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# Steminism: Analyzing Factors That Improve Retention of Women in STEM

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Abstract

Our co-authored research ‘Steminism: Analyzing Factors That Improve Retention for Women as STEM Majors’ analyzed factors that contributed to the retention of women in science, technology, engineering, and mathematics (STEM) programs at Missouri University of Science & Technology (Missouri S&T). Women make up half of the US population, and while careers in (STEM) are an integral part of the US economy, women are underrepresented in these career fields. The purpose of our dissertation is to address the underrepresentation of women in STEM majors. Our methodology included homogeneous sampling to collect qualitative data. More specifically, we consulted with academic advisors and admissions staff to identify women with at least 48 credit hours and completed four semesters of STEM majors at Missouri University of Science and Technology (Missouri S&T). We then conducted a basic qualitative study using a purposeful sampling approach. We examined the student’s perceptions of (1) early access programs, (2) the importance of arts integration, (3) and the impact of extracurricular activities as tools for retention and found that the major factors that inhibit the retention of women in STEM is the shortcoming of achieving communal goal congruence. All interviews were conducted with Zoom, and Ottr software was used to transcribe the data. Solution-focused, our research affirmed that to achieve communal goal congruence, students participated in extracurricular activities, student life, and work-study. As practitioners, we used our co-authored research to develop *EmpowHer: A Steminist Guide to Cultural Border Crossing*, a manual for administrators in higher education and prospective STEM students.

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## Chapter 1: Problem of Practice

Chien–Shiung Wu came to the United States from China in the 1930s to complete a doctorate in physics. Wu had completed undergraduate studies in China at the prestigious National Central University in Nanjing, and she received a PhD in physics at the University of California, Berkeley. Wu then worked with J. Robert Oppenheimer on the Manhattan Project which developed the atomic bomb during World War II. This was just the beginning of Wu's career (Chiang, 2014).

Wu's crowning achievement in physics was the design of the experiment that challenged parity conservation, an unquestioned theory in physics that was considered a principle. The experiment she designed disproved the principle of parity and was used as primary evidence in the 1957 Nobel Prize–winning paper written by Chen Ning Yang and Tsung Dao Lee (Chiang, 2014; Nobel Prize, 2022). Dr. Wu's brilliance in physics was not recognized until decades later, in part because Dr. Wu was a woman (Chiang, 2014). Wu was overshadowed by her male counterparts and was not recognized with international acclaim. Her male colleagues, however,were lauded with esteemed prizes for achievements in physics (Chiang, 2014).

Another example of a female pioneer in STEM unacknowledged during her lifetime is that of Rosalind Franklin. Franklin discovered the double helix structure after careful observation, testing, and using more precise imaging techniques to discover the structure of DNA (Elkin, 2003), although James Watson and Francis Crick received the Nobel Prize in 1962 for discovering the molecular structure of DNA (Elkin, 2003). While James Watson and Francis Crick's research was heavily based on the work of Franklin, she received no credit or any acknowledgment during her lifetime outside of a few small mentions in later works by James Watson and Francis Crick (Elkin, 2003). Unfortunately, Rosalind Franklin would never receive the credit she deserved in life due to her death at age 37 from cancer (Elkin, 2003).

Unfortunately, Wu's and Franklin's experience as women in the studies related to STEM are still the exception to the rule of male dominance in the studies of science, technology, engineering, and mathematics (STEM). Women in STEM fields of study encounter varying degrees of hostility in their learning environments and in order for them to persist to graduation and subsequent recruitment and retention in STEM disciplines, more efforts need to be made for their retention (Kim & Meister, 2022). The following research seeks to understand the experiences of women as they matriculate as undergraduates in a STEM program and retention efforts made on behalf of a technology research institution to retain them.

**Background of the Problem – Social, Cultural, Historical Perspectives**

We live in an unjust society where people contend with systems of oppression, like sexism, designed to keep women from achieving success. Issues of sexism in society manifest socially – whereby the marginalization of women is normalized. This behavior then becomes part of the culture and persists for generations.

**Historical Perspective**

The relevance of STEM as it applies to daily life in the United States emerged with early technological inventions. Major events like the Cold War and World War II were pivotal for STEM as scientists and the military worked congruently to create technology and tools for war (Widya et al., 2019; Wolfe, 2013). In the 1950s and 1960s, the Cold War brought to light the need for more research and development as the U.S. competed against

Russia in a race to be the more technologically advanced in warfare, which then influenced the need for greater technology in other aspects of life (Wolfe, 2013). The emphasis on STEM in education became a prominent focus in the United States in the 1980s and further developed into the 1990s (Breiner et al., 2012; Widya et al., 2019). STEM education is significant in the fields of mathematics, natural sciences, engineering, and computer and information sciences, but also in such social/behavioral sciences as psychology, economics, sociology, and political science (Beiner et al., 2012). The importance of STEM education is to prepare people to work in these careers, which are also responsible for much of the country's economic contributions. Further, STEM advancements improve quality of life with developed technology and stimulants to the economy through innovation and research (Rothwell, 2013). It has been documented that success in science and math correlates to strong college retention, economic growth and development, national security and innovation, and competitiveness in the global market (Beiner, et al., 2012). STEM education also develops the skills of problem–solving, innovation, self–reliance, logical thinking, and technological literacy (Widya et al., 2012).

