peers. It is possible that GEMP STEM students repeated exposure to highly competitive math courses begins to impact and reduce their MSC. Non GEMP STEM students, in contrast, take few (if any) mathematics courses and may not find their MSC challenged as much as GEMP STEM students relative to their peers.
International students were considerably more likely to be enrolled in a GEMP STEM major compared to non-international students. U.S. policy may impact how international students select a major. In 2015, President Obama signed the STEM Education Bill which made the green card process easier for students with STEM degrees (Interstride, 2023). The Optional Practice Training program also offers an extended 24-month extension to STEM students (Interstride, 2023). This may help to explain why international students select a general STEM major, but why the considerable increase in likelihood of selecting a GEMP STEM major as compared to non-GEMP STEM? Greater availability of STEM positions in math related fields which can lead to sponsorship in the US as well as typically higher salaries in these fields (Bureau of Labor Statistics, 2022) may add to the influence of the STEM Education Bill and the Optional Training Practice program and encourage international students to select a GEMP STEM major over non-GEMP STEM majors.

First-generation students were less likely to be enrolled in GEMP STEM, confirming previous research and statistics at universities across the country (Vielma, 2016). This may be a result of lack of exposure to more math related coursework in high school as well as resources to support pursuing a more math driven curriculum. Class standing showed that freshman were more likely to be enrolled in GEMP STEM compared to seniors. This outcome is somewhat expected given that a high proportion of incoming freshman in the sampling frame declare a STEM major and 31.85% leave STEM as a freshman. More than 35% of students in the sampling frame also changed their major before taking at least 12 credits in their program and higher attrition is seen among GEMP STEM freshman students than non-GEMP STEM freshman students (32.70% versus 30.82%).
Of the parental influence variables, only father’s education was significant and showed higher levels of education indicated respondents were less likely to be enrolled in GEMP STEM. This was seen with more non-GEMP STEM participants indicating their fathers had doctoral or professional degrees than GEMP STEM respondents. The indicators of “studied STEM” and “worked in STEM” were not significant predictors. Given that they do not differentiate between GEMP and non-GEMP STEM status, this outcome is not surprising. GEMP STEM enrollment was the outcome of interest; however, these questions simply asked if a male or female guardian studied or worked in a STEM field, not a GEMP STEM field. It is possible they would be significant indicators of enrollment in STEM but not GEMP STEM enrollment. It may also be possible that questions related to experience studying or working in GEMP STEM may have been significant indicators of enrollment in GEMP STEM. As stated, they were not significant. Additionally, omitted variable bias is likely present with parental influence factors extending beyond education level and experience in STEM. It is expected that parents influence is complex and additional influences likely impact enrollment in GEMP STEM.

Contrary to previous research related to STEM, high school factors were not significantly connected to GEMP STEM enrollment with the exception of math ACT/SAT scores (Ackerman et al., 2013; Rask, 2010). Early indicators may indeed make a difference in enrollment in STEM but did not differentiate between GEMP STEM and non-GEMP STEM enrollment.

Overall, study findings confirmed the connection between MSE, gender, and GEMP STEM enrollment. Examining the low representation of women in math intensive STEM fields both within the workforce and in higher education, along with high attrition rates, the issue and importance of women in GEMP STEM majors becomes more apparent. We know that women rate their abilities lower than men in math and science (Gurski, 2016). Given the findings in the
present study that MSE is connected with a higher likelihood of being enrolled in GEMP STEM, it becomes increasingly important to identify ways to address low MSE and in turn increase representation of women in GEMP STEM. Various methods for increasing MSE have been shown in the literature such as cognitive behavior therapy, tutoring and mentoring, training for faculty and administrators, and early warning systems (Sithole et al., 2017). Positive experience and prior achievement are also likely to improve self-efficacy (Falk, 2015). These, taken together, suggest a variety of methods available to leadership in higher education to make a difference in improving MSE in students. This increase in MSE can, in turn, help to increase representation of women in the more math intensive GEMP STEM majors.

Limitations and Recommendations

Limitations of this study should be considered. The current research was conducted using cross-sectional data. Longitudinal data may increase understanding of the impact of MSE and MSC on original decisions to enroll in GEMP STEM. It is recommended that MSE and MSC be measured on multiple occasions, particularly during high school years to identify how MSE and MSC in high school affects enrollment decisions at the postsecondary level. Additional insights could also be gained by tracking how MSE and MSC changes over time after enrollment.

Omitted variable bias is always a concern with a observational designs and should be considered in this context. It is possible that a variable omitted from the model could have a confounding effect on the outcome.

An additional consideration is due to the limited research related specifically to math intensive GEMP STEM. Much has been studied as it pertains to STEM; however, a lack of prior research makes it difficult to lay a foundation for a particular study. It is recommended that
additional studies be conducted related to GEMP STEM enrollment to increase the foundational knowledge in this area.

This study highlighted the importance of MSE, and gender as it relates to GEMP STEM enrollment. It is recommended that leadership and faculty in postsecondary institutions work to improve self-efficacy in students. Some research demonstrating effective methods of improving self-efficacy in individuals was presented earlier; however, further exploration of this topic is recommended.

Conclusion

The research presented here sought to investigate the association between enrollment in math intensive GEMP STEM majors and the factors of MSE, MSC, and gender. The study also brought together elements presented in previous research such as parental influence, high school math experience, and factors associated with their GEMP STEM major.

Results indicated that the three factors of MSE, MSC, and gender were significant with MSE and male positively associated with enrollment in GEMP STEM and MSC negatively associated with GEMP STEM enrollment. This was the case despite any significant difference in math achievement between genders. These findings further emphasize the connection between mathematics and enrollment in more math intensive STEM majors and highlight the need to focus on MSE as a factor for increasing enrollment in GEMP STEM resulting in an increase in representation of women in these areas. The need for more women in GEMP STEM majors is apparent given the low representation in the workforce and projected demand for growth in these areas. Raising MSE in students is a possible avenue to increase representation of women in GEMP STEM, meet future demand in job growth, and begin to reduce gaps between genders.
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APPENDIX A

Extended Review of the Literature

In the United States, women make up less than half of all the degrees awarded in several STEM areas, with some of these areas showing less than 20% of degrees awarded to women and others exhibiting a decline in degrees awarded to women between 1998 and 2018 as shown in Figure A1 (Hamrick et al., 2019). Additionally, although both men and women leave STEM programs, women leave in higher numbers and for different reasons than men (Ackerman et al., 2013; Chen & Soldner, 2013).

Figure A1

*Figures Awarded to Women in STEM Fields*

Although many programs within STEM demonstrate low female representation, not all STEM majors are plagued with low female enrollment and high attrition. Many of the Agricultural and Biological Sciences have national averages at or above 50%. Biology, for example, has had above 50% female representation among graduates since 1996 (Hamrick et al., 2019). Programs sometimes referred to as GEMP (Geosciences, Engineering/Economics, Mathematics/Computer Science, and Physical Sciences) tend to be the STEM programs with lower female representation. These GEMP STEM programs are also considered to be more math intensive (Kahn & Ginther, 2017).

**Diversity in the Workplace**

Women make up almost half of the workforce in the United States, but only account for 27% of the STEM workforce (Martinez & Christnacht, 2021). STEM occupations have grown by 79% since 1990 and are projected to continue growing with STEM job growth expected to be between 8% - 31% from 2019 to 2029 for various areas of STEM. Combined, these opportunities translate to nearly 800,000 new positions in STEM areas (Martinez & Christnacht, 2021). Diversity in the workplace matters with studies demonstrating that diversity can lead to increased creativity, innovation, and efficiency as well as reduced turnover and greater efficiencies (Fine et al., 2020; Roberge & Van Dick, 2010; Saxena, 2014).

Adding to the lack of representation of women in the workforce, is the added concern of gender pay gaps. Although gender pay gaps exist within both GEMP and non-GEMP STEM fields, an additional concern relates to fewer women graduating with GEMP STEM degrees (Beede et al., 2011; Blau & Kahn, 2017). Graduates of more math intensive (GEMP) fields have been shown to earn more than those in less math-intensive fields (Beede et al., 2011;
Weinberger, 1999). With fewer women graduating in math intensive GEMP STEM, the majority of female graduates are not even eligible for higher paying GEMP STEM positions.

**Math Ability and Achievement**

Despite low representation of women in math intensive GEMP STEM programs, evidence suggests that a gap in math ability between genders either does not exist or is negligible. Gaps in achievement have been closing over the past several decades as women have begun taking more advanced math courses with the gap virtually disappearing (Hyde et al., 2008). Several studies found that males have a small advantage, but the difference tends to be trivial (Friedman-Sokuler & Justman, 2016; Fryer & Levitt, 2010; Penner & Paret, 2008; Pope & Sydnor, 2010). Kahn and Ginther (2017) summarized research related to women in GEMP STEM and found that even the largest differences demonstrated are objectively small and have decreased from previous decades.

Although differences in mean scores tend to be negligible, variance in math scores has been shown to be greater among men which can translate into gender differences at the highest levels of performance. This higher ratio of males-to-females in the upper echelons of scores can contribute to overrepresentation of men in GEMP STEM where many programs have limited enrollment and review exam scores for admittance (Friedman-Sokuler & Justmand, 2016; Fryer & Levitt, 2010; Hyde et al., 2008; Pope & Snydor, 2010; Stoet & Geary, 2013). Although males and females may be admitted with the same criteria, the higher variability in scores among men can result in a higher proportion of males being admitted and can lead to differences in gender representation, though not in performance. It should also be noted that fewer women take advanced math courses in high school and college (Fennema, 1979). Many assessments used in large scale studies are given to students regardless of the level of math they have completed.
With less exposure to advanced math courses, we would expect to see reduced variability on the upper end of scores for females as compared to males.

**Math Self-Efficacy and Self-Concept**

An additional concern is that despite negligible differences in math ability between men and women, significant differences in math self-efficacy and math self-concept do exist between genders and impact enrollment and attrition. Women often rate their abilities lower on math and science, but higher on critical thinking, problem-solving, and teamwork (Gurski, 2016). For more than 40 years, men have consistently rated themselves higher in math self-concept than women (Sax et al., 2015). Even when women scored in the top 10% in the math portion of the SAT, they were far less likely than men with similar scores to report their math ability as “highest 10%” (Sax et al., 2015).

With fewer women in math intensive STEM majors despite no inherent difference in ability between men and women besides gaps in math self-efficacy and math self-concept, differences in opportunity and representation persist. Fewer advanced math courses are taken, lower representation in GEMP STEM programs is seen, and higher attrition both in education and industry occurs. All this results in women having access to fewer opportunities in GEMP STEM fields and the associated benefits.

**Factors Impacting Enrollment and Attrition**

Various influences have been studied regarding their impact on attraction and retention of women in STEM programs in higher education. Many of these factors have been shown to have a positive impact by increasing female enrollment and reducing attrition. Some examples are increased female representation amongst faculty (Vieyra et al., 2011), research experience (Wilker, 2017), faculty attitudes and support (Blair et al., 2017), early selection of a STEM
major, and exemplary high school grades (Rask, 2010). Mentoring programs have also been beneficial in retaining women and increasing female students’ perception of their ability to succeed within these programs (Cheryan et al., 2011). Early exposure to STEM in elementary and middle school has also had a significant impact on attraction to STEM (Bishop, 2015; Valla & Williams, 2015).

Alternatively, certain factors have been shown to negatively impact enrollment and retention and increase attrition of women in these programs. Psychological factors such as stereotype threat (Beasley & Fischer, 2012), and demographic factors such as being a female first-generation student (Vielma, 2016) increase the risk of attrition. Perceptions of male dominance and “unconscious gender bias remains widespread” (Corbett & Hill, 2015) and contributes to a culture that also increases attrition of women in these programs.

In addition to the factors above that both positively and negatively impact enrollment and attrition of women in STEM programs, math achievement along with math self-efficacy and math self-concept have both been shown to have significant impacts on women in STEM programs.

Math Achievement and Exposure

The following section discusses math achievement and early exposure to STEM and how that has impacted enrollment and attrition from STEM.

Enrollment

Math achievement and exposure impacts enrollment in advanced math courses and postsecondary STEM programs. Completing advanced math courses in high school is a large and significant predictor of pursuing a postsecondary degree in STEM (Wang, 2013; Xie & Shaumann, 2003). Girls are less likely to take advanced math and science courses, which in turn
affects their enrollment in postsecondary STEM programs (Xie & Shaumann, 2003). Riegle-Crumb et al. (2012) found that high school scores in STEM subjects were correlated with expected enrollment in postsecondary STEM programs. Additionally, several studies have shown that both high school and introductory grades impact choice of major, particularly for STEM and economics majors (Main & Ost, 2014; Ost, 2010; Owen, 2010; Rask, 2010; Stinebrickner & Stinebrickner, 2011).

**Attrition**

Math achievement not only affects enrollment in STEM programs but also has additional implications on retention within postsecondary STEM programs. Lang (2008) found that performance in coursework impacts persistence in associated majors. Ackerman et al. (2013) found that traditional predictors of academic success such as high school GPA and SAT/ACT scores are significant predictors of STEM persistence.

Math-intensive GEMP STEM majors are likely to be affected by math achievement. Many of these GEMP STEM majors require completion of calculus as a prerequisite to subsequent coursework. Ellis et al. (2016) found that women were 1.5 times more likely to switch to non-STEM programs after Calculus I. Dabney and Tai (2014) also found that introductory courses that are designed to “weed out” students are more harmful for underrepresented minorities and women. Tutoring has been found to counteract this with significant impacts on the level of math attained (Robinson, 2007) which can indirectly affect retention by reducing the number who leave due to math achievement and math intensity. Although many studies have looked at the impact of various aspects of math achievement on enrollment and attrition in STEM majors, there has been a lack of focus on GEMP STEM programs and the impact of math intensity on enrollment and attrition.
Math Self-Efficacy and Math Self-Concept – Enrollment and Attrition

In addition to math achievement impacting STEM programs, math self-concept and math self-efficacy have also been linked to enrollment and attrition (Ackerman et al., 2013; Aryee, 2017; Gurski, 2016).

Math self-concept and self-efficacy are defined as two distinct concepts; however, many similarities exist between the two constructs. Academic self-concept has been defined as “one’s perceived competence in a specific domain (often an academic subject) in a normative way (in comparison to peers or the average person) that includes both cognitive and affective evaluations of the self” (Sax et al., 2015). Self-efficacy is defined as, “people’s judgements of their capabilities to organize and execute courses of action required to attain designated types of performances” (Bandura & National Institute of Mental Health, 1986). Self-concept focuses more on perceived competence in an academic area and social comparison and may play a role as women compare themselves to men in STEM programs. Self-efficacy is focused more on perceived ability to execute and master specific requirements. Although there are differences between the two constructs, they are both concerned with personal perception of competency and are considered collectively for our purposes since both math self-concept and math self-efficacy may impact a women’s decision to enroll or persist in a STEM program.

The impact of self-concept and self-efficacy on STEM enrollment and attrition is not fully known, but much has been studied regarding the ways we view ourselves and the possible implications for enrollment and attrition in STEM programs. We know that women often rate their abilities lower on math and science, but higher on critical thinking, problem-solving, and teamwork and that women who persist in postsecondary STEM programs on have higher than average self-efficacy (Gurski, 2016). A women’s self-efficacy can be influenced by stereotypes
that STEM is masculine and that women have lower perceived natural talent in these male-dominated fields (Bench et al., 2015; Luong & Knobloch-Westerwick, 2017; Rea, 2015; Shaffer et al., 2013).

**Enrollment**

Bieri Buschor et al. (2014) found that students develop a sense of identity associated with STEM from childhood. Gender differences in attitude toward STEM careers begin to manifest as early as kindergarten and increase in subsequent years (Ceci et al., 2014). These early and varied gender attitudes towards STEM translate into women having lower propensities to major in STEM (Ceci et al., 2014) despite similar abilities in math achievement. Park et al. (2016) even found that women were likely to show less interest in STEM to appear more desirable to romantic partners in campus environments. Conversely, Beri Buschor et al.’s study (2014) showed that the majority of women who intended to major in STEM continued on in their intended major two years later. Math self-concept has consistently been a positive predictor of enrollment in a STEM major for both men and women (Sax et al., 2015). Its salience has fluctuated over time and its impact tends to vary by STEM discipline and gender; however, math self-concept remains a persistent predictor of STEM enrollment.

**Attrition**

Math self-concept and math self-efficacy have important implications not only for enrollment but also for attrition. Although both men and women leave STEM programs, women leave in higher numbers and for different reasons (Ackerman et al., 2013; Chen & Soldner, 2013). Low math self-concept is a significant predictor of women leaving STEM programs (Ackerman et al., 2013). Similarly, students with a high sense of self-efficacy are more likely to persist in STEM and go on to complete a STEM degree (Aryee, 2017). Women who leave STEM
have significantly lower math self-concept than men and also significantly lower math self-concept than women who persist (Ackerman et al., 2013). Ellis et al. (2016) found that women with above average ability in calculus start and end the term with lower mathematical confidence (math self-concept) than men, suggesting that math self-concept is likely responsible for attrition rather than ability.

Recognizing that women tend to rate themselves lower in math self-efficacy and math self-concept despite similar achievement, it becomes apparent that increasing math self-efficacy and self-concept in women is likely an important tool in retention of women. Studies have shown a reciprocal relationship between math achievement and math self-concept with both having a positive impact on the other (Falk, 2015; Schöber et al., 2018. Goldman and Penner (2014) found that math self-concept was more closely related to an inclination towards a career using mathematics than achievement was. They also found that differences in math self-concept between genders varied by country with more egalitarian countries seeing smaller differences.

**Gaps in the Literature**

Although much has been studied related to women in STEM, there are still significant gaps in the literature. The largest gap is related to GEMP STEM. Much has been studied related to the enrollment and attrition of women in STEM programs; however, very little has focused on GEMP STEM specifically and predictors of female enrollment or attrition in these areas. Separately, studies have looked into the effects of introductory math courses or general classifications as math intensive, but no studies (at least not to the best of my knowledge) have measured the level of overall math intensity of a program and looked at the effects of math intensity on enrollment. Studies have also looked at math self-efficacy and math self-concept but have not combined these effects while controlling for the math intensity of a program to see the
impact on enrollment and attrition. Lastly, studies have not synthesize previous research by bringing together MSE, MSC, gender and additional variables related to parental influence, previous math experience, and program experience to see the impacts on STEM enrollment and attrition.

**Social Cognitive Career Theory**

Understanding low enrollment and high attrition of women in STEM begins with an understanding of the influences on choice and behavior. Social Cognitive Career Theory (SCCT) was developed to explain (a) how academic and career interests develop, (b) how academic and career choices are made, and (c) how academic and career success is obtained. SCCT was first introduced by Lent et al. in 1994 and stemmed from Albert Bandura’s development of Social Cognitive Theory (1986) which was a theory of behavior and what influences behavior. Social Cognitive Theory proposed that learning occurs through the dynamic and reciprocal interaction of personal, behavior, and environmental determinants as shown in Figure A2.

Building upon this foundation of Social Cognitive Theory, SCCT explains the three linked components of academic and career development, namely interest, choice, and success. These three components within SCCT have been used to help explain a student’s major selection and particularly why some select and persist in STEM majors while others may select a STEM major but not persist. SCCT is prominent throughout the literature regarding women in STEM and is a dominant theoretical framework used to explain academic choice of enrollment and persistence in STEM. SCCT posits that there are three factors that determine academic and career interest, choice, and success. These factors are self-efficacy, outcome expectations, and goals.
Self-efficacy is derived from past performance and accomplishments, through vicarious experiences of others, and through social persuasion. Individuals are more likely to choose activities in which they have a strong sense of self-efficacy (Lent, 2013). Outcome expectations are those “imagined consequences” of certain behaviors, the expected outcome from some choice of action. The choices individuals make are largely determined by the probability of an expected outcome (Lent et al., 1994). Individuals act based on the likely outcome of those actions (Bandura & National Institute of Mental Health, 1986). Goals also play an important role in choice and behavior. Goal setting contributes to persistence and links self-satisfaction with goal achievement (Lent et al., 1994). Goals, along with expected career outcomes can influence career plans, which in turn can influence choice of major.