STEM careers are an integral part of the economy in this country, however, women are severely underrepresented in these career fields. Women account for approximately 47% of the total workforce, but only 29% of the STEM labor force (U.S. Department of Labor, 2021). In 2018, of the women who earned degrees, only 36% of them were in the STEM field (Women in STEM USA, 2022). The lack of women in STEM majors and in STEM careers pose several threats to society (Diekman et al., 2017; Kenney et al., 2012; Shapiro & Sax, 2011). For example, one concern is that society suffers an economic and scientific loss due to a shortage of women in STEM, as the breadth of subject areas that are explored is limited with less diversity of personnel since women account for approximately half of the population (Syed & Chemers, 2011). When any underrepresented minority (whether women, ethnic minorities, or people with disabilities) is represented in the STEM field, educational potential is greater as diversified perspectives are considered. Research has shown that more women in STEM would lead to advanced collective intelligence therein, contributing to a higher level of innovation, creativity, and possibilities for further experimentation in varying areas (Botella et al., 2019; Hill et al., 2011).

Another issue is that women will continue to be undervalued as wage earners and the wage gap will continue to expand (Gartsetein & Hancock, 2021; Kenney et al., 2012). Women in STEM earn approximately 33% more than women in other career fields (Diekman et al., 2017). If more women are retained in STEM, women would have greater earning potential. An additional result is the lack of women in STEM will restrict future generations' opportunities and social expectations. If women are not represented in STEM, girls and young women are less likely to persist in those occupations (Diekman et al., 2017).

The representation of women and people of color in STEM fields has been a concern for decades. Underrepresented minority (URM) groups consist of Native Americans, African–Americans, Latinos, women, and other underrepresented groups who have been prevalent in the United States for much of our nation's history. In 1972, the National Institutes of Health (NIH) initiated minority–focused research training programs to enhance the participation of women in STEM (Syed & Chemers, 2011). While the success of many components of the program were not reported, researchers identified themes that have discouraged women from pursuing STEM fields, including "individual psychological and life context variables, such as self–efficacy identity, and social categorization," which are also referred to as "social identity threats" (Syed & Chemers, 2011, p. 438).

In more recent efforts, Congress passed the America Competes Act in 2007, which was implemented to invest in educational research in STEM for students from kindergarten through graduate school (Blackburn, 2017). The act was designed with the intention of investing in research and innovation to enhance the competitiveness of the United States in the global economy (Gonzalez, 2011). Countries such as China and India have achieved significant gains in innovation in the world's high–value job market (Gonzalez, 2011). In 2010, Congress adjusted STEM educational policy and passed the America Competes Reauthorization Act which included several measures, such as $45.6 billion in funding for research and development, and goals to increase the number of URM in STEM (Blackburn, 2017; Gonzalez, 2011). Despite the influx of resources and emphasis on URM in STEM, there is still a significant disparity in women in STEM majors and the STEM field. Women and minorities account for 70% of college students, but less than 45% of STEM degrees (Blackburn, 2017).

**Retention Defined**

To address the underrepresentation of women in STEM majors, it is necessary to evaluate the retention of women in STEM in postsecondary institutions. However, it is imperative that we define the term "retention," as various scholars have utilized differing definitions throughout recent history.

Retention can be defined in various ways as it pertains to college students and their progression through the completion of a 4–year degree program. When discussing college student retention, specifically women who pursue STEM majors, it is pertinent to clearly define our terminology in order to conduct quality research that can be informative to the intended audience of educational administrators who are invested in increasing the representation of women in STEM majors and careers. Retention has been defined as follows:

- the ability of an individual to remain in college until graduation (Seidman, 2016)
- successful completion of a student’s academic goal of degree attainment (Levitz & Noel, 2008)
- students who meet clearly defined educational objectives, whether course credits, advancement in career, or acquiring new skills (Levitz & Noel, 2008; Tinto, 1993)
- staying in school until the completion of a degree (Hagedorn, 2006; Oseguera & Rhee, 2009)
- retention is an institutional measure, whereas “persistence” is a student measure (Hagedorn, 2006; Holder et al., 2016)
- the percentage of first–time undergraduate students who return to the same institution the following fall (NCES, 2022)
- The federal government defines retention as following full–time students through the completion of their program, but also requires that institutions report their first to second–year retention rates (Holder et al., 2016).

The differing interpretations of retention encompass common themes. Each definition involves an element of “returning” to the institution (Hagedorn, 2006; Holder et al., 2016; Levitz & Noel, 2008; NCES, 2022; Oseguera & Rhee, 2009; Seidman, 2016; Tinto, 1993). The differences between the definitions are contingent upon the time frame in which retention is measured. Multiple definitions consider retention as a measure that should be considered until graduation or the completion/attainment of a degree. Hagedorn (2004) states that retention is a construct that is considered from the vantage point of the institution. Retention for this study will be defined as continuing study within a major or discipline. The research is most relevant to the concept of degree completion for women in STEM which coincides with definitions that Hagedorn (2006), Oseguera & Rhee (2009), Levitz & Noel (2008), Tinto (1993), and Seidman (2016) provide.

**Retention of Women in STEM**

The retention of women in STEM should be of great concern to the United States. The statistics indicate low graduation rates for women with degrees in STEM majors (McCullough, 2019). Much of the future success of the world economy is reliant on performance in STEM careers (Waite & McDonald, 2019). The economic status and standard of living for this country are vulnerable if there is not more emphasis on STEM education to remain globally competitive (Waite & McDonald, 2019). There is a shortage of laborers in STEM jobs, but the lack of women is even more significant; and despite a high graduation rate, women are severely underrepresented in STEM majors (Koch et al., 2022). In 2021, 67% of female students graduated from 4–year colleges, while 61% of men graduated from 4–year colleges (Best Colleges, 2022). Approximately 36% of the women who graduated have completed STEM degrees, which has been a consistent statistic spanning the last 20 years (Davies, 2022). While in college or universities, women also tend to leave STEM programs at a higher rate in postsecondary education than men (Koch et al., 2022). Women have been successful in STEM careers and can adequately fulfill the requirements of such professions, however women are in the minority with regard to completing and graduating with STEM degrees, resulting in less women who are represented among STEM careers (Davies, 2022; Kenney & McGee, 2012).

Figure 1.1 demonstrates the number of male and female students by ethnicity who completed a STEM degree in 2020–2021, which is the most recent data available. The total number of women who earned their STEM degree or certificate account for 34.9% of the population, which is compatible with the 20 year average discussed above (National Center for Education Statistics, 2023).

**Figure 1.1**

*Number of STEM Degrees/Certificates Conferred by Postsecondary Institutions*

*Number of science, technology, engineering, and mathematics (STEM) degrees/certificates conferred by postsecondary institutions, by race/ethnicity, level of degree/certificate, and sex of student: 2020–21*

| Sex and year | Total | American Indian/Alaska Native | Asian/Pacific Islander | | | Black | Hispanic | White | Two or more races | U.S. nonresident |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Total | Asian | Pacific Islander | | | | | |
| Total, all levels of degrees/certificates | | | | | | | | | | |
| **Total** | 790,752 | 3,158 | 92,217 | 90,930 | 1,287 | 59,848 | 101,761 | 385,194 | 28,389 | 120,185 |
| Males | 514,323 | 2,065 | 55,101 | 54,221 | 880 | 35,330 | 64,609 | 261,183 | 17,129 | 78,906 |
| Females | 276,429 | 1,093 | 37,116 | 36,709 | 407 | 24,518 | 37,152 | 124,011 | 11,260 | 41,279 |

*Note*. The figure denotes recipients of STEM degrees/certificate by ethnicity and gender. Adapted from the *National Center for Education Statistics, Table 318.45, Copyright 2023 by Digest of education statistics*. U.S. Department of Education, Institute of Education Sciences. (https://nces.ed.gov/programs/digest/d22/tables/dt22_318.45.asp**).** In the public domain.

**Social and Cultural Perspectives**

Despite governing policies implemented to address the lack of women and URM in STEM, there are social and cultural contributions that could be contributing factors. Gender stereotypes, gender roles, and sense of belonging contribute to low retention rates of women in STEM majors and fields (Blackburn, 2017;  Campos et al., 2022; Green & Sanderson, 2018; Koch et al., 2022; Mcguire et at., 2020).

Gender stereotypes and gender roles provide an explanation for the lack of women in STEM fields. Hand and Greenlee (2017) conducted a meta–analysis that identifies a prejudice against girls and women in relation to their ability to succeed in STEM. Although there is minimal awareness, both men and women display gender bias that associates with traditional gender role stereotypes and characterize women as being less capable in STEM areas (Ertl et al., 2017; Hand & Greenlee, 2017). These stereotypes create biases against women and have an extensive impact on female students, educators, and administrators (Hand & Greenlee, 2017; Rice & Barth, 2017). Negative stereotypes result in poor self–efficacy for women who want to consider STEM majors and career paths (Dika et al., 2016). Self–Efficacy is the belief in one's ability to succeed (Leslie et al., 1998). People are more likely to complete a task if they believe they can accomplish it, thus self–efficacy is essential when choosing a STEM degree (Perna et al., 2009). However, Bandura (1977) defines self–efficacy as one’s own beliefs about their skills while navigating through circumstances, affecting how they behave and cope, and whether they would rather persist or not endure the circumstances altogether. Perceptions and support of family and peers, among other factors, shape self–efficacy (Perna et al., 2009). Therefore, some women believe that they are not as capable or competent as men in STEM due to stereotypes that have been ingrained in them, creating a negative academic self–concept (Ertl et al., 2017; Rice & Greenlee, 2017).