The three intertwined and reciprocal influences continue to affect one another with goal achievement affecting self-efficacy and outcome expectations, self-efficacy influencing outcome expectations and goal setting, and finally outcome expectations affecting self-efficacy and goals.
Goal achievement or failure can serve to confirm or alter perceptions about self-efficacy and similarly alter expected outcomes. Self-efficacy contributes to expected outcomes through an individual’s belief about their capabilities to accomplish a task and similarly impact goals that are made. Goals tend to be made consistent with perceived levels of ability (self-efficacy). Outcome expectations are often influenced by the level of an individual’s self-efficacy and decisions regarding goal selection (Lent et al., 1994).

The three components of self-efficacy, outcome expectations, and goal mechanisms are intertwined and additionally impacted by our experiences, interests, and contextual influences. Lent et al. (1994) presented the model seen in Figure A3 to demonstrate the complex interactions that ultimately determine our choices and behavior.

Given this framework, SCCT can help us understand what influences impact a student’s choice to enroll and persist in math-intensive STEM majors. We begin to see the impact that math achievement and math self-concept might have an individual’s choice to enroll and persist. Particularly important is if women report low math self-concept/self-efficacy despite comparable levels of achievement with their male counterparts. If self-efficacy impacts academic and career interests, choices, and success, it is imperative we understand math self-concept/self-efficacy and identify ways to influence it. Additionally, women may be influenced by stereotype threats in male-dominated STEM career paths, which also contribute to decision to enroll and persist in STEM through outcome expectations and goal setting.
Figure A3

Model of Self-Efficacy, Outcome Expectations, and Goal Mechanisms Affecting Academic and Career Choices and Behaviors


Definition of Terms

Self-Efficacy: Self-efficacy is defined as, “people’s judgements of their capabilities to organize and execute courses of action required to attain designated types of performances” (Bandura & National Institute of Mental Health, 1986, p. 391).

Self-Concept: Self-concept is broadly defined as a person’s perception of him or herself. Rosenberg (1979) defined self-concept as “the totality of the individual’s thoughts and feelings having reference to himself…” Shavelson et al. (1976) stated that, “One’s
perceptions of himself are thought to influence the ways in which he acts, and his acts in turn influence the ways in which he perceives himself.”

**Academic Self-Concept:** “Academic self-concept has been defined as “one’s perceived competence in a specific domain (often an academic subject) in a normative way (in comparison to peers or the average person) that includes both cognitive and affective evaluations of the self” (Sax et al., 2015).

**GEMP STEM:** GEMP STEM refers to the STEM areas of geosciences, engineering/economics, math/computer science, and physical sciences (Kahn & Ginther, 2017).

**GEMP STEM Enrollment:** GEMP STEM Enrollment is an outcome variable of interest. It is a binary yes or no response as to whether or not they were enrolled in a GEMP STEM program.

**STEM Attrition:** STEM Attrition is an outcome variable of interest. It is a binary yes or no data element categorized by whether or not they were previously enrollment in STEM and left or not. Only students who were previously enrolled in a STEM program and are no longer enrolled in STEM are categorized as yes for STEM attrition.

**STEM Pipeline:** In 1983, Berryman began using the term “pipeline” to describe the entire pathway of women in STEM, from early exposure and interest to education and training, and on all the way through to career completion.

**Leaky Pipeline:** In 1993, the idea of a STEM pipeline was revisited by Joe Alper and Ann Gibbons in their article titled “The Pipeline is Leaking Women all the Way Along” where they address females’ lack of early exposure to STEM in younger years, low attraction rates to STEM courses and programs, and the loss of women at each of the points along the trajectory, particularly from educational STEM programs and again in the workforce.
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https://doi.org/10.1080/00220485.2014.859953


https://doi.org/10.1016/j.econedurev.2010.06.011

https://doi.org/10.1080/00220485.2010.486718


APPENDIX B

Extended Methodology and Results

This section includes additional information on methodologies and results used in both Article 1 (STEM retention) and Article 2 (GEMP STEM enrollment). Some information may be duplicated here that was contained in the article; however, this section is meant to provide a complete overview of processes and procedures followed.

Participants – Extended

Participants included in the two studies were separate samples. Respondents who were enrolled in a STEM major in 2020 or 2021 were eligible to participate in the STEM retention study and respondents who were enrolled in a STEM major in fall 2022 were eligible to participate in the GEMP STEM enrollment model. There was some overlap between the two samples with some students meeting the definition for inclusion in both studies (i.e., they were enrolled in a STEM major as of 2020 or 2021 and were also still enrolled in a STEM major in fall 2022).

STEM Retention Model

Thirty-five percent of students who were considered retained were selected via random selection and were sent the survey used in this study. Over sampling of students considered not retained was conducted with 100% of not retained students being sampled to ensure proper representation due to lower numbers in the not retained group and in anticipation of lower response rates from those not retained. Participation was not obligatory, and responses were collected via elective participation.

Study participants for Article 1 were those who had been enrolled in a STEM major in 2020 or 2021. Their retention status was determined based upon fall 2022 as shown in Table B1.
They were considered retained if they were enrolled, deferred, on leave of absence, or had graduated from a STEM major. Those considered not retained were those who had switched to a non-STEM major, graduated from a non-STEM major, or left the University. The final sample included the 2,121 respondents mentioned in the article.

**Table B1**

*Retention Status as of Fall 2022*

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<thead>
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<th></th>
<th>Retained</th>
<th>Not Retained</th>
</tr>
</thead>
<tbody>
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<td>declared STEM major but on deferment or leave of absence</td>
<td>Enrolled but not in STEM declared non-STEM major but on deferment or leave of absence</td>
</tr>
<tr>
<td>Graduated with a STEM degree</td>
<td></td>
<td>Graduated with a non-STEM degree</td>
</tr>
<tr>
<td>Left University</td>
<td></td>
<td>Left University</td>
</tr>
</tbody>
</table>

*All participants were originally enrolled in a STEM major in 2020 or 2021*

**GEMP STEM Enrollment Model**

Article 2 included only participants who were enrolled in a STEM major as of fall 2022. Thirty-five percent of respondents were sampled and only those who were enrolled as of fall 2022 were included in the sampling frame. Previous enrollment did not factor in and inclusion in the study was only based on status as of fall 2022. The final sample for article 2 included the 1,159 respondents mentioned in the article.

**Measures – Extended**

This section provides additional information on measures used, including an explanation of math saturation and how that was calculated and more detailed explanations of the previously developed scales for math self-efficacy, and math self-concept. Also included is additional information on the survey that was administered.
Math Saturation

As previously mentioned, low female representation is not equal across all STEM majors and programs that tend to exhibit low representation are those that tend to be more math intensive. In an attempt to identify how this level of math intensity impacts STEM retention, a proxy measure was included called math saturation of a major. Math saturation represents the proportion of required coursework in a major that qualifies as either a mathematics course or a course with a mathematics course prerequisite. These can include both direct prerequisites or indirect prerequisites as shown below in Figure B1. To assess the level of math saturation within a program, required coursework was reviewed and analyzed for each STEM program. The total number of credits requiring math or math prerequisites was determined along with the total number of credits overall that were required by the program. This was used to calculate the percentage of total coursework within a program that required math or math prerequisites. Although this does not fully capture the idea of how math intensive a program is, it is a start to begin to account for this and how it impacts retention.

Figure B1

Direct and Indirect Mathematics Prerequisites
Preliminary analysis related to this issue was conducted to understand basic relationships between math saturation and female representation levels in STEM programs. Aligning STEM programs by math saturation from least saturated to most saturated and simultaneously graphing the percentage of females in a program as seen in Figure B2, allows us to see that as math saturation increases female representation tends to trend downward. It becomes apparent that this connection between math intensity and low female representation needs to be further investigated. The retention model attempted to address the extent to which these math saturation levels impact retention in STEM. It should be noted that education majors such as math education or chemistry education were omitted from this analysis. An interesting shift in enrollment occurs when a STEM major is focused on education with more women enrolled than men.

Math saturation was not used in the GEMP STEM enrollment model due to its high correlation with GEMP STEM. There is a fairly definite cutoff between GEMP STEM and non-GEMP STEM at around 50% math saturation with those programs above 50% classified as GEMP STEM and those below classified as non-GEMP STEM. Math saturation becomes almost definitional for GEMP STEM status and as such was not included in this model since the outcome was GEMP STEM status. The retention model had a different outcome (STEM retention) and math saturation was able to be incorporated in the model to identify relationships with math saturation and STEM retention.
Figure B2

*Math Saturation and Female Enrollment in STEM*
Math Self-Efficacy

To assess mathematics self-efficacy, a subscale from the Mathematics Self-Efficacy Scale (MSES) was used (Betz & Hackett, 1983). The scale was developed to assess self-efficacy expectations of late adolescent and college age students in mathematics. The subscale included 16 items that asked students to respond to how confident they were in successfully completing college courses requiring prior knowledge of mathematics. The 16 courses used in the original scale were accounting, advanced calculus, algebra 1, algebra 2, basic college mathematics, biochemistry, business administration, calculus, computer science, economics, geometry, philosophy, physiology, statistics, trigonometry, and zoology. The confidence ratings were on a 9-point scale ranging from 0 (not at all confident) to 8 (completely confident). In the original subscale, students were asked to indicate their confidence in their ability to complete the course with a grade of “B” or better. The question was changed asking them to instead indicate “their confidence in their ability to complete the course successfully” in order to allow the respondent to define for themselves what successfully means. Since self-efficacy is a belief about oneself and is individually constructed, it is important to allow them to define success individually.

Betz and Hackett reported an internal consistency reliability for each of the subscales (.90, and .93 for tasks and courses, respectively). The overall reliability was .96 for the full scale. In 1985, Hackett and O’Halloran reported a test-retest reliability for the full scale of .88 and .91 for the courses subscale (cited in Hackett & Betz, 1989). The MSES has been validated as recently as 2022 and was found to have an internal consistency for each subscale of .80 or higher (Morán-Soto & González Peña). The MSEs scale also demonstrated construct validity with a correlation of .66 between the MSE scale and the prior developed mathematical confidence subscale from the Mathematical Attitude Scales (Fennema & Sherman, 1976).
The survey included an additional subscale of the Mathematics Self-Efficacy Scale (MSES) that focused on tasks; however, this subscale was not used in the final model. The task subscale asked participants to respond to how confident they were they could perform the task listed on each item. Items 1 and 15 on the subscale were outdated and were replaced with more current references. The original phrases of “work with a slide rule” and “balance your checkbook without a mistake” were replaced with “use appropriate technology to solve mathematical problems” and “reconcile your checking account without a mistake.” The confidence ratings were on the same 9-point scale as the courses subscale, ranging from 0 to eight (0 = not at all confident to 8 = completely confident).

This subscale focused on tasks was not used in the final model for a few reasons. Although some modifications were made to bring the scale up to date, the final version still seemed a little outdated with questions that are no longer as common as they once were. Examples are the questions asking about buying material to make curtains and even reconciling a bank account is not as common as reconciling a checking account once was. Overall, there was some concern that not all of the tasks represented “behaviors used in everyday life” as the original authors intended (Betz & Hackett, 1983). The largest issue in inclusion was due to substantial convergence issues when attempting to run models using SEM in Mplus. Additionally, factor loadings were above acceptable limits but were still not as high as was seen on the self-efficacy scale related to courses and the self-concept scale. MSE related to courses ranged from 0.60 to 0.83 with an average factor loading of 0.71, the MSC scale ranged from 0.62 to 0.87 with an average of 0.72, and the MSE related to tasks ranged from .51 to 0.73 with an average loading of 0.65. Only the subscale focused on self-efficacy as it relates to courses was used for this study.
Math Self-Concept

To assess mathematics self-concept, a mathematics subscale of the Self-Description Questionnaire III (SDQ III) was used (Marsh & O’Neill, 1984). The SDQ III was a redesigned version of a previously developed multidimensional self-concept scale consisting of 13 facets and 136 items. The 13 facets of self-concept in the SDQ III are broken into three categories of academic self-concept (mathematics, verbal, academic), non-academic self-concept (problem-solving/creativity, physical abilities/sports, physical appearance, relations with same sex peers, relations with opposite sex peers, relations with parents, religion/spirituality, honesty/reliability, emotional stability), and a general self-concept. Each facet is represented by 10 – 12 items. Responses were given on an 8-point scale from 1 (definitely false) to 8 (definitely true). The 8-point scale was intentionally set at 8 as opposed to 9 “to disrupt response biases and make the tasks more distinct” (Marsh & O’Neill, 1984, p. 157). The mathematics subscale is made up of 10 items and was used for this study.

SDQ III was validated for use among late adolescent and traditional university age students by Marsh and O’Neill (1984). Several other studies have used exploratory and confirmatory factor analysis to demonstrate that the academic self-concept facets demonstrate construct validity and also that the three facets are distinct from one another (Byrne & Shavelson, 1986; Marsh et al., 1986; Marsh & O'Neill, 1984). Bryne and Shavelson (1986) found strong evidence of convergent validity in the subscales with each of the academic facets highly correlated with self-concept facets from other instruments (mean \( r = .71 \)). Additionally, they found evidence of discriminant validity for the subscales along with several other studies (mean \( r = .23 \); Byrne & Shavelson, 1986; Marsh et al., 1986; Marsh & O’Neill, 1984). Barbara M. Byrne (1988) reviewed multiple studies and found internal consistency reliability coefficients that
ranged from .79 to .95 (mean $\alpha = .90$; Byrne & Shavelson, 1986; Marsh et al., 1986; Marsh & O’Neill, 1984), and test-retest reliability coefficients that ranged from .66 to .94 (mean $r = .86$; Marsh et al., 1986). The academic self-concept facets have also been shown to be highly correlated with academic outcomes (mean $r = .50$; Marsh & O’Neill, 1984). Only the mathematics self-concept subscale of the SDQ III was used for this study.

Several questions in the MSC scale were reverse coded for analysis to ensure higher scores of MSC indicated a higher level of self-concept. These questions were “I have hesitated to take courses that involve mathematics,” “mathematics makes me feel inadequate,” “I have trouble understanding anything that is based upon mathematics,” “I never do well on tests that require mathematical reasoning,” and “I have never been excited about mathematics.”

**Survey**

Data was collected from respondents via a Qualtrics survey. The survey contained six sections with a total of 72 items that addressed math self-efficacy, math self-concept, demographics, parental influence, previous math experience, and program experience. The survey took approximately 15 minutes to complete. For math self-efficacy and math self-concept, the previously established scales were used and were discussed above.

The parental influence section included six items that asked about parental education level and experience studying and working in STEM fields for each parent. Additional demographic information was also collected in the survey that asked respondents to rate the extent to which they struggled to pay for college on a scale from 1 (not at all) to 5 (a great deal). The survey also included questions regarding marital status, number of dependents, and if they had deferred for a service mission.
Previous math experience contained seven items and was assessed with both data regarding high school math GPA and the number of credits taken in mathematics as well as questions meant to address personal feelings regarding their experience in mathematics (“I felt confident in my ability to do well in my last high school math class,” “I enjoyed my last high school math class,” and “I did well in my last high school math class”). These questions were asked for both their previous high school math experience and their college math experience.

Items pertaining to a student’s experience with math at the postsecondary level were asked in the original survey but were not included in the final study. Although a response was not required, an option was not provided for respondents to select if they had not taken math at the postsecondary level. Analysis after administration of the survey revealed that 17.21% of the respondents in the sample for Article 1 (STEM retention) and 35.03% of respondents in the sample for Article 2 (GEMP STEM enrollment) had not taken a math class during their postsecondary education. Additionally, more than 85% of students in both samples who had not taken math during their postsecondary studies had responded to the question despite a lack of experience taking mathematics in college. Due to this, large amount of missing data, and other concerns with convergence, these items were not included in the final study. A future study may seek to incorporate postsecondary experience with math to determine its effect on GEMP STEM enrollment and retention in STEM.

For program experience, respondents were asked to rate both their male peers and female peers as well as faculty on a scale from 0 (negative experience) to 10 (positive experience). Additional questions regarding research participation, club engagement, and whether or not they had a mentor and a role model in their field of study were included.
Preliminary Analysis

Preliminary analysis was conducted of all variables. Descriptive statistics were analyzed, and bivariate correlations were run as well as preliminary regression analysis to investigate the unadjusted relationships between variables and the outcome in each model.

Bivariate Correlations

Bivariate correlations were examined for all variables with extra attention given to correlations with the outcomes and primary explanatory variables in both models. Most correlations were in expected ranges and theoretically reasonable. For instance, age was correlated with class standing in both models \(r = .54, p < .001\), STEM retention model; \(r = .69, p < .001\), GEMP STEM enrollment model) and married with dependents in the STEM retention model \(r = .62, p < .001\). Additionally, high correlation was seen between some of the items on the MSE scale with calculus highly correlated with advanced calculus \(r = .82, p < .001\), STEM retention model; \(r = .81, p < .001\), GEMP STEM enrollment model) and algebra I with algebra II \(r = .87, p < .001\), STEM retention model; \(r = .86, p < .001\), GEMP STEM enrollment model).

Male was significantly correlated with each outcome from the two models and was correlated with STEM retention at \(r = .17 (p < .001)\) and with GEMP STEM enrollment at \(r = .28 (p < .001)\). Bivariate correlations with the outcome for MSE items ranged from .03 to .06 for the STEM retention model and from .22 to .37 for the GEMP STEM enrollment model, while bivariate correlations with the outcome for MSC items ranged from .02 to .03 for the STEM retention model and .08 to .31 for the GEMP STEM enrollment model. The rest of the bivariate correlations did not reveal any surprising results.
**Preliminary Regressions**

Logistic regression was used to run preliminary analysis for bivariate relationships of main explanatory variables to identify unadjusted relationships. This was followed by the outcomes being regressed on variables from each group (demographic, parental influence, high school math experience, major experience) to identify relationships with the outcome of each grouping. Logistic regression was used due to the dichotomous nature of the outcomes in both models (enrolled in GEMP STEM or not and retained in STEM or not).

Gender was often included as a secondary step. Male was always significant in all models it was included in and indicated that males were between two and three times as likely to persist in STEM as women and two to three times as likely to be enrolled in GEMP STEM compared to women.

Examining bivariate relationships of MSE and MSC with the outcome reveal that both MSE and MSC have a positive association with the outcomes in both models. For every point increase in MSE, participants are 31% more likely to be retained in STEM than not retained ($e^{0.27} = 1.31, p < .001$) and 87% more likely to be enrolled in GEMP STEM than non-GEMP STEM ($e^{0.63} = 1.87, p < .001$). For every point increase in MSC, participants were 19% more likely to be retained in STEM than not retained ($e^{0.18} = 1.19, p < .001$) and 52% more likely to be enrolled in GEMP STEM than non-GEMP STEM ($e^{0.42} = 1.52, p < .001$).

These positive associations with the outcomes change, however, when MSE and MSC are run together. In the STEM retention model, MSC becomes a negative indicator of STEM retention when adjusted for MSE. In the GEMP STEM enrollment model MSC is reduced considerably when adjusted for MSE and when all variables are included becomes a negative
indicator of GEMP STEM enrollment. The results from this regression along with the bivariate regression results can be seen in Figure B3 and Figure B4.

Figure B3

*Preliminary Regressions for MSE and MSC With STEM Retention*

### Variables in the Equation

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<th>Sig.</th>
<th>Exp(B)</th>
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a. Variable(s) entered on step 1: mse_mean.

### Variables in the Equation

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<th>Wald</th>
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a. Variable(s) entered on step 1: msc_mean.

### Variables in the Equation

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a. Variable(s) entered on step 1: mse_mean, msc_mean.
Outcomes were regressed on groupings of variables (demographic, parental influence, high school math experience, major experience) and results demonstrated were similar to those found in the final models. The STEM retention model showed that male, age, married, and dependents were significant indicators of STEM retention. No parental influence variables were significant and the only high school variable that was significant was math ACT/SAT score. Several of the program variables were significant such as research participation, club engagement, having a role model and faculty and male peer ratings. A few differences in
significant indicators were seen between preliminary regressions and the final model, namely, having dependents and a role model were not significant in the final model.

The GEMP STEM enrollment model demonstrated that male, international, first generation, class standing, and being married were significant indicators of being enrolled in GEMP STEM. Similar to the STEM retention model, no variables from the parental influence group were significant and the only predictor from the high school grouping was math ACT/SAT. Program variables of mentor, faculty ratings, and female peer ratings were significant. Differences between preliminary regression and the final model were found with age and was significant in the final model but not in the preliminary regression.

Various interactions with male were examined with none showing as significant predictors in either model. This suggests that there is not a differential impact across genders; however, there may still be differences across genders. One example of this is seen when looking at MSE as an interaction with gender. The interaction was not significant indicating that MSE is a positive indicator of STEM retention with a similar effect for both male and females; however, average levels of MSE are lower for females. MSE may have a positive effect on retention in STEM, but we would still expect to see higher attrition from those with lower MSE.

**Confirmatory Factor Analyses**

Confirmatory factor analyses were performed on both the MSE scale and MSC scale to confirm factor structure of the observable variables and to test how well the observed variables measure the latent construct. In this section CFAs are addressed separately by model (STEM retention, GEMP STEM enrollment) and by scale (MSE, MSC) to facilitate understanding.
STEM Retention Model

CFAs for the STEM retention model are addressed in this section beginning with MSE and followed by MSC.

Math Self-Efficacy CFA. The CFA for MSE was run using all 16 courses listed in the original scale; however, model fit did not meet sufficient thresholds (RMSEA = 0.19, SRMR = 0.12, CFI = .63, TLI = 0.57). Five of the original courses (biochemistry, business administration, philosophy, physiology, and zoology) demonstrated low factor loadings relative to the other 11 courses (0.50, 0.45, 0.37, 0.27, and 0.30, respectively) and are not traditionally considered math related courses. All other factor loadings ranged from 0.60 to 0.85 for the 11 other courses. The CFA was rerun using only the 11 courses with factor loadings above 0.60 and with covariances allowed between common courses such as calculus and advanced calculus, algebra I with algebra II, basic math with algebra I and algebra II, accounting with economics, and geometry with trigonometry. Three out of four model fit indices met appropriate thresholds. SRMR was below 0.08 and equaled 0.05, CFI and TLI were both above the 0.90 threshold and equaled .95 and 0.93, respectively, and RMSEA was above a little above the 0.08 threshold and equaled 0.10. Factor loadings were all above 0.60. The final CFA model for MSE can be seen in Figure B5.
Math Self-Concept CFA. A CFA for MSC was also conducted using the 10 items from the original scale with covariance between items 1 and 10 and items 6 and 8 (Item 1: “I find many mathematical problems interesting and challenging,” Item 10: “I have never been excited about mathematics,” Item 6: “I have trouble understanding anything that is based upon
mathematics,” and Item 8: “I never do well on tests that require mathematical reasoning”). Items one and 10 are assumed to be negatively correlated. Fit indices indicated good model fit with three out of the four indices at appropriate thresholds with SRMR below the 0.08 threshold equaling 0.04, CFI and TLI above the 0.90 threshold equaling .951 and 0.93, respectively, and RMSEA just above the 0.90 threshold at 0.93. The final CFA model for MSC can be seen in Figure B6.

**Figure B6**

*Confirmatory Factor Analysis for Math Self-Concept*
GEMP STEM Enrollment Model

CFAs for the GEMP STEM enrollment model are addressed in this section beginning with MSE and followed by MSC.

Math Self-Efficacy CFA. A CFA was run for MSE using the 16 courses from the original scale. The model results indicated poor model fit and did not meet recommended thresholds of RMSEA and SRMR below 0.08 and CFI and TLI above 0.90 (RMSEA = 0.20, SRMR = 0.14, CFI = .61, TLI = 0.54). Five of the original courses demonstrated poor factor loadings (biochemistry = 0.45, business administration = 0.45, philosophy = 0.38, physiology = 0.20, and zoology = 0.23) and can be seen in Figure B7. Although these courses were included in the original scale, they are often not considered to be math related courses. For the 11 other courses factor loadings ranged from 0.57 to 0.81.

The CFA was run again without the five courses that exhibited poor factor loadings and with covariances allowed between courses with higher correlation such as advanced calculus with calculus, algebra I with algebra II, accounting with economics, and geometry with trigonometry. Three of the four fit indices indicated good model fit (SRMR = 0.05, CFI = .95, TLI = 0.93, and RMSEA = 0.10). Factor loadings were all above 0.58 and ranged up to 0.82. The final model and standardized factor loadings can be seen in Figure B8.
Figure B7

*Confirmatory Factor Analysis for Math Self-Efficacy With 16 Original Courses*
Figure B8

Confirmatory Factor Analysis for Math Self-Efficacy With 11 Remaining Courses and Covariances
Math Self-Concept CFA. A CFA for MSC was run with the 10 original items and no covariances as can be seen in Figure B9. The model results demonstrated appropriate fit for only two out of the four fit indices (RMSEA = 0.12, SRMR = 0.05, CFI = .92, and TLI = 0.90).

Figure B9

Confirmatory Factor Analysis for Math Self-Concept
The model was rerun allowing covariances between a few items that were highly correlated. Items 1 and 10 and items 6 and 8 were allowed to covary. Items one and 10 were assumed to be negatively correlated. (Item 1: “I find many mathematical problems interesting and challenging,” Item 10: “I have never been excited about mathematics,” Item 6: “I have trouble understanding anything that is based upon mathematics,” and Item 8: “I never do well on tests that require mathematical reasoning”). Three out of the four fit indices met appropriate thresholds with the fourth relatively close (RMSEA = 0.08, SRMR = 0.03, CFI = .96, and TLI = 0.95). The final model can be seen with standardized factor loadings below in Figure B10.

**Figure B10**

*Confirmatory Factor Analysis for Math Self-Concept With Covariances*
**Math Self-Efficacy – Tasks Subscale**

The survey included an additional subscale of the Mathematics Self-Efficacy Scale (MSES) that focused on tasks; however, this subscale was not used in the final model. The task subscale asked participants to respond to how confident they were they could perform the task listed on each item. Items 1 and 15 on the subscale are outdated and were replaced with more current references. The original phrases of “work with a slide rule” and “balance your checkbook without a mistake” were replaced with “use appropriate technology to solve mathematical problems” and “reconcile your checking account without a mistake.” The confidence ratings were on the same 9-point scale as the course subscale, ranging from 0 (not at all confident) to 8 (completely confident).

This subscale was not used in the final model for a few reasons. Although some modifications were made to bring the scale up to date, the final version still seemed a little outdated with questions that are no longer as common as they once were. Examples are the questions asking about buying material to make curtains and even reconciling a bank account is not as common as reconciling a checking account once was. Overall, there was some concern that not all of the tasks represented “behaviors used in everyday life” as the original authors intended (Betz & Hackett, 1983). The largest issue in inclusion was due to substantial convergence issues when attempting to run models using SEM in Mplus. The scale had about 10% missing data, but this was not any more than was missing from the other MSE subscale (courses). Factor loadings were above acceptable limits but were still not as high as was seen on the self-efficacy scale related to courses and the self-concept scale. MSE related to courses ranged from 0.60 to 0.83 with an average factor loading of 0.71, the MSC scale ranged from 0.62 to 0.87 with an average of 0.72, and the MSE related to tasks ranged from .51 to 0.73 with an
average loading of 0.65. Only the subscale focused on math self-efficacy as it relates to courses and the math self-concept scales were used for this study.

**Model Analysis**

**Model Assumptions**

Model assumptions of multivariate normality, missing data, and sufficient sample size were reviewed. Assumptions of logistic regression were also assessed through independence of observations, multicollinearity, and linearity (through a logit link). Normality was assessed using probability – probability (p-p) plots and quantile – quantile (q-q) plots in SPSS. Sample size was more than sufficient according to Wang and Wang (2019). Missing data was analyzed and is addressed below. Additionally, variable frequencies and floor and ceiling effects were examined. Bivariate correlations were examined for multicollinearity.

**Missing Data**

Missing data was analyzed. The outcome variables for both models contained no missing data (retained in STEM or not and enrolled in GEMP STEM or not). Additionally, there was no missing data on the explanatory variable of male. The MSC scale was missing about 5% of data while the MSE scale was missing about 9% in both samples. Comparisons in amount of missing data were made between males and females for both models, GEMP and non-GEMP STEM students for the GEMP STEM enrollment model, and between those who were retained in STEM and those who were not retained in the STEM retention model. Table B2 below shows these comparisons for the STEM retention model. Comparisons were broken down further by category (demographic, parental influence, high school experience, and program experience) and by the percent of respondents missing data from that category. For example, 6.19% of women were missing 100% of the items for the MSC scale for the STEM retention model. Table B3 shows
this for the GEMP STEM enrollment model. Women were on average missing slightly more data than males in most categories. Missing data was handled using full information maximum likelihood (FIML) in the Bayesian estimation process.
Table B2

**Missing Data Comparisons by Gender and Retention Status for the STEM Retention Model**

<table>
<thead>
<tr>
<th></th>
<th>Females</th>
<th>Males</th>
<th>Retained</th>
<th>Left</th>
</tr>
</thead>
<tbody>
<tr>
<td># Respondents</td>
<td>937</td>
<td>1184</td>
<td>1509</td>
<td>612</td>
</tr>
<tr>
<td>% Respondents</td>
<td>44.18%</td>
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<td>71.15%</td>
<td>28.85%</td>
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</table>

<table>
<thead>
<tr>
<th>Category</th>
<th>All Model Data</th>
<th>Demographic Questions</th>
<th>MSC Scale</th>
<th>MSE Scale</th>
<th>Both Scales</th>
<th>Parental Influence</th>
<th>HS Math</th>
<th>Program</th>
</tr>
</thead>
<tbody>
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<td>All Model Data</td>
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<td>0.01%</td>
<td>0.01%</td>
<td>0.01%</td>
<td>0.01%</td>
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</tr>
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<tr>
<td>Missing 100% in Category Listed</td>
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</table>
Table B3

**Missing Data Comparisons by Gender and GEMP STEM Status for the GEMP STEM Enrollment Model**

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<th>Males</th>
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</thead>
<tbody>
<tr>
<td># Respondents</td>
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<td>42.67%</td>
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**Missing 100% in Category Listed**

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<td>Program</td>
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</tbody>
</table>
Model Selection

For both models, Bayesian estimation using a logit link was used for model estimation in Mplus. Mplus does not currently return fit statistics, log likelihood values, predictive p-values, or the Bayesian Wald test for models that use Bayes estimation with a logit link, so additional modeling was done using the same model structure with maximum likelihood estimation (MLE) to select the appropriate model and address model fit. Additionally, Asparouhov and Muthén (2021) suggest that model fit can be assessed by comparing model estimated distribution tables with observed distribution tables. An additional suggestion was to add parameters individually (Asparouhov & Muthén, 2021). If added parameters are significant then the more restricted model is not appropriate. Model results are reported in Article 1 and Article 2.
References

https://doi.org/10.1037/a0032338

https://doi.org/10.1080/10705511.2021.1878896

https://doi.org/10.1016/0001-8791(83)90046-5

https://doi.org/10.1207/s15327906mbr2303_5

https://doi.org/10.1037/0022-0663.78.6.474

https://doi.org/10.2307/748467


Memorandum

To: Sterling Hilton  
Department: BYU - EDUC - Educational Leadership & Foundations  
From: Sandee Aina, MPA, HRPP Associate Director  
Wayne Larsen, MAcc, IRB Administrator  
Date: October 13, 2022  
IRB#: IRB2022-393  
Title: The Impact of Math Self-Efficacy and Math Self-Concept on STEM Enrollment and Attrition

Brigham Young University’s IRB has approved the research study referenced in the subject heading as exempt level, Category 2. This study does not require an annual continuing review. Each year near the anniversary of the approval date, you will receive an email reminding you of your obligations as a researcher and to check on the status of the study. You will receive this email each year until you close the study.

The study is approved as of 10/13/2022. Please reference your assigned IRB identification number in any correspondence with the IRB.

Continued approval is conditional upon your compliance with the following requirements:

1. A copy of the approved informed consent statement can be found in iRIS. No other consent statement should be used. Each research subject must be provided with a copy or a way to access the consent statement.
2. Any modifications to the approved protocol must be submitted, reviewed, and approved by the IRB before modifications are incorporated into the study.
3. All recruiting tools must be submitted and approved by the IRB prior to use.
4. Instructions to access approved documents, submit modifications, and report adverse events can be found on the IRB website, iRIS guide: https://irb.byu.edu/iris-training-resources
5. All non-serious unanticipated problems should be reported to the IRB within 2 weeks of the first awareness of the problem by the PI. Prompt reporting is important, as unanticipated problems often require some modification of study procedures, protocols, and/or informed consent processes. Such modifications require the review and approval of the IRB. Please refer to the IRB website for more information.
APPENDIX D

Consent Email

Title of the Research Study: The Impact of Math Self-Efficacy and Math Self-Concept on STEM Enrollment and Attrition

IRB ID#: IRB2022-393

Subject Line: College Survey

You are invited to participate in a study to help us identify and understand factors influencing student experience while studying science, engineering, technology, and mathematics (STEM) at BYU. The results of this study will be used to identify areas of possible improvement for future semesters and to understand patterns of enrollment and attrition.

Survey responses will have no effect on your academic or BYU standing. Your participation is completely voluntary, and you may choose not to participate at any time. If you choose to participate, you will be asked to complete a survey that should take approximately 10 – 15 minutes to complete.

Responses will be kept completely confidential. Survey answers will be obtained via Qualtrics in a password protected electronic format. Data will be downloaded and stored behind a firewall and will be password protected and only the researcher will have access to the data. At the conclusion of the study, data will be kept in a University Box account with restricted access.

We appreciate your willingness to take this survey and look forward to exploring positive changes we can make in the College!

Be sure to complete the survey and enter for a chance to win $25 Cougar Cash and some BYU SWAG!!

If you are willing to participate in this study, click the [Start Survey] button to begin the survey.

This study is being conducted by Marcia Bingham, Director of Research & Reporting for Enrollment Services, in conjunction with the College of (College Name). Marcia is also a PhD student at BYU and is conducting this research under the supervision of Dr. Sterling Hilton, Department of Educational Leadership and Foundations. Odds of winning Cougar Cash and BYU SWAG are estimated to be 15 to 2374.
Questions? Please contact Marcia Bingham at marcia_bingham@byu.edu. If you have questions or concerns about your rights as a research participant, you can call the BYU Human Research Protections Program at 801-422-1461 or BYU.HRPP@byu.edu.
APPENDIX E

Surveys

Five different versions of the survey were used depending on the status of the student and the model being analyzed. The model referenced in article one (GEMP STEM enrollment) used data from the first survey listed and was given to all students enrolled in a STEM major in fall 2022. The model referenced in article two (STEM Retention) used data from the five different versions and was given to students who were enrolled in a STEM major in 2020 or 2021 and fell into one of the five categories below in fall of 2022. Students received the version of the survey that matched their status as of fall 2022.

1. STEM major – enrolled, deferred, or on a leave of absence
2. STEM major – graduated from a STEM major
3. Formerly STEM major – graduated from a non-STEM major
4. Formerly STEM major – changed major and enrolled, deferred, or on leave of absence
5. STEM major – left the University and would have to reapply to return

All versions of the survey addressed the same questions with minor variations in tense and major referenced. An example of this can be seen below. The two questions both address whether or not the student had a mentor in their field of study; however, the question for students who graduated STEM as of fall 2022 references previous time in their graduated major while the question asked of students enrolled in STEM as of fall 2022 references their current field of study.
• **Graduated STEM**: “During your time in {graduated_major}, did you have a mentor that helped provide guidance, motivation, and/or emotional support related to your field of study?”

• **STEM Major**: “Do you have a mentor that helps provide guidance, motivation, and/or emotional support related to your field of study?”

Similar examples of this can be seen in the different versions of the survey.
Survey 1: STEM Major (Enrolled, Deferred, or Leave of Absence)

Start of Block: Introduction

Q1.1
This survey has been designed to help us understand factors influencing student experience while studying science, technology, engineering, and mathematics (STEM) at BYU. The results of this study will be used to identify areas of possible improvement for future semesters. Responses will be kept confidential. The survey should take about 10 to 15 minutes to complete.

Be sure to complete the survey for a chance to win $25 Cougar Cash and some BYU SWAG!!

We value your feedback and appreciate your time!
Odds of winning are estimated to be 15 to 2350.

End of Block: Introduction

Start of Block: Math Self-Concept Questionnaire

Q2.1 The following items are a series of statements that are more or less true (or more or less false) descriptions of you. Please use the following eight-point response scale to indicate how true (or false) each item is as a description of you. Respond to the items as you now feel even if you felt differently at some other time in your life. In a few instances, an item may no longer be appropriate to you, though it was at an earlier period of your life. In such cases, respond to the item as you would have when it was appropriate. Try to avoid leaving any items blank.

Q2.2 I find many mathematical problems interesting and challenging.

Indicate how true or false the description is of you.

- Definitely False (1)
- False (2)
- Mostly False (3)
- More False Than True (4)
- More True Than False (5)
- Mostly True (6)
- True (7)
- Definitely True (8)
Q2.3 I have hesitated to take courses that involve mathematics. 
*Indicate how true or false the description is of you.*

- Definitely False (1)
- False (2)
- Mostly False (3)
- More False Than True (4)
- More True Than False (5)
- Mostly True (6)
- True (7)
- Definitely True (8)

Q2.4 I have generally done better in mathematics courses than other courses. 
*Indicate how true or false the description is of you.*

- Definitely False (1)
- False (2)
- Mostly False (3)
- More False Than True (4)
- More True Than False (5)
- Mostly True (6)
- True (7)
- Definitely True (8)
Q2.5 Mathematics makes me feel inadequate.  
*Indicate how true or false the description is of you.*

- Definitely False (1)
- False (2)
- Mostly False (3)
- More False Than True (4)
- More True Than False (5)
- Mostly True (6)
- True (7)
- Definitely True (8)

Q2.6 I am quite good at mathematics.  
*Indicate how true or false the description is of you.*

- Definitely False (1)
- False (2)
- Mostly False (3)
- More False Than True (4)
- More True Than False (5)
- Mostly True (6)
- True (7)
- Definitely True (8)
Q2.7 I have trouble understanding anything that is based upon mathematics. 
*Indicate how true or false the description is of you.*

- Definitely False (1)
- False (2)
- Mostly False (3)
- More False Than True (4)
- More True Than False (5)
- Mostly True (6)
- True (7)
- Definitely True (8)

Q2.8 I have always done well in mathematics courses. 
*Indicate how true or false the description is of you.*

- Definitely False (1)
- False (2)
- Mostly False (3)
- More False Than True (4)
- More True Than False (5)
- Mostly True (6)
- True (7)
- Definitely True (8)
Q2.9 I never do well on tests that require mathematical reasoning. 
*Indicate how true or false the description is of you.*

- Definitely False (1)
- False (2)
- Mostly False (3)
- More False Than True (4)
- More True Than False (5)
- Mostly True (6)
- True (7)
- Definitely True (8)

Q2.10 At school, my friends always came to me for help in mathematics. 
*Indicate how true or false the description is of you.*

- Definitely False (1)
- False (2)
- Mostly False (3)
- More False Than True (4)
- More True Than False (5)
- Mostly True (6)
- True (7)
- Definitely True (8)
Q2.11 I have never been excited about mathematics. 
*Indicate how true or false the description is of you.*

- Definitely False (1)
- False (2)
- Mostly False (3)
- More False Than True (4)
- More True Than False (5)
- Mostly True (6)
- True (7)
- Definitely True (8)

End of Block: Math Self-Concept Questionnaire

Start of Block: Math Self-Efficacy Questionnaire - Part A

Q3.1 For the following items, please **indicate your confidence in your ability to successfully perform the task.** You are not asked to complete the task, only to indicate your confidence in your ability to successfully perform the task. As an example, if the item states, "divide two large numbers (8246 ÷ 2431) in your head," you are not asked to actually divide the two numbers to find an answer, but simply respond how confident you are in your ability to successfully perform that task.