Stereotypes also contribute to educators' and employers' decision–making processes regarding the participation of women in STEM programs for particular jobs (Galperin, 2019; Hand & Greenlee, 2017). Studies have indicated stereotypes of “what women and men are like” and “what women and men should be like” that are closely linked with hiring practices (Galperin, 2019, p. 1091). Descriptive stereotypes encompass the ideas of what women *are* and should *be*, which can hinder a woman's self–efficacy and belief that she is competent to fulfill the requirements of a job. However, this is a perceived notion based on stereotypes suggesting that women are not as capable as men in STEM careers. Scholars have determined that women have just as much ability to perform and achieve success in STEM careers as men (Ertl et al., 2017).

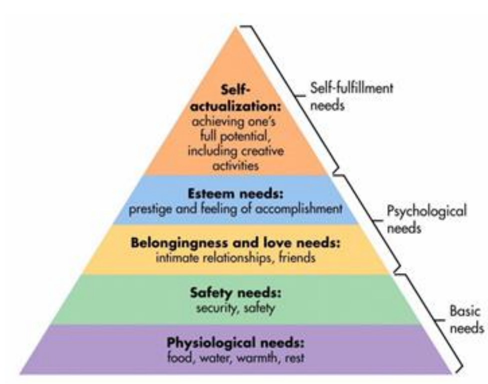
A supplemental aspect of societal and cultural perspectives that impact the desire of women to persist in STEM majors and career fields is a sense of belonging. Persistence and progress through STEM programs for women are impacted by several variables that are relative to sense of belonging: internal motivation or commitment, perceived support from advisors, adequate secondary education, classroom success, support from family, support from the campus community, and a strong women peer group (Blackburn, 2017).

Sense of belonging is best articulated as a communal goal. Communal goals are the need for relatability, collaboration, and the ability to help others, stimulating relationships, the human need for belonging, and self–efficacy (Diekman et al., 2017). Motivating factors are also supported by Maslow's Hierarchy of Needs which are self–actualization: desire to become the most that one can be; esteem: respect, self–esteem, status, recognition, strength, freedom; love and belonging: friendship, intimacy, family, sense of connection; safety needs: personal security, employment, resources, health, property; physiological needs: air, water, food, shelter, sleep, clothing, reproduction (Diekman et al., 2017; McLeod, 2018). Communal goals are important to human physiological needs but even more valuable to women, which can be attributed to the traditional roles that women have incurred as caregivers which highlight communal qualities, for example nurturing and aiding others (Diekman et al., 2017).

Figure 1.2 is a representation of Maslow's Hierarchy of Needs and figure 1.3 is a flow chart that depicts Amanda Diekman's Communal Goal Congruity framework. As discussed above, both figures encompass complementary concepts (Diekman et al., 2017; McLeoad, 2018).