Q3.2 Use appropriate technology to solve mathematical problems
*Please indicate your confidence in your ability to successfully perform the task.*
Q3.3 Determine how much interest you will end up paying on a $675 loan over 2 years at 14 ¾% interest

Please indicate your confidence in your ability to successfully perform the task.

<table>
<thead>
<tr>
<th>No Confidence at All</th>
<th>Neutral</th>
<th>Complete Confidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>4</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>7</td>
<td>8</td>
<td>9</td>
</tr>
</tbody>
</table>

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Q3.4 Figure out how much lumber you need to buy in order to build a set of bookshelves

Please indicate your confidence in your ability to successfully perform the task.

<table>
<thead>
<tr>
<th>No Confidence at All</th>
<th>Neutral</th>
<th>Complete Confidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>4</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>7</td>
<td>8</td>
<td>9</td>
</tr>
</tbody>
</table>

0

Q3.5 Compute your income taxes for the year

Please indicate your confidence in your ability to successfully perform the task.

<table>
<thead>
<tr>
<th>No Confidence at All</th>
<th>Neutral</th>
<th>Complete Confidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>4</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>7</td>
<td>8</td>
<td>9</td>
</tr>
</tbody>
</table>

0
Q3.6 Figure out how much material to buy in order to make curtains
*Please indicate your confidence in your ability to successfully perform the task.*

<table>
<thead>
<tr>
<th>No Confidence at All</th>
<th>Neutral</th>
<th>Complete Confidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 2 3 4 5 6 7 8 9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Q3.7 Understand a graph accompanying an article on business profits
*Please indicate your confidence in your ability to successfully perform the task.*

<table>
<thead>
<tr>
<th>No Confidence at All</th>
<th>Neutral</th>
<th>Complete Confidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 2 3 4 5 6 7 8 9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Q3.8 Understand how much interest you will earn on your savings account in 6 months, and how the interest is computed
*Please indicate your confidence in your ability to successfully perform the task.*

<table>
<thead>
<tr>
<th>No Confidence at All</th>
<th>Neutral</th>
<th>Complete Confidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 2 3 4 5 6 7 8 9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Q3.9 Add two large numbers (e.g., 5739 + 62543) in your head
*Please indicate your confidence in your ability to successfully perform the task.*

<table>
<thead>
<tr>
<th>No Confidence at All</th>
<th>Neutral</th>
<th>Complete Confidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 2 3 4 5 6 7 8 9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>4</td>
<td></td>
</tr>
</tbody>
</table>

Q3.10 Estimate your grocery bill in your head as you pick up items
*Please indicate your confidence in your ability to successfully perform the task.*

<table>
<thead>
<tr>
<th>No Confidence at All</th>
<th>Neutral</th>
<th>Complete Confidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 2 3 4 5 6 7 8 9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>5</td>
<td></td>
</tr>
</tbody>
</table>

Q3.11 Determine the amount of sales tax on a clothing purchase
*Please indicate your confidence in your ability to successfully perform the task.*

<table>
<thead>
<tr>
<th>No Confidence at All</th>
<th>Neutral</th>
<th>Complete Confidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 2 3 4 5 6 7 8 9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>3</td>
<td></td>
</tr>
</tbody>
</table>
Q3.12 Figure out the tip on your part of a dinner bill split 8 ways

Please indicate your confidence in your ability to successfully perform the task.

<table>
<thead>
<tr>
<th>Confident</th>
<th>Neutral</th>
<th>Complete</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 2 3 4 5 6 7 8 9</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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Q3.13 Figure out how long it will take to travel from city A to city B driving 55 mph

Please indicate your confidence in your ability to successfully perform the task.

<table>
<thead>
<tr>
<th>Confident</th>
<th>Neutral</th>
<th>Complete</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 2 3 4 5 6 7 8 9</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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Q3.14 Compute your car's gas mileage

Please indicate your confidence in your ability to successfully perform the task.

<table>
<thead>
<tr>
<th>Confident</th>
<th>Neutral</th>
<th>Complete</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 2 3 4 5 6 7 8 9</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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Q3.15 Set up a monthly budget by yourself
*Please indicate your confidence in your ability to successfully perform the task.*

<table>
<thead>
<tr>
<th>No Confidence at All</th>
<th>Neutral</th>
<th>Complete Confidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 2 3 4 5 6 7 8 9</td>
<td></td>
<td></td>
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</tbody>
</table>

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Q3.16 Reconcile your bank account without a mistake
*Please indicate your confidence in your ability to successfully perform the task.*

<table>
<thead>
<tr>
<th>No Confidence at All</th>
<th>Neutral</th>
<th>Complete Confidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 2 3 4 5 6 7 8 9</td>
<td></td>
<td></td>
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</tbody>
</table>

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Q3.17 Figure out which of two summer jobs is the better offer; one with higher salary but no benefits, the other with a lower salary plus room, board, and travel expenses
*Please indicate your confidence in your ability to successfully perform the task.*

<table>
<thead>
<tr>
<th>No Confidence at All</th>
<th>Neutral</th>
<th>Complete Confidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 2 3 4 5 6 7 8 9</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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Q3.18 Figure out how much you would save if there is a 15% markdown on an item you wish to buy
Please indicate your confidence in your ability to successfully perform the task.

<table>
<thead>
<tr>
<th>No Confidence at All</th>
<th>Neutral</th>
<th>Complete Confidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>0</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Q3.19 Calculate recipe quantities for a dinner for 41 when the original recipe is for 12 people
Please indicate your confidence in your ability to successfully perform the task.

<table>
<thead>
<tr>
<th>No Confidence at All</th>
<th>Neutral</th>
<th>Complete Confidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
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<tr>
<td>0</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

End of Block: Math Self-Efficacy Questionnaire - Part A

Start of Block: Math Self-Efficacy Questionnaire - Part B
Q4.1 For each course listed below, **indicate your confidence in your ability to successfully complete the course.**

<table>
<thead>
<tr>
<th>Course</th>
<th>No Confidence at All</th>
<th>Neutral</th>
<th>Complete Confidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Advanced Calculus ()</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Philosophy ()</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Biochemistry ()</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Statistics ()</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Computer Science ()</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Physiology ()</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Trigonometry ()</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Economics ()</td>
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<td></td>
<td></td>
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<tr>
<td>Zoology ()</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Accounting ()</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Business Administration ()</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Geometry ()</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Algebra II ()</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Calculus ()</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Algebra I ()</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Basic College Math ()</td>
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</tbody>
</table>
Q4.2 For each course listed below, **indicate the amount of mathematics you believe you would encounter** while taking the course.

<table>
<thead>
<tr>
<th>Course</th>
<th>None</th>
<th>Very Little</th>
<th>Some</th>
<th>A Moderate Amount</th>
<th>An Extensive Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Advanced Calculus ()</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Philosophy ()</td>
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<tr>
<td>Biochemistry ()</td>
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<tr>
<td>Statistics ()</td>
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<td>Computer Science ()</td>
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<td>Physiology ()</td>
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<td>Trigonometry ()</td>
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<td>Economics ()</td>
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<td>Zoology ()</td>
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<tr>
<td>Accounting ()</td>
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<td>Business Administration ()</td>
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<tr>
<td>Geometry ()</td>
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<tr>
<td>Algebra II ()</td>
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<td>Calculus ()</td>
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</tr>
<tr>
<td>Algebra I ()</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Basic College Math ()</td>
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<td></td>
</tr>
</tbody>
</table>

End of Block: Math Self-Efficacy Questionnaire - Part B

Start of Block: Math Experience
Q5.1 Rate your level of agreement with each statement below regarding your high school experience.

<table>
<thead>
<tr>
<th>Strongly Disagree (1)</th>
<th>Disagree (2)</th>
<th>Neither Agree nor Disagree (3)</th>
<th>Agree (4)</th>
<th>Strongly Agree (5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I felt confident in my ability to do well in my last high school math class. (2)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I enjoyed my last high school math class. (1)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I did well in my last high school math class. (3)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Q5.2 In high school, did you participate in honors, plus, or AP courses related to mathematics?

- Yes (1)
- No (2)

Q5.3 Rate your level of agreement with each statement below regarding your college experience.

<table>
<thead>
<tr>
<th>Strongly Disagree (1)</th>
<th>Disagree (2)</th>
<th>Neither Agree nor Disagree (3)</th>
<th>Agree (4)</th>
<th>Strongly Agree (5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I felt confident in my ability to do well in my most recent college math class. (2)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I enjoyed my most recent college math class. (1)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I did well in my most recent college math class. (3)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

End of Block: Math Experience

Start of Block: Demographic
Q6.1 What is the highest level of education obtained by your mother/female parental guardian?
   - Less than high school degree (1)
   - High school graduate (high school diploma or equivalent including GED) (2)
   - Some college but no degree (3)
   - Associate degree in college (2-year) (4)
   - Bachelor's degree in college (4-year) (5)
   - Master's degree (6)
   - Doctoral degree (7)
   - Professional degree (JD, MD) (8)

Q6.2 What is the highest level of education obtained by your father/male parental guardian?
   - Less than high school degree (1)
   - High school graduate (high school diploma or equivalent including GED) (2)
   - Some college but no degree (3)
   - Associate degree in college (2-year) (4)
   - Bachelor's degree in college (4-year) (5)
   - Master's degree (6)
   - Doctoral degree (7)
   - Professional degree (JD, MD) (8)
Q6.3 Did one or more of your parents/parental guardians study STEM (science, technology, engineering, mathematics) during college?

- Yes (1)
- No (2)

Display This Question:
If Did one or more of your parents/parental guardians study STEM (science, technology, engineering,... = Yes

Q6.4 If yes, please select which one(s) studied STEM. Select all that apply.

- Mother (1)
- Father (2)
- Stepmother (3)
- Stepmother (4)
- Other (5) __________________________________________________

Q6.5 Did one or more of your parents/parental guardians work in STEM (science, technology, engineering, mathematics) during their career?

- Yes (1)
- No (2)

Display This Question:
If Did one or more of your parents/parental guardians work in STEM (science, technology, engineering... = Yes
Q6.6 If yes, please select which one(s) worked in an STEM field. *Select all that apply.*

- [ ] Mother (1)
- [ ] Father (2)
- [ ] Stepmother (3)
- [ ] Stepfather (4)
- [ ] Other (5) ________________________________

Q6.7 Have you served a mission for the Church of Jesus Christ of Latter-day Saints?

- [ ] Yes (1)
- [ ] No (2)

Display This Question:

If Have you served a mission for the Church of Jesus Christ of Latter-day Saints? = Yes
Q6.8 During what year(s) did you serve a mission? Select all that apply.

- [ ] Prior to 2012 (1)
- [ ] 2012 (2)
- [ ] 2013 (3)
- [ ] 2014 (4)
- [ ] 2015 (5)
- [ ] 2016 (6)
- [ ] 2017 (7)
- [ ] 2018 (8)
- [ ] 2019 (9)
- [ ] 2020 (10)
- [ ] 2021 (11)
- [ ] 2022 (12)

Q6.9 Is \$\text{current_major}\$ still your current major?

- [ ] Yes (1)
- [ ] No (2)

---

Display This Question:

\text{If Is } \$\text{current_major}\$ \text{ still your current major? = No}

Q6.10 If no, what is your current major?

________________________________________________________________

---

Q6.11 To what degree did you struggle to pay for college during the times specified below?
<table>
<thead>
<tr>
<th>Q6.12 Please select your marital status during the times specified below.</th>
</tr>
</thead>
<tbody>
<tr>
<td>When you first enrolled in ${e://Field/current_major} (1)</td>
</tr>
<tr>
<td>Never Married (1)</td>
</tr>
<tr>
<td>When you first enrolled in ${e://Field/current_major} (1)</td>
</tr>
<tr>
<td>Current marital status (3)</td>
</tr>
<tr>
<td>○</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Q6.13 Please select the number of dependents you had during the times specified below.</th>
</tr>
</thead>
<tbody>
<tr>
<td>When you first enrolled in ${e://Field/current_major} (1)</td>
</tr>
<tr>
<td>0 (1)</td>
</tr>
<tr>
<td>When you first enrolled in ${e://Field/current_major} (1)</td>
</tr>
<tr>
<td>Current number of dependents (3)</td>
</tr>
<tr>
<td>○</td>
</tr>
</tbody>
</table>

End of Block: Demographic

Start of Block: Experience in Program

Q7.1 Please respond to each of the following items regarding your experience in ${e://Field/current_major} within the College of $e://Field/current_college$. 
Q7.2 Have you ever participated in research with faculty in the College of $\{e://Field/current\_college\}$?

- Yes (1)
- No (2)

Display This Question:

If current_college = Engineering

Q7.3 Have you ever participated in the Women in Engineering (WE) Research Mentorship Program or the BYU Engineering Together (BE Together) Research Mentorship Program through the College of Engineering?

- Yes (1)
- No (2)

Q7.4 Have you been involved in any clubs or associations related to your field of study?

- Yes (1)
- No (2)

Q7.5 Do you have a mentor that helps provide guidance, motivation, and/or emotional support related to your field of study?

- Yes (1)
- No (2)

Q7.6 Do you have a role model related to your field of study?

- Yes (1)
- No (2)
Q7.7 Please rate your experience with faculty in \$e://Field/current_major\$.

<table>
<thead>
<tr>
<th>Negative Experience</th>
<th>Positive Experience</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>10</td>
</tr>
</tbody>
</table>

Q7.8 Describe why you gave the rating you did. \textit{(Optional)}

________________________________________________________________
________________________________________________________________
________________________________________________________________
________________________________________________________________

Q7.9 Please rate your experience with \textbf{male students} in \$e://Field/current_major\$.

<table>
<thead>
<tr>
<th>Negative Experience</th>
<th>Positive Experience</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>10</td>
</tr>
</tbody>
</table>

Q7.10 Describe why you gave the rating you did. \textit{(Optional)}

________________________________________________________________
________________________________________________________________
________________________________________________________________
________________________________________________________________


Q7.11 Please rate your experience with female students in $\{e://Field/current_major\}.

<table>
<thead>
<tr>
<th>Negative Experience</th>
<th>Positive Experience</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1</td>
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<tr>
<td>2</td>
<td>3</td>
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<tr>
<td>4</td>
<td>5</td>
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<td>6</td>
<td>7</td>
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<tr>
<td>8</td>
<td>9</td>
</tr>
<tr>
<td>10</td>
<td></td>
</tr>
</tbody>
</table>

Q7.12 Describe why you gave the rating you did. (Optional)

________________________________________________________________
________________________________________________________________
________________________________________________________________
________________________________________________________________
________________________________________________________________

Q7.13 Please describe what led to your decision to enroll in $\{e://Field/current_major\}$.

________________________________________________________________
________________________________________________________________
________________________________________________________________
________________________________________________________________
________________________________________________________________

Q7.14 Is there anything else you would like to tell us that would help us improve the experience for students in the College of $\{e://Field/current_college\}$ in the future? (Optional)

________________________________________________________________
________________________________________________________________
________________________________________________________________
________________________________________________________________
________________________________________________________________

End of Block: Experience in Program

Start of Block: End
Q8.1 Would you be willing to participate in a follow-up interview to help us understand more about your experience?

- Yes (1)
- No (2)

Display This Question:

If Would you be willing to participate in a follow-up interview to help us understand more about you... = Yes

Q8.2 If yes, please enter your name and email address below. Your previous responses will still be kept confidential.

- First Name (1) __________________________________________________
- Last Name (2) _________________________________________________
- Email Address (3) ____________________________________________

Q8.3 Would you like to be redirected to enter the raffle to win a $25 cougar cash prize and BYU SWAG? Your responses will still be kept confidential.

- Yes (1)
- No (2)

End of Block: End
Survey 2: Graduated From a STEM Major

Start of Block: Introduction

Q1.1
This survey has been designed to help us understand factors influencing student experience while studying science, technology, engineering, and mathematics (STEM) at BYU. As a graduate of a STEM program, your feedback is very valuable to us. The results of this study will be used to identify areas of possible improvement for future semesters. Responses will be kept confidential. This survey should take about 10 to 15 minutes to complete.

Be sure to complete the survey for a chance to win a $25 gift card and some BYU SWAG!!

We value your feedback and appreciate your time!
Odds of winning are estimated to be 15 to 2350.

End of Block: Introduction
Start of Block: Math Self-Concept Questionnaire - Final

Q1 The following items are a series of statements that are more or less true (or more or less false) descriptions of you. Please use the following eight-point response scale to indicate how true (or false) each item is as a description of you. Respond to the items as you now feel even if you felt differently at some other time in your life. In a few instances, an item may no longer be appropriate to you, though it was at an earlier period of your life. In such cases, respond to the item as you would have when it was appropriate. Try to avoid leaving any items blank.
Q2 I find many mathematical problems interesting and challenging.

*Indicate how true or false the description is of you.*

- [ ] Certainly False (1)
- [ ] False (2)
- [ ] Mostly False (3)
- [ ] More False Than True (4)
- [ ] More True Than False (5)
- [ ] Mostly True (6)
- [ ] True (7)
- [ ] Definitely True (8)

Q3 I have hesitated to take courses that involve mathematics.

*Indicate how true or false the description is of you.*

- [ ] Certainly False (1)
- [ ] False (2)
- [ ] Mostly False (3)
- [ ] More False Than True (4)
- [ ] More True Than False (5)
- [ ] Mostly True (6)
- [ ] True (7)
- [ ] Definitely True (8)
Q4 I have generally done better in mathematics courses than other courses.

*Indicate how true or false the description is of you.*

- Definitely False (1)
- False (2)
- Mostly False (3)
- More False Than True (4)
- More True Than False (5)
- Mostly True (6)
- True (7)
- Definitely True (8)

Q5 Mathematics makes me feel inadequate.

*Indicate how true or false the description is of you.*

- Definitely False (1)
- False (2)
- Mostly False (3)
- More False Than True (4)
- More True Than False (5)
- Mostly True (6)
- True (7)
- Definitely True (8)
Q6 I am quite good at mathematics.

*Indicate how true or false the description is of you.*

- Definitely False (1)
- False (2)
- Mostly False (3)
- More False Than True (4)
- More True Than False (5)
- Mostly True (6)
- True (7)
- Definitely True (8)

Q7 I have trouble understanding anything that is based upon mathematics.

*Indicate how true or false the description is of you.*

- Definitely False (1)
- False (2)
- Mostly False (3)
- More False Than True (4)
- More True Than False (5)
- Mostly True (6)
- True (7)
- Definitely True (8)
Q8 I have always done well in mathematics courses.

*Indicate how true or false the description is of you.*

- Definitely False (1)
- False (2)
- Mostly False (3)
- More False Than True (4)
- More True Than False (5)
- Mostly True (6)
- True (7)
- Definitely True (8)

Q9 I never do well on tests that require mathematical reasoning.

*Indicate how true or false the description is of you.*

- Definitely False (1)
- False (2)
- Mostly False (3)
- More False Than True (4)
- More True Than False (5)
- Mostly True (6)
- True (7)
- Definitely True (8)
Q10 At school, my friends always came to me for help in mathematics.

Indicate how true or false the description is of you.

- Definitely False (1)
- False (2)
- Mostly False (3)
- More False Than True (4)
- More True Than False (5)
- Mostly True (6)
- True (7)
- Definitely True (8)

Q11 I have never been excited about mathematics.

Indicate how true or false the description is of you.

- Definitely False (1)
- False (2)
- Mostly False (3)
- More False Than True (4)
- More True Than False (5)
- Mostly True (6)
- True (7)
- Definitely True (8)
Q1 For the following items, please **indicate your confidence in your ability to successfully perform the task**.

You are not asked to complete the task, only to indicate your confidence in your ability to successfully perform the task. As an example, if the item states, "divide two large numbers (8246 ÷ 2431) in your head," you are not asked to actually divide the two numbers to find an answer, but simply respond how confident you are in your ability to successfully perform that task.

---

Q2 Use appropriate technology to solve mathematical problems

*Please indicate your confidence in your ability to successfully perform the task.*

<table>
<thead>
<tr>
<th>No Confidence at All</th>
<th>Neutral</th>
<th>Complete Confidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 2 3 4 5 6 7 8 9</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

---

Q3 Determine how much interest you will end up paying on a $675 loan over 2 years at 14 ¾% interest

*Please indicate your confidence in your ability to successfully perform the task.*

<table>
<thead>
<tr>
<th>No Confidence at All</th>
<th>Neutral</th>
<th>Complete Confidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 2 3 4 5 6 7 8 9</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

---
Q4 Figure out how much lumber you need to buy in order to build a set of bookshelves

*Please indicate your confidence in your ability to successfully perform the task.*

<table>
<thead>
<tr>
<th>No Confidence at All</th>
<th>Neutral</th>
<th>Complete Confidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 2 3 4 5 6 7 8 9</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| 0                    |         |                     |

Q5 Compute your income taxes for the year

*Please indicate your confidence in your ability to successfully perform the task.*

<table>
<thead>
<tr>
<th>No Confidence at All</th>
<th>Neutral</th>
<th>Complete Confidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 2 3 4 5 6 7 8 9</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| 0                    |         |                     |

Q6 Figure out how much material to buy in order to make curtains

*Please indicate your confidence in your ability to successfully perform the task.*

<table>
<thead>
<tr>
<th>No Confidence at All</th>
<th>Neutral</th>
<th>Complete Confidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 2 3 4 5 6 7 8 9</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| 0                    |         |                     |
Q7 Understand a graph accompanying an article on business profits

*Please indicate your confidence in your ability to successfully perform the task.*

<table>
<thead>
<tr>
<th>No Confidence at All</th>
<th>Neutral</th>
<th>Complete Confidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 2 3 4 5 6 7 8 9</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

0

Q8 Understand how much interest you will earn on your savings account in 6 months, and how the interest is computed

*Please indicate your confidence in your ability to successfully perform the task.*

<table>
<thead>
<tr>
<th>No Confidence at All</th>
<th>Neutral</th>
<th>Complete Confidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 2 3 4 5 6 7 8 9</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

0

Q9 Add two large numbers (e.g., 5739 + 62543) in your head

*Please indicate your confidence in your ability to successfully perform the task.*

<table>
<thead>
<tr>
<th>No Confidence at All</th>
<th>Neutral</th>
<th>Complete Confidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 2 3 4 5 6 7 8 9</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

0
Q10 Estimate your grocery bill in your head as you pick up items.

*Please indicate your confidence in your ability to successfully perform the task.*

<table>
<thead>
<tr>
<th>No Confidence at All</th>
<th>Neutral</th>
<th>Complete Confidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 2 3 4 5 6 7 8 9</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

0

Q11 Determine the amount of sales tax on a clothing purchase.

*Please indicate your confidence in your ability to successfully perform the task.*

<table>
<thead>
<tr>
<th>No Confidence at All</th>
<th>Neutral</th>
<th>Complete Confidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 2 3 4 5 6 7 8 9</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

0

Q12 Figure out the tip on your part of a dinner bill split 8 ways.

*Please indicate your confidence in your ability to successfully perform the task.*

<table>
<thead>
<tr>
<th>No Confidence at All</th>
<th>Neutral</th>
<th>Complete Confidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 2 3 4 5 6 7 8 9</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

0
Q13 Figure out how long it will take to travel from city A to city B driving 55 mph

*Please indicate your confidence in your ability to successfully perform the task.*

<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td></td>
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<td></td>
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</tr>
</tbody>
</table>

Q14 Compute your car's gas mileage

*Please indicate your confidence in your ability to successfully perform the task.*

<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Q15 Set up a monthly budget by yourself

*Please indicate your confidence in your ability to successfully perform the task.*

<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Q16 Reconcile your bank account without a mistake

*Please indicate your confidence in your ability to successfully perform the task.*

<table>
<thead>
<tr>
<th>No Confidence at All</th>
<th>Neutral</th>
<th>Complete Confidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 2 3 4 5 6 7 8 9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Q17 Figure out which of two summer jobs is the better offer; one with higher salary but no benefits, the other with a lower salary plus room, board, and travel expenses. *Please indicate your confidence in your ability to successfully perform the task.*

<table>
<thead>
<tr>
<th>No Confidence at All</th>
<th>Neutral</th>
<th>Complete Confidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 2 3 4 5 6 7 8 9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Q18 Figure out how much you would save if there is a 15% markdown on an item you wish to buy

*Please indicate your confidence in your ability to successfully perform the task.*

<table>
<thead>
<tr>
<th>No Confidence at All</th>
<th>Neutral</th>
<th>Complete Confidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 2 3 4 5 6 7 8 9</td>
<td></td>
<td></td>
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<tr>
<td>0</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Q19 Calculate recipe quantities for a dinner for 41 when the original recipe is for 12 people

*Please indicate your confidence in your ability to successfully perform the task.*

<table>
<thead>
<tr>
<th>No Confidence at All</th>
<th>Neutral</th>
<th>Complete Confidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 2 3 4 5 6 7 8 9</td>
<td></td>
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<tr>
<td>0</td>
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<td></td>
</tr>
</tbody>
</table>

End of Block: Math Self-Efficacy Questionnaire - Part A

Start of Block: Math Self-Efficacy Questionnaire - Part B
Q1 For each course listed below, **indicate your confidence in your ability to successfully complete the course.**

<table>
<thead>
<tr>
<th>Course</th>
<th>No Confidence at All</th>
<th>Neutral</th>
<th>Complete Confidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Advanced Calculus ()</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Philosophy ()</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Biochemistry ()</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Statistics ()</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Computer Science ()</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Physiology ()</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Trigonometry ()</td>
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<td></td>
<td></td>
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<tr>
<td>Economics ()</td>
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<tr>
<td>Zoology ()</td>
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<tr>
<td>Accounting ()</td>
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<tr>
<td>Business Administration ()</td>
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<tr>
<td>Geometry ()</td>
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<td></td>
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<tr>
<td>Algebra II ()</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Calculus ()</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Algebra I ()</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Basic College Math ()</td>
<td></td>
<td></td>
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</tbody>
</table>
Q2 For each course listed below, indicate the amount of mathematics you believe you would encounter while taking the course.

<table>
<thead>
<tr>
<th>Course</th>
<th>None</th>
<th>Very Little</th>
<th>Some</th>
<th>A Moderate Amount</th>
<th>An Extensive Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Advanced Calculus ()</td>
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<td></td>
<td></td>
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<tr>
<td>Philosophy ()</td>
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</tr>
<tr>
<td>Economics ()</td>
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<tr>
<td>Zoology ()</td>
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<tr>
<td>Accounting ()</td>
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<tr>
<td>Business Administration ()</td>
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<tr>
<td>Geometry ()</td>
<td></td>
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<tr>
<td>Algebra II ()</td>
<td></td>
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<tr>
<td>Calculus ()</td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Algebra I ()</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Basic College Math ()</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

End of Block: Math Self-Efficacy Questionnaire - Part B

Start of Block: Math Experience
Q4.1 Rate your level of agreement with each statement below regarding your high school experience.

<table>
<thead>
<tr>
<th></th>
<th>Strongly Disagree (1)</th>
<th>Disagree (2)</th>
<th>Neither Agree nor Disagree (3)</th>
<th>Agree (4)</th>
<th>Strongly Agree (5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I felt confident in my ability to do well in my last high school math class. (2)</td>
<td>o</td>
<td>o</td>
<td>o</td>
<td>o</td>
<td>o</td>
</tr>
<tr>
<td>I enjoyed my last high school math class. (1)</td>
<td>o</td>
<td>o</td>
<td>o</td>
<td>o</td>
<td>o</td>
</tr>
<tr>
<td>I did well in my last high school math class. (3)</td>
<td>o</td>
<td>o</td>
<td>o</td>
<td>o</td>
<td>o</td>
</tr>
</tbody>
</table>

Q4.2 In high school, did you participate in honors, plus, or AP courses related to mathematics?

- Yes (1)
- No (2)

Q4.3 Rate your level of agreement with each statement below regarding your college experience.

<table>
<thead>
<tr>
<th></th>
<th>Strongly Disagree (1)</th>
<th>Disagree (2)</th>
<th>Neither Agree nor Disagree (3)</th>
<th>Agree (4)</th>
<th>Strongly Agree (5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I felt confident in my ability to do well in my most recent college math class. (2)</td>
<td>o</td>
<td>o</td>
<td>o</td>
<td>o</td>
<td>o</td>
</tr>
<tr>
<td>I enjoyed my most recent college math class. (1)</td>
<td>o</td>
<td>o</td>
<td>o</td>
<td>o</td>
<td>o</td>
</tr>
<tr>
<td>I did well in my most recent college math class. (3)</td>
<td>o</td>
<td>o</td>
<td>o</td>
<td>o</td>
<td>o</td>
</tr>
</tbody>
</table>
Q5.1 What is the highest level of education obtained by your mother/female parental guardian?

- Less than high school degree (1)
- High school graduate (high school diploma or equivalent including GED) (2)
- Some college but no degree (3)
- Associate degree in college (2-year) (4)
- Bachelor's degree in college (4-year) (5)
- Master's degree (6)
- Doctoral degree (7)
- Professional degree (JD, MD) (8)

Q5.2 What is the highest level of education obtained by your father/male parental guardian?

- Less than high school degree (1)
- High school graduate (high school diploma or equivalent including GED) (2)
- Some college but no degree (3)
- Associate degree in college (2-year) (4)
- Bachelor's degree in college (4-year) (5)
- Master's degree (6)
- Doctoral degree (7)
- Professional degree (JD, MD) (8)
Q5.3 Did one or more of your parents/parental guardians **study** STEM (science, technology, engineering, mathematics) during college?

- Yes (1)
- No (2)

---

Display This Question:

If Did one or more of your parents/parental guardians study STEM (science, technology, engineering,... = Yes

Q5.4 If yes, please select which one(s) **studied** STEM. Select all that apply.

- Mother (1)
- Father (2)
- Stepmother (3)
- Stepmother (3)
- Stepmother (3)
- Stepfather (4)
- Other (5) ____________________________________________________

---

Q5.5 Did one or more of your parents/parental guardians **work** in a STEM (science, technology, engineering, mathematics) field during their career?

- Yes (1)
- No (2)

---

Display This Question:

If Did one or more of your parents/parental guardians work in a STEM (science, technology, engineeri... = Yes
Q5.6 If yes, please select which one(s) worked in a STEM field. Select all that apply.

☐ Mother  (1)
☐ Father  (2)
☐ Stepmother  (3)
☐ Stepmother  (4)
☐ Other  (5) __________________________________________________

Q5.7 Have you served a mission for the Church of Jesus Christ of Latter-day Saints?

☐ Yes  (1)
☐ No  (2)

Display This Question:

If Have you served a mission for the Church of Jesus Christ of Latter-day Saints? = Yes
Q5.8 During what year(s) did you serve a mission? *Select all that apply.*

- [ ] Prior to 2012 (1)
- [ ] 2012 (2)
- [ ] 2013 (3)
- [ ] 2014 (4)
- [ ] 2015 (5)
- [ ] 2016 (6)
- [ ] 2017 (7)
- [ ] 2018 (8)
- [ ] 2019 (9)
- [ ] 2020 (10)
- [ ] 2021 (11)
- [ ] 2022 (15)

Q5.9 The following items reference your experience in $\{e://Field/graduated_major\}$ in the College of $\{e://Field/graduated_college\}$.
Q230 To what degree did you struggle to pay for college during the times specified below?

<table>
<thead>
<tr>
<th>When you first enrolled in ${e://Field/graduated_major}$ (1)</th>
<th>Not at All (1)</th>
<th>A Little (2)</th>
<th>A Moderate Amount (3)</th>
<th>A Lot (4)</th>
<th>A Great Deal (5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>During your last semester before graduating from ${e://Field/graduated_major}$ (3)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Q5.11 Please select your marital status during the times specified below.

<table>
<thead>
<tr>
<th>When you first enrolled in ${e://Field/graduated_major}$ (1)</th>
<th>Never Married (1)</th>
<th>Married (2)</th>
<th>Widowed (3)</th>
<th>Divorced (4)</th>
<th>Separated (5)</th>
<th>Prefer Not to Answer (6)</th>
</tr>
</thead>
<tbody>
<tr>
<td>During your last semester before graduating from ${e://Field/graduated_major}$ (3)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Current marital status (5)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Q5.12 Please select the number of dependents you had during the times specified below.

<table>
<thead>
<tr>
<th>When you first enrolled in ${e://Field/graduated_major}$ (1)</th>
<th>0 (1)</th>
<th>1 (2)</th>
<th>2 (3)</th>
<th>3 (4)</th>
<th>4 (5)</th>
<th>5 or more (6)</th>
<th>Prefer Not to Answer (7)</th>
</tr>
</thead>
<tbody>
<tr>
<td>During your last semester before graduating from ${e://Field/graduated_major}$ (3)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Current number of dependents (5)</td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>
Q6.1 Did you ever participate in research with a faculty member in the College of $\{\text{Field/graduated_college}\}$?

- Yes (1)
- No (2)

Display This Question:
If $\text{graduated_college} = \text{Engineering}$

Q6.2 Did you ever participate in the Women in Engineering (WE) Research Mentorship Program or the BYU Engineering Together (BE Together) Research Mentorship Program through the College of Engineering?

- Yes (1)
- No (2)

Q6.3 During your time in $\{\text{Field/graduated_major}\}$, were you involved in any clubs or associations related to your field of study?

- Yes (1)
- No (2)

Q6.4 During your time in $\{\text{Field/graduated_major}\}$, did you have a mentor that helped provide guidance, motivation, and/or emotional support related to your field of study?

- Yes (1)
- No (2)
Q6.5 During your time in $e://Field/graduated_major$, did you have a role model in your field of study?

- Yes (1)
- No (2)

Q6.6 Please rate your experience with faculty in $e://Field/graduated_major$.

<table>
<thead>
<tr>
<th></th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td>Negative</td>
<td></td>
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<td></td>
<td></td>
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<tr>
<td>Experience</td>
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<tr>
<td>Positive</td>
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<td>Experience</td>
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<tr>
<td>Rating</td>
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</tbody>
</table>

Q6.7 Describe why you gave the rating you did. (Optional)

________________________________________________________________
________________________________________________________________

Q226 Please rate your experience with male students in $e://Field/graduated_major$.

<table>
<thead>
<tr>
<th></th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td>Negative</td>
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<td>Experience</td>
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<td>Rating</td>
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</tr>
</tbody>
</table>

Q6.9 Describe why you gave the rating you did. (Optional)

________________________________________________________________
________________________________________________________________
Q227 Please rate your experience with female students in {Field/graduated_major}.  

<table>
<thead>
<tr>
<th>Negative Experience</th>
<th>Positive Experience</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>

Q6.11 Describe why you gave the rating you did. *(Optional)*
________________________________________________________________
________________________________________________________________

Q6.12 Please describe what led to your original decision to enroll in {Field/graduated_major} within the College of {Field/graduated_college}.
________________________________________________________________
________________________________________________________________

Q7.1 Is there anything else you would like to tell us that would help us improve the experience for students in the College of {Field/graduated_college} in the future? *(Optional)*
________________________________________________________________
________________________________________________________________

End of Block: Experience in Program

Start of Block: End
Q7.2 Would you be willing to participate in a follow-up interview to help us understand more about your experience?

- Yes (1)
- No (2)

---

Display This Question:
If Would you be willing to participate in a follow-up interview to help us understand more about you... = Yes

Q7.3 If yes, please enter your name and email address below. Your previous responses will still be kept confidential.

- First Name (1) ________________________________
- Last Name (2) ________________________________
- Email Address (3) ________________________________

Q7.4 Would you like to be redirected to enter the raffle to win a $25 gift card and BYU SWAG? Your responses will still be kept confidential.

- Yes (1)
- No (2)

---

End of Block: End
Survey 3: Graduated From a Non-STEM Major

Start of Block: Introduction

Q1.1
This survey has been designed to help us understand factors influencing student experience while studying science, technology, engineering, and mathematics (STEM) at BYU. As a graduate of BYU who was formerly enrolled in a STEM program, your feedback is very valuable to us. The results of this study will be used to identify areas of possible improvement for future semesters. Responses will be kept confidential. This survey should take about 10 to 15 minutes to complete.

Be sure to complete the survey for a chance to win a $25 gift card and some BYU SWAG!!

We value your feedback and appreciate your time!
Odds of winning are estimated to be 15 to 2350.

End of Block: Introduction

Start of Block: Math Self-Concept Questionnaire - Final

Q1 The following items are a series of statements that are more or less true (or more or less false) descriptions of you. Please use the following eight-point response scale to indicate how true (or false) each item is as a description of you. Respond to the items as you now feel even if you felt differently at some other time in your life. In a few instances, an item may no longer be appropriate to you, though it was at an earlier period of your life. In such cases, respond to the item as you would have when it was appropriate. Try to avoid leaving any items blank.

Q2 I find many mathematical problems interesting and challenging.
Indicate how true or false the description is of you.

- Definitely False (1)
- False (2)
- Mostly False (3)
- More False Than True (4)
- More True Than False (5)
- Mostly True (6)
- True (7)
- Definitely True (8)
Q3 I have hesitated to take courses that involve mathematics. 
*Indicate how true or false the description is of you.*

- [ ] Definitely False (1)
- [ ] False (2)
- [ ] Mostly False (3)
- [ ] More False Than True (4)
- [ ] More True Than False (5)
- [ ] Mostly True (6)
- [ ] True (7)
- [ ] Definitely True (8)

---

Q4 I have generally done better in mathematics courses than other courses. 
*Indicate how true or false the description is of you.*

- [ ] Definitely False (1)
- [ ] False (2)
- [ ] Mostly False (3)
- [ ] More False Than True (4)
- [ ] More True Than False (5)
- [ ] Mostly True (6)
- [ ] True (7)
- [ ] Definitely True (8)
Q5 Mathematics makes me feel inadequate. 
Indicate how true or false the description is of you.

☐ Definitely False (1)
☐ False (2)
☐ Mostly False (3)
☐ More False Than True (4)
☐ More True Than False (5)
☐ Mostly True (6)
☐ True (7)
☐ Definitely True (8)

Q6 I am quite good at mathematics. 
Indicate how true or false the description is of you.

☐ Definitely False (1)
☐ False (2)
☐ Mostly False (3)
☐ More False Than True (4)
☐ More True Than False (5)
☐ Mostly True (6)
☐ True (7)
☐ Definitely True (8)
Q7 I have trouble understanding anything that is based upon mathematics. 
*Indicate how true or false the description is of you.*

- Definitely False (1)
- False (2)
- Mostly False (3)
- More False Than True (4)
- More True Than False (5)
- Mostly True (6)
- True (7)
- Definitely True (8)

Q8 I have always done well in mathematics courses. 
*Indicate how true or false the description is of you.*

- Definitely False (1)
- False (2)
- Mostly False (3)
- More False Than True (4)
- More True Than False (5)
- Mostly True (6)
- True (7)
- Definitely True (8)
Q9 I never do well on tests that require mathematical reasoning.  
*Indicate how true or false the description is of you.*

- [ ] Definitely False (1)
- [ ] False (2)
- [ ] Mostly False (3)
- [ ] More False Than True (4)
- [ ] More True Than False (5)
- [ ] Mostly True (6)
- [ ] True (7)
- [ ] Definitely True (8)

Q10 At school, my friends always came to me for help in mathematics.  
*Indicate how true or false the description is of you.*

- [ ] Definitely False (1)
- [ ] False (2)
- [ ] Mostly False (3)
- [ ] More False Than True (4)
- [ ] More True Than False (5)
- [ ] Mostly True (6)
- [ ] True (7)
- [ ] Definitely True (8)
Q11 I have never been excited about mathematics. 