**Figure 1.2**

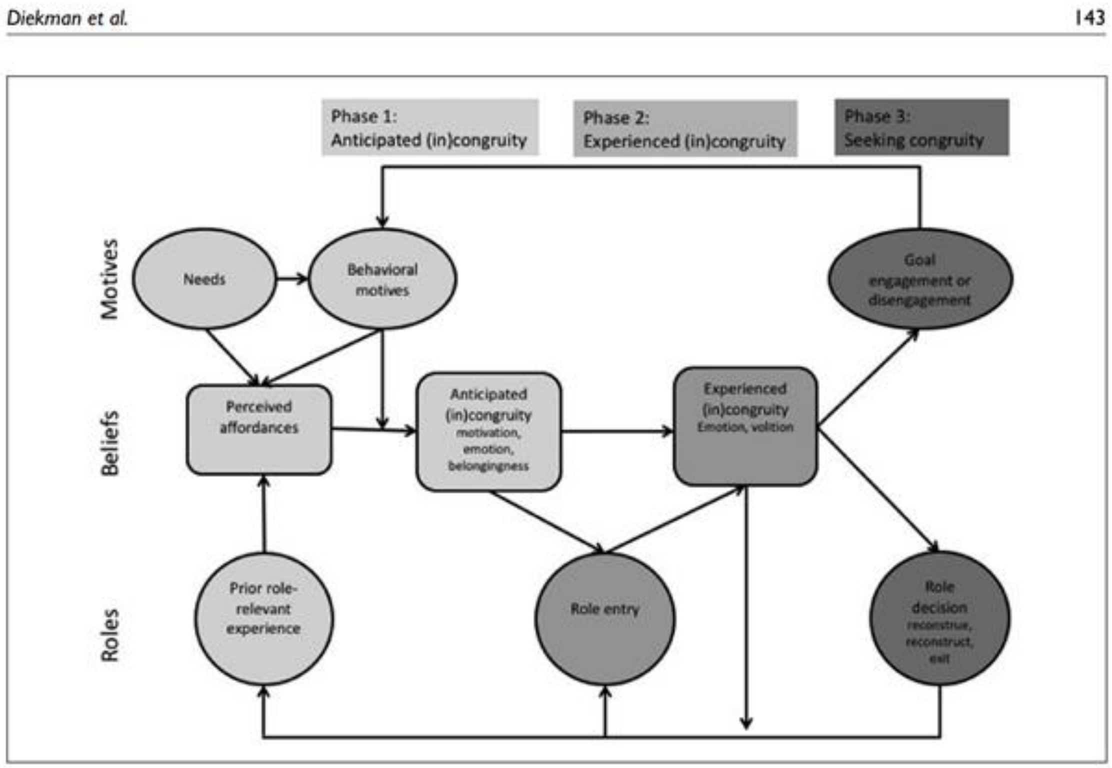
*Maslow's Hierarchy of Needs*




*Note*. *Maslow's Hierarchy of Needs,* by S. McLeoad, 2018, p.1. Copyright 2018 by Simply Psychology.

**Figure 1.3**

*A General Model of Goal Congruity Process*




*Note*. Adapted from *Personality and Psychology Review*, by A. Deikman, 2017, *2*(21), p.143. Copyright 2017 by the Society for Personality and Social Psychology, Inc.

The combination of gender stereotypes against women and the lack of community and communal goals available to women in STEM deter women from persisting through a STEM major and career path. While women have proven to be a valuable and competent asset to STEM fields, there are social and cultural factors that contribute to gender stereotypes and roles that have impacted the sense of belonging for women.

**Social Justice implications**

Institutions of higher learning are microcosms of the broader society and many of the issues prevalent in society exist on college campuses as well. Aikenhead and Jegede

(1999) assert that "the transition from a student's life–world into a science classroom is a cross–cultural experience for most students" (p. 271). In addition, the cultural experiences of students in their home or "life world" often conflict with the culture of college life,  and in this case, STEM learning environments. As mentioned, students enter college having acquired their own cultural identities, which impact how they learn. From an anthropological lens, we learn that culture is learned and shared and is "an ordered system of meanings and symbols, in terms of which social interaction takes place" (Geertz, 1977, p. 366).

Historically, society has characterized females as nurturers and people of color as uneducated, and in addition to gender stereotypes, research supports that women in STEM fields encounter many forms of gender and, among URM groups, race–based discrimination throughout their careers such as microaggressions and identity threats while they endeavor to culturally border cross into STEM fields (Kim & Meister, 2022; Morton & Nkrumah 2020).

Successful cultural border crossing into the microculture of STEM contributes to female student retention. However, among the litany of discriminatory practices that women, regardless of race or ethnicity encounter, microaggressions have become part of the culture in STEM departments, and are the most common type of discriminatory practice. Kim and Meister (2022) found that there are three different types of microaggressions that women face in the workplace: microassault, microinsult, and microinvalidation. In each, women face varying degrees of indignities that contribute to feelings of isolation. Among these microaggressions, microassault is characterized as the most overt, as in calling women pejorative names. Further, microinsults occur in behaviors that unintentionally degenerate women, as in calling only on male students during class discussions (Kim & Meister, 2022). Lastly, microinvalidation minimizes the struggles that women face through the invalidation of their lived experiences and situational issues that had taken place (i.e. sexism) in the past. Aikenhead and Jegebe (1999) stated it in this way:

> Within every culture there are subgroups or social communities that more or less share unique combinations of norms, values, beliefs, expectations, and conventional actions. Border–crossings between microcultures can occur whenever someone moves from one social community to another: for instance, when students move from their peer group in the hallway of a school into a different group of students in a science classroom. (p. 272)

More recently, Morton and Nkrumah (2020) postulated that to be successful in border – crossing, participants must change who they are and conform to STEM culture. Moreover, because STEM has been traditionally a male dominated field, they argue that part of that change is adhering to patriarchal norms. For women of color, particularly African American women, there is resistance to conforming to the hegemonic culture of STEM, and Morton and Nkrumah articulate this as a “resistance frame for Black women’s STEM engagement” (p. 488). Furthermore, they affirm that for African American women, they are resilient and achieve regardless of their circumstances. For example, in spite of microaggressions, African American women matriculate to graduation to prove their worthiness to themselves and to their counterparts (Morton & Nkrumah, 2020).

**Local Contextual Perspectives**

Careers in STEM are projected to grow by 10.8% by 2031 in comparison to non–STEM occupations’ projected employment increase of 4.9% (US Bureau of Labor Statistics, 2022). STEM occupations provide higher salaries, particularly in engineering, as the mean annual wage in Missouri is $95,200 (Missouri Economic Research and Information Center, 2021). Research also demonstrates that there is a gender gap among wages – women annually earn $17,000 less than men in STEM fields (Carnevale et al., 2011). Both the occupational outlook and median wage earnings make STEM fields desirable to undergraduate students.

There are disproportionate numbers of female students in STEM majors enrolled at institutions of higher education, particularly when isolating degree pathways in engineering, computer science, and mathematics (Hunt et al., 2021). Research indicates that STEM majors often choose their career pathway in high school, and as women matriculate through undergraduate degree programs into graduate programs and/or careers, they gradually leave the STEM field; this phenomenon has been described as the “leaky pipeline” (Hunt et al., 2021). During all of these stages, women have lower representation than their male counterparts. Even after they have entered the workforce, women are less likely to hold leadership positions in STEM careers and have higher career attrition rates (Park et al., 2022).

The underrepresentation of women in STEM is further magnified when examining this occupational field in the state of Missouri. Women only account for 10.9% of engineers in Missouri (Missouri Economic Research and Information Center, 2019). One of the main pipelines for engineering degrees conferred in the state is

Missouri S&T, as it is the only designated technological research university in the state, and one of only 16 institutions with this distinction in the United States (University of Missouri System, 2021). In the fall of 2022, Missouri S&T had the highest number of females enrolled in its history, 24.2% (Hasner, 2022). If Missouri wants to remain technologically competitive, increasing the number of STEM graduates is important, and increasing the number of women in those fields should be a priority.

Table 1.1 illustrates the differences in degree attainment among the male and female population within the University of Missouri System. The data identifies an uneven distribution of graduates according to gender with males accounting for the vast majority of conferred undergraduate engineering degrees (College Factual, 2022).

**Table 1.1**

*Undergraduate Engineering Degrees Conferred Within the University of Missouri System*

| University | Total Engineering Degrees | Male Graduates | Female Graduates |
|---|---|---|---|
| Missouri University of Science & Technology | 920 | 76.1% | 23.9% |
| University of Missouri - Columbia | 359 | 81.6% | 18.4% |
| University of Missouri-Kansas City | 125 | 80.8% | 19.2% |
| University of Missouri-Saint Louis | 71 | 84.5% | 15.5% |

**Candidate Perspective**

In the following section we offer examples of social learning environments and we discuss the experiences that motivated our research. We provide examples of social learning practices that were designed to increase support for STEM education in the state of Missouri. We also discuss the experiences that motivated us to pursue the topic of the retention of women in STEM.

***Practices Observed Within Local Contexts***

For the purpose of this study, we are examining social learning environments designed to increase support for STEM education in the state of Missouri. These practices include scholarships, early college entrance academies, outreach programs, living–learning programs and community engagement (Elmore, 2011; Inkelas, 2011; Jones, 2009; Landgraf et al., 2008; Szelényi & Inkelas, 2011). These practices are related to advanced placement and extracurricular activities and play a role in decreasing barriers that thwart the success of women in STEM, including addressing inadequate academic preparation by elementary and secondary schools, inadequate attention to the psychological barriers that negatively impact persistence, and inadequate financial support from colleges and universities (Perna et al., 2009).

Elmore (2011) touted the fact that scholarships like the Women in Science and Engineering (WISE) and Minority Engineering and Science Program (MEP) significantly increase the number of minority and female students that Missouri S&T enrolls in its science and engineering programs. In addition, the recipients of these scholarships are also exposed to career opportunities. Along with outreach, recruitment and retention efforts from middle school to the undergraduate levels, these scholarships increase the number of women in science, engineering, math, and technology fields.

The provision of a rich academic and social experience for women at Missouri S&T characterizes the WISE program, as it offers support programs like mentoring, advising, professional/technical workshops, and social activities (Elmore, 2011). Under–

represented students who select engineering and science programs as a specialization at Missouri S&T are provided crucial financial support from MEP scholarships, and they are connected with a close–knit MEP network of friends, mentors, and Missouri S&T staff. The MEP scholarship has provided the added benefit of sponsored events, activities, and organizations for 30 years (Elmore, 2011).

The increase of support for high school students' interest in STEM among science and engineering clubs has a positive impact on self–efficacy (Dika et al., 2016). Early college entrance academies like the Missouri Academy of Science, Mathematics, and Computing at Northwest Missouri State University in Maryville have provided a method to increase the number of graduates who enroll in STEM programs. In addition, students who participate in this program earn high school credit and an associate's degree (Jones, 2009). Students at the Missouri Academy of Science achieved major successes, including: an average grade point average (GPA) of 3.65, a general accrual of 72 credit hours in two years. Nearly 100 percent of graduates completed a baccalaureate degree, 85 percent of graduates pursued studies in STEM fields, and 56 percent of graduates entered post–baccalaureate studies (Northwest Missouri State University). Unfortunately, financial and enrollment issues caused the closure of the Missouri Academy of Science in 2017 (Barnett, 2017).