Indicate how true or false the description is of you.

- Definitely False (1)
- False (2)
- Mostly False (3)
- More False Than True (4)
- More True Than False (5)
- Mostly True (6)
- True (7)
- Definitely True (8)

End of Block: Math Self-Concept Questionnaire - Final

Start of Block: Math Self-Efficacy Questionnaire - Part A

Q1 For the following items, please indicate your confidence in your ability to successfully perform the task. You are not asked to complete the task, only to indicate your confidence in your ability to successfully perform the task. As an example, if the item states, "divide two large numbers (8246 ÷ 2431) in your head," you are not asked to actually divide the two numbers to find an answer, but simply respond how confident you are in your ability to successfully perform that task.

Q2 Use appropriate technology to solve mathematical problems

Please indicate your confidence in your ability to successfully perform the task.

<table>
<thead>
<tr>
<th>No Confidence at All</th>
<th>Neutral</th>
<th>Complete Confidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 2 3 4 5 6 7 8 9</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>()</th>
</tr>
</thead>
</table>
Q3 Determine how much interest you will end up paying on a $675 loan over 2 years at 14 ¾% interest.  
*Please indicate your confidence in your ability to successfully perform the task.*

<table>
<thead>
<tr>
<th>No Confidence at All</th>
<th>Neutral</th>
<th>Complete Confidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 2 3 4 5 6 7 8 9</td>
<td></td>
<td>0</td>
</tr>
</tbody>
</table>

Q4 Figure out how much lumber you need to buy in order to build a set of bookshelves.  
*Please indicate your confidence in your ability to successfully perform the task.*

<table>
<thead>
<tr>
<th>No Confidence at All</th>
<th>Neutral</th>
<th>Complete Confidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 2 3 4 5 6 7 8 9</td>
<td></td>
<td>0</td>
</tr>
</tbody>
</table>

Q5 Compute your income taxes for the year.  
*Please indicate your confidence in your ability to successfully perform the task.*

<table>
<thead>
<tr>
<th>No Confidence at All</th>
<th>Neutral</th>
<th>Complete Confidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 2 3 4 5 6 7 8 9</td>
<td></td>
<td>0</td>
</tr>
</tbody>
</table>
Q6 Figure out how much material to buy in order to make curtains
*Please indicate your confidence in your ability to successfully perform the task.*

<table>
<thead>
<tr>
<th>No Confidence at All</th>
<th>Neutral</th>
<th>Complete Confidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 2 3 4 5 6 7 8 9</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

0

Q7 Understand a graph accompanying an article on business profits
*Please indicate your confidence in your ability to successfully perform the task.*

<table>
<thead>
<tr>
<th>No Confidence at All</th>
<th>Neutral</th>
<th>Complete Confidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 2 3 4 5 6 7 8 9</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

0

Q8 Understand how much interest you will earn on your savings account in 6 months, and how the interest is computed
*Please indicate your confidence in your ability to successfully perform the task.*

<table>
<thead>
<tr>
<th>No Confidence at All</th>
<th>Neutral</th>
<th>Complete Confidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 2 3 4 5 6 7 8 9</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

0
Q9 Add two large numbers (e.g., 5739 + 62543) in your head
*Please indicate your confidence in your ability to successfully perform the task.*

<table>
<thead>
<tr>
<th>No Confidence at All</th>
<th>Neutral</th>
<th>Complete Confidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 2 3 4 5 6 7 8 9</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Q10 Estimate your grocery bill in your head as you pick up items
*Please indicate your confidence in your ability to successfully perform the task.*

<table>
<thead>
<tr>
<th>No Confidence at All</th>
<th>Neutral</th>
<th>Complete Confidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 2 3 4 5 6 7 8 9</td>
<td></td>
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</tbody>
</table>

Q11 Determine the amount of sales tax on a clothing purchase
*Please indicate your confidence in your ability to successfully perform the task.*

<table>
<thead>
<tr>
<th>No Confidence at All</th>
<th>Neutral</th>
<th>Complete Confidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 2 3 4 5 6 7 8 9</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Q12 Figure out the tip on your part of a dinner bill split 8 ways

*Please indicate your confidence in your ability to successfully perform the task.*

<table>
<thead>
<tr>
<th>No Confidence at All</th>
<th>Neutral</th>
<th>Complete Confidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 2 3 4 5 6 7 8 9</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Q13 Figure out how long it will take to travel from city A to city B driving 55 mph

*Please indicate your confidence in your ability to successfully perform the task.*

<table>
<thead>
<tr>
<th>No Confidence at All</th>
<th>Neutral</th>
<th>Complete Confidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 2 3 4 5 6 7 8 9</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Q14 Compute your car's gas mileage

*Please indicate your confidence in your ability to successfully perform the task.*

<table>
<thead>
<tr>
<th>No Confidence at All</th>
<th>Neutral</th>
<th>Complete Confidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 2 3 4 5 6 7 8 9</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Q15 Set up a monthly budget by yourself

Please indicate your confidence in your ability to successfully perform the task.

<table>
<thead>
<tr>
<th>No Confidence at All</th>
<th>Neutral</th>
<th>Complete Confidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 2 3 4 5 6 7 8 9</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Q16 Reconcile your bank account without a mistake

Please indicate your confidence in your ability to successfully perform the task.

<table>
<thead>
<tr>
<th>No Confidence at All</th>
<th>Neutral</th>
<th>Complete Confidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 2 3 4 5 6 7 8 9</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Q17 Figure out which of two summer jobs is the better offer; one with higher salary but no benefits, the other with a lower salary plus room, board, and travel expenses

Please indicate your confidence in your ability to successfully perform the task.

<table>
<thead>
<tr>
<th>No Confidence at All</th>
<th>Neutral</th>
<th>Complete Confidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 2 3 4 5 6 7 8 9</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Q18 Figure out how much you would save if there is a 15% markdown on an item you wish to buy.

*Please indicate your confidence in your ability to successfully perform the task.*

<table>
<thead>
<tr>
<th>No Confidence at All</th>
<th>Neutral</th>
<th>Complete Confidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1 2 3 4 5 6 7 8 9</td>
<td></td>
</tr>
</tbody>
</table>

Q19 Calculate recipe quantities for a dinner for 41 when the original recipe is for 12 people.

*Please indicate your confidence in your ability to successfully perform the task.*

<table>
<thead>
<tr>
<th>No Confidence at All</th>
<th>Neutral</th>
<th>Complete Confidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1 2 3 4 5 6 7 8 9</td>
<td></td>
</tr>
</tbody>
</table>

End of Block: Math Self-Efficacy Questionnaire - Part A

Start of Block: Math Self-Efficacy Questionnaire - Part B
Q1 For each course listed below, *indicate your confidence in your ability to successfully complete the course.*

<table>
<thead>
<tr>
<th>Course</th>
<th>No Confidence at All</th>
<th>Neutral</th>
<th>Complete Confidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Advanced Calculus ()</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Philosophy ()</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Biochemistry ()</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Statistics ()</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Computer Science ()</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Physiology ()</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trigonometry ()</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Economics ()</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Zoology ()</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Accounting ()</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Business Administration ()</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Geometry ()</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Algebra II ()</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Calculus ()</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Algebra I ()</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Basic College Math ()</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Q2 For each course listed below, indicate the amount of mathematics you believe you would encounter while taking the course.

<table>
<thead>
<tr>
<th>Course</th>
<th>None</th>
<th>Very Little</th>
<th>Some</th>
<th>A Moderate Amount</th>
<th>An Extensive Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Advanced Calculus ()</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Philosophy ()</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Biochemistry ()</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Statistics ()</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Computer Science ()</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Physiology ()</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trigonometry ()</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Economics ()</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Zoology ()</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Accounting ()</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Business Administration ()</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Geometry ()</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Algebra II ()</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Calculus ()</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Algebra I ()</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Basic College Math ()</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

End of Block: Math Self-Efficacy Questionnaire - Part B

Start of Block: Math Experience
Q4.1 Rate your level of agreement with each statement below regarding your high school experience.

<table>
<thead>
<tr>
<th>Statement</th>
<th>Strongly Disagree (1)</th>
<th>Disagree (2)</th>
<th>Neither Agree nor Disagree (3)</th>
<th>Agree (4)</th>
<th>Strongly Agree (5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I felt confident in my ability to do well in my last high school math class. (2)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I enjoyed my last high school math class. (1)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I did well in my last high school math class. (3)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Q4.2 In high school, did you participate in honors, plus, or AP courses related to mathematics?

- Yes (1)
- No (2)

Q4.3 Rate your level of agreement with each statement below regarding your college experience.

<table>
<thead>
<tr>
<th>Statement</th>
<th>Strongly Disagree (1)</th>
<th>Disagree (2)</th>
<th>Neither Agree nor Disagree (3)</th>
<th>Agree (4)</th>
<th>Strongly Agree (5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I felt confident in my ability to do well in my most recent college math class. (2)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I enjoyed my most recent college math class. (1)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I did well in my most recent college math class. (3)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

End of Block: Math Experience

Start of Block: Demographic
Q5.1 What is the highest level of education obtained by your mother/female parental guardian?

- Less than high school degree  (1)
- High school graduate (high school diploma or equivalent including GED)  (2)
- Some college but no degree  (3)
- Associate degree in college (2-year)  (4)
- Bachelor's degree in college (4-year)  (5)
- Master's degree  (6)
- Doctoral degree  (7)
- Professional degree (JD, MD)  (8)

Q5.2 What is the highest level of education obtained by your father/male parental guardian?

- Less than high school degree  (1)
- High school graduate (high school diploma or equivalent including GED)  (2)
- Some college but no degree  (3)
- Associate degree in college (2-year)  (4)
- Bachelor's degree in college (4-year)  (5)
- Master's degree  (6)
- Doctoral degree  (7)
- Professional degree (JD, MD)  (8)
Q5.3 Did one or more of your parents/parental guardians study STEM (science, technology, engineering, mathematics) during college?

○ Yes (1)
○ No (2)

Display This Question:
If Did one or more of your parents/parental guardians study STEM (science, technology, engineering,... = Yes

Q5.4 If yes, please select which one(s) studied STEM. Select all that apply.

☐ Mother (1)
☐ Father (2)
☐ Stepmother (3)
☐ Stepfather (4)
☐ Other (5) __________________________________________________

Q5.5 Did one or more of your parents/parental guardians work in a STEM (science, technology, engineering, mathematics) field during their career?

○ Yes (1)
○ No (2)

Display This Question:
If Did one or more of your parents/parental guardians work in a STEM (science, technology, engineeri... = Yes
Q5.6 If yes, please select which one(s) worked in a STEM field. Select all that apply.

☐ Mother (1)
☐ Father (2)
☐ Stepmother (3)
☐ Stepfather (4)
☐ Other (5) __________________________________________________

Q5.7 Have you served a mission for the Church of Jesus Christ of Latter-day Saints?

☐ Yes (1)
☐ No (2)

Display This Question:

If Have you served a mission for the Church of Jesus Christ of Latter-day Saints? = Yes
Q5.8 During what year(s) did you serve a mission? Select all that apply.

- Prior to 2012 (1)
- 2012 (2)
- 2013 (3)
- 2014 (4)
- 2015 (5)
- 2016 (6)
- 2017 (7)
- 2018 (8)
- 2019 (9)
- 2020 (10)
- 2021 (11)
- 2022 (15)

Q5.9 The following items reference your experience in your previous major ($e://Field/previous_stem_major$) within the College of $e://Field/previous_stem_college$.

Q232 To what degree did you struggle to pay for college during the times specified below?

<table>
<thead>
<tr>
<th>When you first enrolled in $e://Field/previous_stem_major$ (1)</th>
<th>Not at All (1)</th>
<th>A Little (2)</th>
<th>A Moderate Amount (3)</th>
<th>A Lot (4)</th>
<th>A Great Deal (5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>When you left $e://Field/previous_stem_major$ (3)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Q5.11 Please select your marital status during the times specified below.

<table>
<thead>
<tr>
<th></th>
<th>Never Married (1)</th>
<th>Married (2)</th>
<th>Widowed (3)</th>
<th>Divorced (4)</th>
<th>Separated (5)</th>
<th>Prefer Not to Answer (6)</th>
</tr>
</thead>
<tbody>
<tr>
<td>When you first enrolled in ${e://Field/previous_stem_major}</td>
<td>〇</td>
<td>〇</td>
<td>〇</td>
<td>〇</td>
<td>〇</td>
<td>〇</td>
</tr>
<tr>
<td>When you left ${{e://Field/previous_stem_major}} (3)</td>
<td>〇</td>
<td>〇</td>
<td>〇</td>
<td>〇</td>
<td>〇</td>
<td>〇</td>
</tr>
<tr>
<td>Current marital status (5)</td>
<td>〇</td>
<td>〇</td>
<td>〇</td>
<td>〇</td>
<td>〇</td>
<td>〇</td>
</tr>
</tbody>
</table>

Q5.12 Please select the number of dependents you had during the times specified below.

<table>
<thead>
<tr>
<th></th>
<th>0 (1)</th>
<th>1 (2)</th>
<th>2 (3)</th>
<th>3 (4)</th>
<th>4 (5)</th>
<th>5 or more (6)</th>
<th>Prefer Not to Answer (7)</th>
</tr>
</thead>
<tbody>
<tr>
<td>When you first enrolled in ${e://Field/previous_stem_major}</td>
<td>〇</td>
<td>〇</td>
<td>〇</td>
<td>〇</td>
<td>〇</td>
<td>〇</td>
<td>〇</td>
</tr>
<tr>
<td>When you left ${{e://Field/previous_stem_major}} (3)</td>
<td>〇</td>
<td>〇</td>
<td>〇</td>
<td>〇</td>
<td>〇</td>
<td>〇</td>
<td>〇</td>
</tr>
<tr>
<td>Current number of dependents (5)</td>
<td>〇</td>
<td>〇</td>
<td>〇</td>
<td>〇</td>
<td>〇</td>
<td>〇</td>
<td>〇</td>
</tr>
</tbody>
</table>

End of Block: Demographic

Start of Block: Experience in Program

Q6.1 To the best of your knowledge, how many credits had you completed in your previous major (${{e://Field/previous_stem_major}}) when you changed majors? (Only estimate credits required for your program, not including GE credits)
Q6.2 Did you ever participate in research with a faculty member in the College of \( e://Field/previous\_stem\_college \)?

- Yes (1)
- No (2)

Display This Question:
If \( previous\_stem\_college \) = Engineering

Q234 Did you ever participate in the Women in Engineering (WE) Research Mentorship Program or the BYU Engineering Together (BE Together) Research Mentorship Program through the College of Engineering?

- Yes (1)
- No (2)

Q6.4 During your time in \( e://Field/previous\_stem\_major \), were you involved in any clubs or associations related to your field of study?

- Yes (1)
- No (2)

Q6.5 During your time in \( e://Field/previous\_stem\_major \), did you have a mentor that helped provide guidance, motivation, and/or emotional support related to your field of study?

- Yes (1)
- No (2)

Q6.6 During your time in \( e://Field/previous\_stem\_major \), did you have a role model in your field of study?

- Yes (1)
- No (2)
Q6.7 Please rate your experience with faculty in ${e://Field/previous_stem_major}.

<table>
<thead>
<tr>
<th>Negative Experience</th>
<th>Positive Experience</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>

Q6.8 Describe why you gave the rating you did. *(Optional)*

________________________________________________________________
________________________________________________________________
________________________________________________________________
________________________________________________________________
________________________________________________________________

Q228 Please rate your experience with male students in ${e://Field/previous_stem_major}.

<table>
<thead>
<tr>
<th>Negative Experience</th>
<th>Positive Experience</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>

Q6.10 Describe why you gave the rating you did. *(Optional)*

________________________________________________________________
________________________________________________________________
________________________________________________________________
________________________________________________________________
________________________________________________________________
Q229 Please rate your experience with **female students** in $\{e://Field/previous_stem_major\}$.

<table>
<thead>
<tr>
<th>Negative Experience</th>
<th>Positive Experience</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>

Q6.12 Describe why you gave the rating you did. *(Optional)*

________________________________________________________________
________________________________________________________________
________________________________________________________________
________________________________________________________________
________________________________________________________________

Q6.13 Please describe what led to your original decision to enroll in $\{e://Field/previous_stem_major\}$ within the College of $\{e://Field/previous_stem_college\}$.

________________________________________________________________
________________________________________________________________
________________________________________________________________
________________________________________________________________
________________________________________________________________

Q235 Please describe what led to your decision to leave $\{e://Field/previous_stem_major\}$.

________________________________________________________________
________________________________________________________________
________________________________________________________________
________________________________________________________________
________________________________________________________________

Q7.1 Is there anything else you would like to tell us that would help us improve the experience for students in the College of $\{e://Field/previous_stem_college\}$ in the future? *(Optional)*

________________________________________________________________
________________________________________________________________
________________________________________________________________
________________________________________________________________
________________________________________________________________

End of Block: Experience in Program

Start of Block: End
Q7.2 Would you be willing to participate in a follow-up interview to help us understand more about your experience?

- Yes (1)
- No (2)

Display This Question:
If Would you be willing to participate in a follow-up interview to help us understand more about you... = Yes

Q7.3 If yes, please enter your name and email address below. Your previous responses will still be kept confidential.

- First Name (1) __________________________________________________
- Last Name (2) ________________________________________________
- Email Address (3) ____________________________________________

Q7.4 Would you like to be redirected to enter the raffle to win a $25 gift card and BYU SWAG? Your responses will still be kept confidential.

- Yes (1)
- No (2)

End of Block: End
Survey 4: Formerly STEM Major (Changed Major and Enrolled, Deferred, or on Leave of Absence)

Start of Block: Introduction

Q1.1
This survey has been designed to help us understand factors influencing student experience while studying science, technology, engineering, and mathematics (STEM) at BYU. As a student of BYU who was formerly enrolled in a STEM program, your feedback is very valuable to us. The results of this study will be used to identify areas of possible improvement for future semesters. Responses will be kept confidential. This survey should take about 10 to 15 minutes to complete.

Be sure to complete the survey for a chance to win $25 Cougar Cash (or gift card) and some BYU SWAG!!

We value your feedback and appreciate your time!
Odds of winning are estimated to be 15 to 2350.

End of Block: Introduction

Start of Block: Math Self-Concept Questionnaire - Final

Q2.1 The following items are a series of statements that are more or less true (or more or less false) descriptions of you. Please use the following eight-point response scale to indicate how true (or false) each item is as a description of you. Respond to the items as you now feel even if you felt differently at some other time in your life. In a few instances, an item may no longer be appropriate to you, though it was at an earlier period of your life. In such cases, respond to the item as you would have when it was appropriate. Try to avoid leaving any items blank.

Q2.2 I find many mathematical problems interesting and challenging.
Indicate how true or false the description is of you.