While the Missouri Academy of Science no longer exists to prepare students in secondary education for STEM programs in post–secondary education, other schools are continuing this mission. Numerous institutions and organizations in the St. Louis area have created STEM related opportunities for community engagement with youth. Students who engage with STEM activities as youth could ignite STEM interests during their collegiate years (Diekman et al., 2015; Ilumoka et al., 2017). The St. Louis Public School District established the Gateway STEM High School, which boasts of preparing students for the programs, with more than 1 million square feet of space to house labs, a greenhouse, an aviator hanger, and other academic learning areas (slps.org, 2022). STEMSTL ecosystem is an organization which works with educators in the St. Louis area to provide sustainable learning initiatives within STEM while also connecting students with career opportunities in order to promote diversity. The organization provides learning and event opportunities with local programs and includes instructional resources through University of Missouri – St. Louis (UMSL), Maryville University, and Boeing. There are professional development opportunities, as well, through Blueprint4 Anti–racism, Center of Creative Arts (COCA), and St. Louis Symphony Orchestra (STEMSTL, 2022).

Outreach programs are also crucial to apprise students of STEM disciplines before college (Elmore & Guess., 2008; Landgraf et al., 2008). Sixty percent of students who attend the Missouri University of Science and Technology Women in Science and Engineering Program outreach programs enroll at the university (Landgraf et al., 2008).

Increasing community engagement within a mutually supportive environment is necessary for retention and persistence in STEM (Palmer et al., 2011; Szelényi & Inkelas, 2011). Living–learning programs (LLP) are referenced using a variety of phrases, including residential college, living–learning communities, residential learning communities, theme houses, and living–learning centers (Inkelas, 2011). They believe that living–learning programs have also been positively associated with STEM graduate school aspirations, while primarily academically supportive residence halls held a negative impact on graduate school. Women tended to perform well in environments composed of individuals with similar interests who shared the same floor of a residence hall and were often socially engaged with one another (Inkelas, 2011; Szelényi & Inkelas, 2011).

Women in STEM majors could be found in almost every type of LLP, including honors programs, transition programs, and women's programs (Inkelas, 2011). Many types of LLPs cater primarily to women in STEM such as the Women in Math, Science, and Engineering (WIMSE) program at the University of Illinois; there are also co–educational programs for all students with STEM interests (Inkelas, 2011). Furthermore, co–educational LLPs focus on one of three aspects of STEM: (1) engineering and computer science, (2) health science, or (3) general science. Engineering and computer science LLPs tended to focus on those two disciplines, while general science programs included a variety of topics ranging from environmental sciences to human ecology. The health sciences programs largely focused on medical fields such as nursing at the University of Missouri (Inkelas, 2011).

Although a significant body of research is lacking in this area, some studies indicate that women in STEM majors who were involved with women–only STEM LLPs or co–educational STEM LLPs were more likely to express a smooth social transition to college than women in STEM majors who did not participate in an LLP. However, only women in co–educational STEM LLPs expressed a smoother academic transition, reporting a successful academic adjustment to college (Inkelas, 2011; Szelényi & Inkelas, 2011).

The purpose of community engagement is to build a stronger environment for women to overcome the obstacles of STEM programs and provide a supportive space in which women can express and engage with peers while also empowering them to share their voice. Universities in St. Louis have established programs to aid in the creation of a smooth transition for female students. For example, Washington University has created Women in STEM (WiSTEM), an organization which commits to community engagement, networking and mentoring, social events, and professional development for women in STEM Programs. The focus specifically addresses current and daily barriers that women face which consist of training and networking to grow a bonding framework between Washington University and the greater St. Louis community (Washington University, 2022). WiSTEM coordinated opportunities for students to interact and link with mentors during events, such as an informal dinner, ice cream social, and professional photoshoot.

Researchers suggested that exposing youth to careers in STEM builds self–efficacy and other benefits. Ilumoka et al. (2017) noted that young students who have early exposure to STEM programs with industry–based mentors pose a 55 percent greater likelihood of interest and confidence in STEM. The WiSTEM organization hosted a local high school to attend a program called *Ask a Scientist* illuminated STEM programs for young women in hopes that they would inspire students (Washington University, 2022). A team of STEM peers from Southern Illinois University – Edwardsville's STEM Center met with young female students in East St. Louis. The goal was to show youth the various STEM programs and to empower the students, especially students of color. One peer encouraged other students to "fail forward" by learning from mistakes, while another stressed the significance of engaging female mentors (Southern Illinois University Edwardsville, 2020, para. 6). Missouri S&T hosted 900 K–12 students on National STEM Day with the intent to expose children “as early as possible” to STEM while learning, interacting, and having fun (Pierce, 2022).