- Definitely False (1)
- False (2)
- Mostly False (3)
- More False Than True (4)
- More True Than False (5)
- Mostly True (6)
- True (7)
- Definitely True (8)
Q2.3 I have hesitated to take courses that involve mathematics. 
*Indicate how true or false the description is of you.*

- Definitely False (1)
- False (2)
- Mostly False (3)
- More False Than True (4)
- More True Than False (5)
- Mostly True (6)
- True (7)
- Definitely True (8)

Q2.4 I have generally done better in mathematics courses than other courses. 
*Indicate how true or false the description is of you.*

- Definitely False (1)
- False (2)
- Mostly False (3)
- More False Than True (4)
- More True Than False (5)
- Mostly True (6)
- True (7)
- Definitely True (8)
Q2.5 Mathematics makes me feel inadequate.
*Indicate how true or false the description is of you.*

- Definitely False (1)
- False (2)
- Mostly False (3)
- More False Than True (4)
- More True Than False (5)
- Mostly True (6)
- True (7)
- Definitely True (8)

Q2.6 I am quite good at mathematics.
*Indicate how true or false the description is of you.*

- Definitely False (1)
- False (2)
- Mostly False (3)
- More False Than True (4)
- More True Than False (5)
- Mostly True (6)
- True (7)
- Definitely True (8)
Q2.7 I have trouble understanding anything that is based upon mathematics. 
*Indicate how true or false the description is of you.*

- Definitely False (1)
- False (2)
- Mostly False (3)
- More False Than True (4)
- More True Than False (5)
- Mostly True (6)
- True (7)
- Definitely True (8)

Q2.8 I have always done well in mathematics courses. 
*Indicate how true or false the description is of you.*

- Definitely False (1)
- False (2)
- Mostly False (3)
- More False Than True (4)
- More True Than False (5)
- Mostly True (6)
- True (7)
- Definitely True (8)
Q2.9 I never do well on tests that require mathematical reasoning. 
*Indicate how true or false the description is of you.*

- Definitely False (1)
- False (2)
- Mostly False (3)
- More False Than True (4)
- More True Than False (5)
- Mostly True (6)
- True (7)
- Definitely True (8)

Q2.10 At school, my friends always came to me for help in mathematics. 
*Indicate how true or false the description is of you.*

- Definitely False (1)
- False (2)
- Mostly False (3)
- More False Than True (4)
- More True Than False (5)
- Mostly True (6)
- True (7)
- Definitely True (8)
Q2.11 I have never been excited about mathematics.  
*Indicate how true or false the description is of you.*

- [ ] Definitely False (1)
- [ ] False (2)
- [ ] Mostly False (3)
- [ ] More False Than True (4)
- [ ] More True Than False (5)
- [ ] Mostly True (6)
- [ ] True (7)
- [ ] Definitely True (8)

---

Start of Block: Math Self-Efficacy Questionnaire - Part A

Q3.1 For the following items, please **indicate your confidence in your ability to successfully perform the task.**

You are not asked to complete the task, only to indicate your confidence in your ability to successfully perform the task. As an example, if the item states, "divide two large numbers (8246 ÷ 2431) in your head," you are not asked to actually divide the two numbers to find an answer, but simply respond how confident you are in your ability to successfully perform that task.

---

Q3.2 Use appropriate technology to solve mathematical problems

*Please indicate your confidence in your ability to successfully perform the task.*

<table>
<thead>
<tr>
<th>No Confidence at All</th>
<th>Neutral</th>
<th>Complete Confidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 2 3 4 5 6 7 8 9</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

---
Q3.3 Determine how much interest you will end up paying on a $675 loan over 2 years at 14 ¾% interest.

Please indicate your confidence in your ability to successfully perform the task.

No Confidence at All | Neutral | Complete Confidence

1 2 3 4 5 6 7 8 9

0

Q3.4 Figure out how much lumber you need to buy in order to build a set of bookshelves.

Please indicate your confidence in your ability to successfully perform the task.

No Confidence at All | Neutral | Complete Confidence

1 2 3 4 5 6 7 8 9

0

Q3.5 Compute your income taxes for the year.

Please indicate your confidence in your ability to successfully perform the task.

No Confidence at All | Neutral | Complete Confidence

1 2 3 4 5 6 7 8 9

0
Q3.6 Figure out how much material to buy in order to make curtains
*Please indicate your confidence in your ability to successfully perform the task.*

<table>
<thead>
<tr>
<th>No Confidence at All</th>
<th>Neutral</th>
<th>Complete Confidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 2 3 4 5 6 7 8 9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Q3.7 Understand a graph accompanying an article on business profits
*Please indicate your confidence in your ability to successfully perform the task.*

<table>
<thead>
<tr>
<th>No Confidence at All</th>
<th>Neutral</th>
<th>Complete Confidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 2 3 4 5 6 7 8 9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Q3.8 Understand how much interest you will earn on your savings account in 6 months, and how the interest is computed
*Please indicate your confidence in your ability to successfully perform the task.*

<table>
<thead>
<tr>
<th>No Confidence at All</th>
<th>Neutral</th>
<th>Complete Confidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 2 3 4 5 6 7 8 9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Q3.9 Add two large numbers (e.g., 5739 + 62543) in your head

*Please indicate your confidence in your ability to successfully perform the task.*

<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Q3.10 Estimate your grocery bill in your head as you pick up items

*Please indicate your confidence in your ability to successfully perform the task.*

<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
</tbody>
</table>

Q3.11 Determine the amount of sales tax on a clothing purchase

*Please indicate your confidence in your ability to successfully perform the task.*

<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Q3.12 Figure out the tip on your part of a dinner bill split 8 ways
*Please indicate your confidence in your ability to successfully perform the task.*

<table>
<thead>
<tr>
<th>No Confidence at All</th>
<th>Neutral</th>
<th>Complete Confidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 2 3 4 5 6 7 8 9</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

0

Q3.13 Figure out how long it will take to travel from city A to city B driving 55 mph
*Please indicate your confidence in your ability to successfully perform the task.*

<table>
<thead>
<tr>
<th>No Confidence at All</th>
<th>Neutral</th>
<th>Complete Confidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 2 3 4 5 6 7 8 9</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

0

Q3.14 Compute your car's gas mileage
*Please indicate your confidence in your ability to successfully perform the task.*

<table>
<thead>
<tr>
<th>No Confidence at All</th>
<th>Neutral</th>
<th>Complete Confidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 2 3 4 5 6 7 8 9</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

0
Q3.15 Set up a monthly budget by yourself
*Please indicate your confidence in your ability to successfully perform the task.*

<table>
<thead>
<tr>
<th>No Confidence at All</th>
<th>Neutral</th>
<th>Complete Confidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 2 3 4 5 6 7 8 9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Q3.16 Reconcile your bank account without a mistake
*Please indicate your confidence in your ability to successfully perform the task.*

<table>
<thead>
<tr>
<th>No Confidence at All</th>
<th>Neutral</th>
<th>Complete Confidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 2 3 4 5 6 7 8 9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Q3.17 Figure out which of two summer jobs is the better offer; one with higher salary but no benefits, the other with a lower salary plus room, board, and travel expenses
*Please indicate your confidence in your ability to successfully perform the task.*

<table>
<thead>
<tr>
<th>No Confidence at All</th>
<th>Neutral</th>
<th>Complete Confidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 2 3 4 5 6 7 8 9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Q3.18 Figure out how much you would save if there is a 15% markdown on an item you wish to buy. 
*Please indicate your confidence in your ability to successfully perform the task.*

<table>
<thead>
<tr>
<th>No Confidence at All</th>
<th>Neutral</th>
<th>Complete Confidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 2 3 4 5 6 7 8 9</td>
<td></td>
<td></td>
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</tbody>
</table>

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Q3.19 Calculate recipe quantities for a dinner for 41 when the original recipe is for 12 people. 
*Please indicate your confidence in your ability to successfully perform the task.*

<table>
<thead>
<tr>
<th>No Confidence at All</th>
<th>Neutral</th>
<th>Complete Confidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 2 3 4 5 6 7 8 9</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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End of Block: Math Self-Efficacy Questionnaire - Part A

Start of Block: Math Self-Efficacy Questionnaire - Part B
Q4.1 For each course listed below, indicate your confidence in your ability to successfully complete the course.

<table>
<thead>
<tr>
<th>Course</th>
<th>No Confidence at All</th>
<th>Neutral</th>
<th>Complete Confidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Advanced Calculus ()</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Philosophy ()</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Biochemistry ()</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Statistics ()</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Computer Science ()</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Physiology ()</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trigonometry ()</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Economics ()</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Zoology ()</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Accounting ()</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Business Administration ()</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Geometry ()</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Algebra II ()</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Calculus ()</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Algebra I ()</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Basic College Math ()</td>
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</tbody>
</table>
Q4.2 For each course listed below, indicate the amount of mathematics you believe you would encounter while taking the course.

<table>
<thead>
<tr>
<th>Course</th>
<th>None</th>
<th>Very Little</th>
<th>Some</th>
<th>A Moderate Amount</th>
<th>An Extensive Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Advanced Calculus ()</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Philosophy ()</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Biochemistry ()</td>
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<tr>
<td>Statistics ()</td>
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<tr>
<td>Computer Science ()</td>
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<td>Physiology ()</td>
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<tr>
<td>Trigonometry ()</td>
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<td>Economics ()</td>
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<td>Zoology ()</td>
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<td>Accounting ()</td>
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<tr>
<td>Business Administration ()</td>
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<tr>
<td>Geometry ()</td>
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<tr>
<td>Algebra II ()</td>
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<tr>
<td>Calculus ()</td>
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<td></td>
</tr>
<tr>
<td>Algebra I ()</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Basic College Math ()</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

End of Block: Math Self-Efficacy Questionnaire - Part B

Start of Block: Math Experience
Q5.1 Rate your level of agreement with each statement below regarding your high school experience.

<table>
<thead>
<tr>
<th>Statement</th>
<th>Strongly Disagree (1)</th>
<th>Disagree (2)</th>
<th>Neither Agree nor Disagree (3)</th>
<th>Agree (4)</th>
<th>Strongly Agree (5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I felt confident in my ability to do well in my last high school math class.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I enjoyed my last high school math class.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I did well in my last high school math class.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Q5.2 In high school, did you participate in honors, plus, or AP courses related to mathematics?

- Yes (1)
- No (2)

Q5.3 Rate your level of agreement with each statement below regarding your college experience.

<table>
<thead>
<tr>
<th>Statement</th>
<th>Strongly Disagree (1)</th>
<th>Disagree (2)</th>
<th>Neither Agree nor Disagree (3)</th>
<th>Agree (4)</th>
<th>Strongly Agree (5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I felt confident in my ability to do well in my most recent college math class.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I enjoyed my most recent college math class.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I did well in my most recent college math class.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

End of Block: Math Experience

Start of Block: Demographic
Q6.1 What is the highest level of education obtained by your mother/female parental guardian?

- Less than high school degree (1)
- High school graduate (high school diploma or equivalent including GED) (2)
- Some college but no degree (3)
- Associate degree in college (2-year) (4)
- Bachelor's degree in college (4-year) (5)
- Master's degree (6)
- Doctoral degree (7)
- Professional degree (JD, MD) (8)

Q6.2 What is the highest level of education obtained by your father/male parental guardian?

- Less than high school degree (1)
- High school graduate (high school diploma or equivalent including GED) (2)
- Some college but no degree (3)
- Associate degree in college (2-year) (4)
- Bachelor's degree in college (4-year) (5)
- Master's degree (6)
- Doctoral degree (7)
- Professional degree (JD, MD) (8)

Q6.3 Did one or more of your parents/parental guardians study STEM (science, technology, engineering, mathematics) during college?

- Yes (1)
- No (2)

Display This Question:

If Did one or more of your parents/parental guardians study STEM (science, technology, engineering,... = Yes
Q6.4 If yes, please select which one(s) **studied** STEM. *Select all that apply.*

- [ ] Mother (1)
- [ ] Father (2)
- [ ] Stepmother (3)
- [ ] Stepfather (4)
- [ ] Other (5) ______________________________________

Q6.5 Did one or more of your parents/parental guardians **work** in a STEM (science, technology, engineering, mathematics) field during their career?

- [ ] Yes (1)
- [ ] No (2)

---

Display This Question:

*If Did one or more of your parents/parental guardians work in a STEM (science, technology, engineering, mathematics) field during their career = Yes*

Q6.6 If yes, please select which one(s) **worked** in a STEM field. *Select all that apply.*

- [ ] Mother (1)
- [ ] Father (2)
- [ ] Stepmother (3)
- [ ] Stepfather (4)
- [ ] Other (5) ______________________________________
Q6.7 Have you served a mission for the Church of Jesus Christ of Latter-day Saints?

- Yes (1)
- No (2)

Display This Question:

If Have you served a mission for the Church of Jesus Christ of Latter-day Saints? = Yes

Q6.8 During what year(s) did you serve a mission? Select all that apply.

- Prior to 2012 (1)
- 2012 (2)
- 2013 (3)
- 2014 (4)
- 2015 (5)
- 2016 (6)
- 2017 (7)
- 2018 (8)
- 2019 (9)
- 2020 (10)
- 2021 (11)
- 2022 (12)
Q6.9 The following items reference your experience in your previous major ($\text{Field/previous_stem_major}$) within the College of $\text{Field/previous_stem_college}$.

Q6.10 To what degree did you struggle to pay for college during the times specified below?

<table>
<thead>
<tr>
<th>When you first enrolled in $\text{Field/previous_stem_major}$</th>
<th>Not at All (1)</th>
<th>A Little (2)</th>
<th>A Moderate Amount (3)</th>
<th>A Lot (4)</th>
<th>A Great Deal (5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>When you left $\text{Field/previous_stem_major}$</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Current degree of struggle to pay for college (7)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Q6.11 Please select your marital status during the times specified below.

<table>
<thead>
<tr>
<th>When you first enrolled in $\text{Field/previous_stem_major}$</th>
<th>Never Married (1)</th>
<th>Married (2)</th>
<th>Widowed (3)</th>
<th>Divorced (4)</th>
<th>Separated (5)</th>
<th>Prefer Not to Answer (6)</th>
</tr>
</thead>
<tbody>
<tr>
<td>When you left $\text{Field/previous_stem_major}$</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Current marital status (5)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Q6.12 Please select the number of dependents you had during the times specified below.

<table>
<thead>
<tr>
<th></th>
<th>0 (1)</th>
<th>1 (2)</th>
<th>2 (3)</th>
<th>3 (4)</th>
<th>4 (5)</th>
<th>5 or more (6)</th>
<th>Prefer Not to Answer (7)</th>
</tr>
</thead>
<tbody>
<tr>
<td>When you first enrolled in ${e://Field/previous_stem_major}$ (1)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>When you left ${e://Field/previous_stem_major}$ (3)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Current number of dependents (5)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

End of Block: Demographic

Start of Block: Experience in Program

Q7.1 To the best of your knowledge, how many credits had you completed in your previous major (${e://Field/previous_stem_major}$) when you changed majors? (Only estimate credits required for your program, not including GE credits)

Q7.2 Did you ever participate in research with a faculty member in the College of ${e://Field/previous_stem_college}$?

- Yes (1)
- No (2)

Display This Question:

If previous_stem_college = Engineering

Q7.3 Did you ever participate in the Women in Engineering (WE) Research Mentorship Program or the BYU Engineering Together (BE Together) Research Mentorship Program through the College of Engineering?

- Yes (1)
- No (2)
Q7.4 During your time in $\text{iField/previous_stem_major}$, were you involved in any clubs or associations related to your field of study?

- Yes (1)
- No (2)

Q7.5 During your time in $\text{iField/previous_stem_major}$, did you have a mentor that helped provide guidance, motivation, and/or emotional support related to your field of study?

- Yes (1)
- No (2)

Q7.6 During your time in $\text{iField/previous_stem_major}$, did you have a role model in your field of study?

- Yes (1)
- No (2)

Q7.7 Please rate your experience with faculty in $\text{iField/previous_stem_major}$.

<table>
<thead>
<tr>
<th>Negative Experience</th>
<th>Positive Experience</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>

Q7.8 Describe why you gave the rating you did. (Optional)

__________________________________________________
__________________________________________________
__________________________________________________

__________________________________________________
Q7.9 Please rate your experience with male students in $\text{previous_stem_major}$.

<table>
<thead>
<tr>
<th>Negative Experience</th>
<th>Positive Experience</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>

Describe why you gave the rating you did. *(Optional)*

________________________________________________________________
________________________________________________________________
________________________________________________________________
________________________________________________________________
________________________________________________________________

Q7.11 Please rate your experience with female students in $\text{previous_stem_major}$.

<table>
<thead>
<tr>
<th>Negative Experience</th>
<th>Positive Experience</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>

Describe why you gave the rating you did. *(Optional)*

________________________________________________________________
________________________________________________________________
________________________________________________________________
________________________________________________________________
________________________________________________________________

Q7.13 Please describe what led to your original decision to enroll in $\text{previous_stem_major}$ within the College of $\text{previous_stem_college}$.  
________________________________________________________________
________________________________________________________________
________________________________________________________________
________________________________________________________________
Q7.14 Please describe what led to your decision to leave ${e://Field/previous_stem_major}.

________________________________________________________________
________________________________________________________________
________________________________________________________________
________________________________________________________________
________________________________________________________________

Q7.15 Is there anything else you would like to tell us that would help us improve the experience for students in the College of ${e://Field/previous_stem_college} in the future? (Optional)

________________________________________________________________
________________________________________________________________
________________________________________________________________
________________________________________________________________

End of Block: Experience in Program

Start of Block: End

Q8.1 Would you be willing to participate in a follow-up interview to help us understand more about your experience?

☐ Yes (1)
☐ No (2)

Display This Question:

If Would you be willing to participate in a follow-up interview to help us understand more about you... = Yes

Q8.2 If yes, please enter your name and email address below. Your previous responses will still be kept confidential.

☐ First Name (1) __________________________________________________
☐ Last Name (2) _________________________________________________
☐ Email Address (3) _____________________________________________

Q8.3 Would you like to be redirected to enter the raffle to win a $25 Cougar Cash prize or gift card and BYU SWAG? Your responses will still be kept confidential.

☐ Yes (1)
☐ No (2)

End of Block: End
Survey 5: STEM Major (Left the University and Would Have to Reapply to Return)

Start of Block: Introduction

Q1.1
This survey has been designed to help us understand factors influencing student experience while studying science, technology, engineering, and mathematics (STEM) at BYU. As a formerly enrolled STEM student, your feedback is very valuable to us. The results of this study will be used to identify areas of possible improvement for future semesters. Responses will be kept confidential. This survey should take about 10 to 15 minutes to complete.

Be sure to complete the survey for a chance to win a $25 gift card and some BYU SWAG!!

We value your feedback and appreciate your time!
Odds of winning are estimated to be 15 to 2350.

End of Block: Introduction

Start of Block: Math Self-Concept Questionnaire - Final

Q1 The following items are a series of statements that are more or less true (or more or less false) descriptions of you. Please use the following eight-point response scale to indicate how true (or false) each item is as a description of you. Respond to the items as you now feel even if you felt differently at some other time in your life. In a few instances, an item may no longer be appropriate to you, though it was at an earlier period of your life. In such cases, respond to the item as you would have when it was appropriate. Try to avoid leaving any items blank.

Q2 I find many mathematical problems interesting and challenging.

Indicate how true or false the description is of you.

- Definitely False (1)
- False (2)
- Mostly False (3)
- More False Than True (4)
- More True Than False (5)
- Mostly True (6)
- True (7)
- Definitely True (8)
Q3 I have hesitated to take courses that involve mathematics. 
*Indicate how true or false the description is of you.*
- Definitely False (1)
- False (2)
- Mostly False (3)
- More False Than True (4)
- More True Than False (5)
- Mostly True (6)
- True (7)
- Definitely True (8)

Q4 I have generally done better in mathematics courses than other courses. 
*Indicate how true or false the description is of you.*
- Definitely False (1)
- False (2)
- Mostly False (3)
- More False Than True (4)
- More True Than False (5)
- Mostly True (6)
- True (7)
- Definitely True (8)
Q5 Mathematics makes me feel inadequate.

*Indicate how true or false the description is of you.*

- Definitely False (1)
- False (2)
- Mostly False (3)
- More False Than True (4)
- More True Than False (5)
- Mostly True (6)
- True (7)
- Definitely True (8)

---

Q6 I am quite good at mathematics.

*Indicate how true or false the description is of you.*

- Definitely False (1)
- False (2)
- Mostly False (3)
- More False Than True (4)
- More True Than False (5)
- Mostly True (6)
- True (7)
- Definitely True (8)

---
Q7 I have trouble understanding anything that is based upon mathematics.

Indicate how true or false the description is of you.

- Definitely False (1)
- False (2)
- Mostly False (3)
- More False Than True (4)
- More True Than False (5)
- Mostly True (6)
- True (7)
- Definitely True (8)

Q8 I have always done well in mathematics courses.

Indicate how true or false the description is of you.

- Definitely False (1)
- False (2)
- Mostly False (3)
- More False Than True (4)
- More True Than False (5)
- Mostly True (6)
- True (7)
- Definitely True (8)
Q9 I never do well on tests that require mathematical reasoning. 
Indicate how true or false the description is of you.

- Definitely False (1)
- False (2)
- Mostly False (3)
- More False Than True (4)
- More True Than False (5)
- Mostly True (6)
- True (7)
- Definitely True (8)

Q10 At school, my friends always came to me for help in mathematics. 
Indicate how true or false the description is of you.

- Definitely False (1)
- False (2)
- Mostly False (3)
- More False Than True (4)
- More True Than False (5)
- Mostly True (6)
- True (7)
- Definitely True (8)
Q11 I have never been excited about mathematics. 
Indicate how true or false the description is of you.

- Definitely False (1)
- False (2)
- Mostly False (3)
- More False Than True (4)
- More True Than False (5)
- Mostly True (6)
- True (7)
- Definitely True (8)

End of Block: Math Self-Concept Questionnaire - Final

Start of Block: Math Self-Efficacy Questionnaire - Part A

Q1 For the following items, please indicate your confidence in your ability to successfully perform the task. You are not asked to complete the task, only to indicate your confidence in your ability to successfully perform the task. As an example, if the item states, "divide two large numbers (8246 ÷ 2431) in your head," you are not asked to actually divide the two numbers to find an answer, but simply respond how confident you are in your ability to successfully perform that task.

Q2 Use appropriate technology to solve mathematical problems
Please indicate your confidence in your ability to successfully perform the task.

<table>
<thead>
<tr>
<th>No Confidence at All</th>
<th>Neutral</th>
<th>Complete Confidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 2 3 4 5 6 7 8 9</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

0
Q3 Determine how much interest you will end up paying on a $675 loan over 2 years at 14 ¾% interest

Please indicate your confidence in your ability to successfully perform the task.

<table>
<thead>
<tr>
<th>No Confidence at All</th>
<th>Neutral</th>
<th>Complete Confidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 2 3 4 5 6 7 8 9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Q4 Figure out how much lumber you need to buy in order to build a set of bookshelves

Please indicate your confidence in your ability to successfully perform the task.

<table>
<thead>
<tr>
<th>No Confidence at All</th>
<th>Neutral</th>
<th>Complete Confidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 2 3 4 5 6 7 8 9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Q5 Compute your income taxes for the year

Please indicate your confidence in your ability to successfully perform the task.

<table>
<thead>
<tr>
<th>No Confidence at All</th>
<th>Neutral</th>
<th>Complete Confidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 2 3 4 5 6 7 8 9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Q6 Figure out how much material to buy in order to make curtains
*Please indicate your confidence in your ability to successfully perform the task.*

<table>
<thead>
<tr>
<th>No Confidence at All</th>
<th>Neutral</th>
<th>Complete Confidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>4</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>7</td>
<td>8</td>
<td>9</td>
</tr>
</tbody>
</table>

Q7 Understand a graph accompanying an article on business profits
*Please indicate your confidence in your ability to successfully perform the task.*

<table>
<thead>
<tr>
<th>No Confidence at All</th>
<th>Neutral</th>
<th>Complete Confidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>4</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>7</td>
<td>8</td>
<td>9</td>
</tr>
</tbody>
</table>

Q8 Understand how much interest you will earn on your savings account in 6 months, and how the interest is computed
*Please indicate your confidence in your ability to successfully perform the task.*

<table>
<thead>
<tr>
<th>No Confidence at All</th>
<th>Neutral</th>
<th>Complete Confidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>4</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>7</td>
<td>8</td>
<td>9</td>
</tr>
</tbody>
</table>
Q9 Add two large numbers (e.g., 5739 + 62543) in your head
*Please indicate your confidence in your ability to successfully perform the task.*

<table>
<thead>
<tr>
<th>No Confidence at All</th>
<th>Neutral</th>
<th>Complete Confidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 2 3 4 5 6 7 8 9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Q10 Estimate your grocery bill in your head as you pick up items
*Please indicate your confidence in your ability to successfully perform the task.*

<table>
<thead>
<tr>
<th>No Confidence at All</th>
<th>Neutral</th>
<th>Complete Confidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 2 3 4 5 6 7 8 9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Q11 Determine the amount of sales tax on a clothing purchase
*Please indicate your confidence in your ability to successfully perform the task.*

<table>
<thead>
<tr>
<th>No Confidence at All</th>
<th>Neutral</th>
<th>Complete Confidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 2 3 4 5 6 7 8 9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Q12 Figure out the tip on your part of a dinner bill split 8 ways
*Please indicate your confidence in your ability to successfully perform the task.*

<table>
<thead>
<tr>
<th>No Confidence at All</th>
<th>Neutral</th>
<th>Complete Confidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 2 3 4 5 6 7 8 9</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Q13 Figure out how long it will take to travel from city A to city B driving 55 mph
*Please indicate your confidence in your ability to successfully perform the task.*

<table>
<thead>
<tr>
<th>No Confidence at All</th>
<th>Neutral</th>
<th>Complete Confidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 2 3 4 5 6 7 8 9</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Q14 Compute your car's gas mileage
*Please indicate your confidence in your ability to successfully perform the task.*

<table>
<thead>
<tr>
<th>No Confidence at All</th>
<th>Neutral</th>
<th>Complete Confidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 2 3 4 5 6 7 8 9</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Q15 Set up a monthly budget by yourself
*Please indicate your confidence in your ability to successfully perform the task.*

<table>
<thead>
<tr>
<th>No Confidence at All</th>
<th>Neutral</th>
<th>Complete Confidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 2 3 4 5 6 7 8 9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Q16 Reconcile your bank account without a mistake
*Please indicate your confidence in your ability to successfully perform the task.*

<table>
<thead>
<tr>
<th>No Confidence at All</th>
<th>Neutral</th>
<th>Complete Confidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 2 3 4 5 6 7 8 9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Q17 Figure out which of two summer jobs is the better offer; one with higher salary but no benefits, the other with a lower salary plus room, board, and travel expenses
*Please indicate your confidence in your ability to successfully perform the task.*

<table>
<thead>
<tr>
<th>No Confidence at All</th>
<th>Neutral</th>
<th>Complete Confidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 2 3 4 5 6 7 8 9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Q18 Figure out how much you would save if there is a 15% markdown on an item you wish to buy

*Please indicate your confidence in your ability to successfully perform the task.*

<table>
<thead>
<tr>
<th>No Confidence at All</th>
<th>Neutral</th>
<th>Complete Confidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 2 3 4 5 6 7 8 9</td>
<td></td>
<td></td>
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<tr>
<td>0</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Q19 Calculate recipe quantities for a dinner for 41 when the original recipe is for 12 people

*Please indicate your confidence in your ability to successfully perform the task.*

<table>
<thead>
<tr>
<th>No Confidence at All</th>
<th>Neutral</th>
<th>Complete Confidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 2 3 4 5 6 7 8 9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Q1 For each course listed below, indicate your confidence in your ability to successfully complete the course.

<table>
<thead>
<tr>
<th>Course</th>
<th>No Confidence at All</th>
<th>Neutral</th>
<th>Complete Confidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Advanced Calculus ()</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Philosophy ()</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Biochemistry ()</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Statistics ()</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Computer Science ()</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Physiology ()</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trigonometry ()</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Economics ()</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Zoology ()</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Accounting ()</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Business Administration ()</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Geometry ()</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Algebra II ()</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Calculus ()</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Algebra I ()</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Basic College Math ()</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Q2 For each course listed below, indicate the amount of mathematics you believe you would encounter while taking the course.

<table>
<thead>
<tr>
<th>Course</th>
<th>None</th>
<th>Very Little</th>
<th>Some</th>
<th>A Moderate Amount</th>
<th>An Extensive Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Advanced Calculus ()</td>
<td></td>
<td></td>
<td>3</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Philosophy ()</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Biochemistry ()</td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Statistics ()</td>
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</tr>
<tr>
<td>Computer Science ()</td>
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<tr>
<td>Physiology ()</td>
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<tr>
<td>Trigonometry ()</td>
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<tr>
<td>Economics ()</td>
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<tr>
<td>Business Administration ()</td>
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<tr>
<td>Geometry ()</td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Algebra II ()</td>
<td></td>
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<tr>
<td>Calculus ()</td>
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<td></td>
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<td></td>
</tr>
<tr>
<td>Basic College Math ()</td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
</tbody>
</table>

End of Block: Math Self-Efficacy Questionnaire - Part B

Start of Block: Math Experience
Q4.1 Rate your level of agreement with each statement below regarding your high school experience.

<table>
<thead>
<tr>
<th></th>
<th>Strongly Disagree (1)</th>
<th>Disagree (2)</th>
<th>Neither Agree nor Disagree (3)</th>
<th>Agree (4)</th>
<th>Strongly Agree (5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I felt confident in my ability to do well in my last high school math class. (2)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I enjoyed my last high school math class. (1)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I did well in my last high school math class. (3)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Q4.2 In high school, did you participate in honors, plus, or AP courses related to mathematics?

- Yes (1)
- No (2)

Q4.3 Rate your level of agreement with each statement below regarding your college experience.

<table>
<thead>
<tr>
<th></th>
<th>Strongly Disagree (1)</th>
<th>Disagree (2)</th>
<th>Neither Agree nor Disagree (3)</th>
<th>Agree (4)</th>
<th>Strongly Agree (5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I felt confident in my ability to do well in my most recent college math class. (2)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I enjoyed my most recent college math class. (1)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I did well in my most recent college math class. (3)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

End of Block: Math Experience

Start of Block: Demographic
Q5.1 What is the highest level of education obtained by your mother/female parental guardian?

- Less than high school degree (1)
- High school graduate (high school diploma or equivalent including GED) (2)
- Some college but no degree (3)
- Associate degree in college (2-year) (4)
- Bachelor's degree in college (4-year) (5)
- Master's degree (6)
- Doctoral degree (7)
- Professional degree (JD, MD) (8)

Q5.2 What is the highest level of education obtained by your father/male parental guardian?

- Less than high school degree (1)
- High school graduate (high school diploma or equivalent including GED) (2)
- Some college but no degree (3)
- Associate degree in college (2-year) (4)
- Bachelor's degree in college (4-year) (5)
- Master's degree (6)
- Doctoral degree (7)
- Professional degree (JD, MD) (8)

Q5.3 Did one or more of your parents/parental guardians study STEM (science, technology, engineering, mathematics) during college?

- Yes (1)
- No (2)

Display This Question:
If Did one or more of your parents/parental guardians study STEM (science, technology, engineering,... = Yes
Q5.4 If yes, please select which one(s) **studied** STEM. *Select all that apply.*

- [ ] Mother (1)
- [ ] Father (2)
- [ ] Stepmother (3)
- [ ] Stepfather (4)
- [ ] Other (5) __________________________________________

Q5.5 Did one or more of your parents/parental guardians **work** in a STEM (science, technology, engineering, mathematics) field during their career?

- [ ] Yes (1)
- [ ] No (2)

---

**Display This Question:**

- If Did one or more of your parents/parental guardians work in a STEM (science, technology, engineering, mathematics) field during their career? = Yes

---

Q5.6 If yes, please select which one(s) **worked** in a STEM field. *Select all that apply.*

- [ ] Mother (1)
- [ ] Father (2)
- [ ] Stepmother (3)
- [ ] Stepfather (4)
- [ ] Other (5) __________________________________________
Q5.7 Have you served a mission for the Church of Jesus Christ of Latter-day Saints?

- Yes (1)
- No (2)

Display This Question:
If Have you served a mission for the Church of Jesus Christ of Latter-day Saints? = Yes

Q5.8 During what year(s) did you serve a mission? Select all that apply.

- Prior to 2012 (1)
- 2012 (2)
- 2013 (3)
- 2014 (4)
- 2015 (5)
- 2016 (6)
- 2017 (7)
- 2018 (8)
- 2019 (9)
- 2020 (10)
- 2021 (11)
- 2022 (15)
Q5.9 The following items reference your experience in `{e://Field/current_major}` within the College of `{e://Field/current_college}`.

Q230 To what degree did you struggle to pay for college during the times specified below?

<table>
<thead>
<tr>
<th></th>
<th>Not at All (1)</th>
<th>A Little (2)</th>
<th>A Moderate Amount (3)</th>
<th>A Lot (4)</th>
<th>A Great Deal (5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>When you first enrolled in <code>{e://Field/current_major}</code> (1)</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>During your last semester enrolled in <code>{e://Field/current_major}</code> (3)</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Current degree of struggle to pay for college (7)</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
</tbody>
</table>

Q5.11 Please select your marital status during the times specified below.

<table>
<thead>
<tr>
<th></th>
<th>Never Married (1)</th>
<th>Married (2)</th>
<th>Widowed (3)</th>
<th>Divorced (4)</th>
<th>Separated (5)</th>
<th>Prefer Not to Answer (6)</th>
</tr>
</thead>
<tbody>
<tr>
<td>When you first enrolled in <code>{e://Field/current_major}</code> (1)</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>During your last semester enrolled in <code>{e://Field/current_major}</code> (3)</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Current marital status (5)</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
</tbody>
</table>
Q5.12 Please select the number of dependents you had during the times specified below.

<table>
<thead>
<tr>
<th>When you first enrolled in ${e://Field/current_major}$ (1)</th>
<th>0 (1)</th>
<th>1 (2)</th>
<th>2 (3)</th>
<th>3 (4)</th>
<th>4 (5)</th>
<th>5 or more (6)</th>
<th>Prefer Not to Answer (7)</th>
</tr>
</thead>
<tbody>
<tr>
<td>During your last semester enrolled in ${e://Field/current_major}$ (3)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Current number of dependents (5)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

End of Block: Demographic

Start of Block: Experience in Program

Q6.1 To the best of your knowledge, at the end of your last semester enrolled at BYU, how many credits had you completed in your major ($\{e://Field/current_major\}$)? (Only estimate credits required for your program, not including GE credits)

Q6.2 Did you ever participate in research with a faculty member in the College of $\{e://Field/current_college\}$?

- Yes (1)
- No (2)

Display This Question:

If current_college = Engineering

Q6.3 Have you ever participated in the Women in Engineering (WE) Research Mentorship Program or the BYU Engineering Together (BE Together) Research Mentorship Program through the College of Engineering?

- Yes (1)
- No (2)
Q6.4 During your time in $\{e://Field/current\_major\}$, were you involved in any clubs or associations related to your field of study?

- Yes (1)
- No (2)

Q6.5 During your time in $\{e://Field/current\_major\}$, did you have a mentor that helped provide guidance, motivation, and/or emotional support related to your field of study?

- Yes (1)
- No (2)

Q6.6 During your time in $\{e://Field/current\_major\}$, did you have a role model in your field of study?

- Yes (1)
- No (2)

Q6.7 Please rate your experience with **faculty** in $\{e://Field/current\_major\}$.

<table>
<thead>
<tr>
<th>Negative Experience</th>
<th>Positive Experience</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>

Q6.8 Describe why you gave the rating you did. *(Optional)*

________________________________________________________________
________________________________________________________________
________________________________________________________________
________________________________________________________________
Q226 Please rate your experience with male students in ${e://Field/current_major}.

<table>
<thead>
<tr>
<th>Negative Experience</th>
<th>Positive Experience</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>

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Q6.10 Describe why you gave the rating you did. *(Optional)*

________________________________________________________________
________________________________________________________________
________________________________________________________________
________________________________________________________________

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Q227 Please rate your experience with female students in ${e://Field/current_major}.

<table>
<thead>
<tr>
<th>Negative Experience</th>
<th>Positive Experience</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>

------------------

Q6.12 Describe why you gave the rating you did. *(Optional)*

________________________________________________________________
________________________________________________________________
________________________________________________________________
________________________________________________________________

------------------

Q6.13 Please describe what led to your original decision to enroll in ${e://Field/current_major} within the College of ${e://Field/current_college}.

________________________________________________________________
________________________________________________________________
________________________________________________________________
Q6.14 Please describe why you are not currently enrolled at BYU.

________________________________________________________________
________________________________________________________________
________________________________________________________________
________________________________________________________________
________________________________________________________________

Q7.1 Is there anything else you would like to tell us that would help us improve the experience for students in the College of $\{e://Field/current\_college\}$ in the future? (Optional)

________________________________________________________________
________________________________________________________________
________________________________________________________________
________________________________________________________________

End of Block: Experience in Program

Start of Block: End

Q7.2 Would you be willing to participate in a follow-up interview to help us understand more about your experience?

  o Yes (1)
  o No (2)

Display This Question:
If Would you be willing to participate in a follow-up interview to help us understand more about you... = Yes

Q7.3 If yes, please enter your name and email address below. Your previous responses will still be kept confidential.

  o First Name (1) __________________________________________________
  o Last Name (2) _________________________________________________
  o Email Address (3) _____________________________________________

Q7.4 Would you like to be redirected to enter the raffle to win a $25 gift card and BYU SWAG? Your responses will still be kept confidential.

  o Yes (1)
  o No (2)
DISSERTATION CONCLUSION

Low representation of women in math intensive areas of STEM remains an issue for postsecondary institutions, particularly with low enrollment of women in math intensive GEMP STEM majors and high attrition of women from STEM. Research demonstrates that this gap in representation is not due to a difference in ability in math between men and women, suggesting that variables such as math self-efficacy and math self-concept may be impacting both enrollment and retention. This research sought to investigate the relationships between MSE, MSC, and gender with enrollment in GEMP STEM majors and retention in STEM as well as the impact of math saturation in STEM programs on retention in STEM.

Results from the two studies demonstrated that MSE is a significant predictor in both GEMP STEM enrollment and retention in STEM. Higher levels of MSE were positively associated with a higher likelihood of being retained in STEM and positively associated with a higher likelihood of being enrolled in GEMP STEM compared to non-GEMP STEM.

Gender was also significant in both models and showed that even after adjusting for other variables in both models, there remains a gender component that impacts both enrollment in GEMP STEM and retention in STEM.

MSC was not significant with regard to STEM retention but was significant in the GEMP STEM enrollment model. Unadjusted relationships showed in preliminary analysis that MSC was positively associated with a higher likelihood of being enrolled in GEMP STEM compared to non-GEMP STEM; however, adjusted relationships in the final model showed a negative association with higher levels of MSC indicating a lower likelihood of being enrolled in GEMP STEM compared to non-GEMP STEM.
Math saturation was investigated due to the link between low enrollment and high attrition in the math intensive GEMP STEM areas. It was not included as a predictor in the GEMP STEM enrollment model due to its connection to GEMP STEM with almost all programs above 50% math saturation designated as GEMP STEM and those below as non-GEMP STEM; however, it was included in the STEM retention model and proved to be significant. Increases in math saturation were shown to be linked to a higher likelihood of not retaining in STEM, indicating that programs with higher math saturation were more likely to have higher rates of attrition.

Also noteworthy was the link between several program related variables and retention in STEM. Research participation, club engagement, faculty ratings, and male peer ratings were all significant and positively associated links to a higher likelihood of being retained in STEM. This highlights variables that faculty and administrators in postsecondary institutions have the ability to influence. Programs and interventions can be designed to improve math self-efficacy. Students can be encouraged and provided more opportunity to be involved in research and participate in clubs. Faculty and peers can be trained on the importance of interactions with females in their programs. Some of the program experience variables were significant indicators of GEMP STEM enrollment as well such as faculty ratings, female peer ratings, and having a mentor in their field of study. These all had a positive association with a higher likelihood of being enrolled in GEMP STEM.

Overall, these findings solidify the connection between mathematics and enrollment in GEMP STEM and retention in STEM. The issue with enrollment and retention goes beyond ability in math and bleeds into math self-efficacy and math saturation of a program with additional impact coming from gender alone. This research highlights the need to focus on math
self-efficacy and further emphasizes the link between mathematics and representation of women in these areas. Ideally, this research will motivate those within postsecondary institutions to further investigate this connection and identify methods to improve MSE as a means to reduce the gap in representation of women in math intensive areas of STEM.