Though supporting the needs of women in STEM at the academic level are important, extracurricular activities also benefit students in many ways (Boucher et al., 2017; Ceglie, 2021). Research from Kim (2022) explained that extracurricular activities greatly enhanced students' leadership development, particularly in women. Exposure to STEM programs during the students’ adolescent years increases the appeal of the subject (Diekman et al., 2015; Maltese & Tai, 2009). Tandon et al. (2021) supports the idea that “Hack Days” helped college students gain experience in STEM and collaborate with others. The idea for Hack Days came from Ariel Waldman and focused on student collaboration across disciplines (for example – computer science with marketing students) during an event that lasted one to two days. The students in Hack Days are given a task to solve with the goal to inspire students and build enthusiasm for science (Waldman, n.d.). Hack Days introduced many students to STEM “who do not typically participate in extracurricular campus activities,” (Tandon et al., 2021, pp. 86–87). Perhaps female post–secondary students should be afforded an opportunity, as an extracurricular activity, to host a Hack Day event at both K–12 schools and universities to demonstrate STEM programs. This opportunity could help female students fulfill communal goals by allowing them to serve their community and promote STEM to more women (Diekman, 2022; Diekman et al., 2015).

All of the programs listed have assisted in the creation of a better environment for women in STEM in Missouri. Outreach programs are able to inspire students before they enter college, and scholarships aid the affordability of college (Elmore, 2011). Early college entrance academies and outreach programs aid in the transitions to college (Elmore, 2011; Jones, 2009). Living–learning programs create an environment where women can persist in STEM and post–secondary education more generally (Inkelas, 2011; Szelényi & Inkelas, 2011). Furthermore, networking (Elmore, 2011; Washington University, 2022), industry–based female mentors (Ilumoka et al., 2017; Southern Illinois University Edwardsville, 2020), and early exposure (Ilumoka et al., 2017; Pierce, 2022) may spark an interest in STEM and, in later years, reinforcing persistence through college.

**Previous and current experiences which lead to the framing of the specific problem of practice**

As the researchers of this study, we have had experience interacting with, teaching, and coaching women in STEM. We are motivated to pursue the topic of retention of women in STEM because we have witnessed the experiences of women who struggle as college students in the higher education environment. We recognize the importance and diversity that women can contribute to STEM fields while enhancing the caliber of production in those jobs. Early access programs, arts integration, and extracurricular activities offer women in STEM the tools they need to succeed in postsecondary education. These factors have motivated each of the researchers in some way. Our team members have witnessed women as they have served in teaching roles, which has motivated us to participate in these roles as well. Experiences in arts integration has been a catalyst for our team members, as it has provided strategies that help us to better understand and conduct research. Experiences in extracurricular activities have also motivated our research team to build community with other students and staff, creating support systems that have helped us to persist. Finally, early access programs have allowed students to succeed in postsecondary education. Our unique experiences propel our passion for assisting women in STEM while providing tangible and feasible solutions to the retention issues for women in STEM.

One member of our research team has a friend who graduated from an undergraduate STEM program. She was a single Black mother who worked full–time and enrolled in a dual program between the University of Missouri–St. Louis and Washington University. If she had access to more vital resources (i.e., work–study, extracurricular activities), she would not have been compelled to serve as a pharmacy tech at Walgreens while attending engineering school. Instead, she could have focused on her role as a mother, engineering student and research assistant.

Furthermore, we have led and mentored women in learning environments and extracurricular contexts and have witnessed the positive impact that supportive communities provide women in STEM. The support received from extracurricular groups has enabled women to empower each other, which has enhanced their confidence and self–efficacy. These experiences fulfill key components within the communal goals framework (Diekman et al., 2017).

**Specific problem of practice**

The specific problem of practice is the retention of female students in STEM fields. One of the major factors that inhibit the retention of women in STEM is the shortcoming of achieving communal goal congruence. For example, researchers articulate that successful STEM majors work together in groups, however women and minority groups are not invited to participate (Kamen & Leri, 2019). Another aspect relative to communal goal congruence is gender normativity to college major selection, and researchers argue that societal norms and cultural beliefs impact student decisions related to the selection of fields of study (Beutel et al., 2017). With regard to societal norms for women, researchers affirm a correlation among behaviors of caregiving that influences choice of major. For example, a societal norm of women as caregivers suggest careers in education as opposed to those in engineering (Beutel et al., 2017). Additionally, researchers affirm that stereotypes for women directly impact self–efficacy within those fields of study, reinforcing cultural normativity (Beutel et al., 2017; Campos et al., 2022; Diekman et al., 2017; Hand et al., 2017).

Gender segregation and personal interest impact experience, correlating to confidence and personal interest for women in engineering, as it is challenging for them to achieve acceptance in male–dominated spaces (Beutel et al., 2017). Beutel et al., are researchers at “SUNY New Paltz” that in 2017 found that networking empowers societal change for women in STEM. For example, researchers found that for Women in Science and Engineering (W.I.S.E.), a networking cohort of female STEM students, that some of the reasons that women were leaving the field of engineering included:

- academic or work environment
- grades or lack of career advancement
- self–efficacy
- high school preparation

- gender (Beutel et al., 2017, p.2)

They continue to describe the academic or work environment as non–supportive and that encourages competition instead of cooperation. Furthermore, that recognition from mentors and working with peers contributes to levels of confidence, which impacts career potential, and that generally, for women and underrepresented minorities in STEM fields, feelings of isolation lead to leaving engineering for fields where they may find community (Dahle, et al., 2022). Membership and belonging is essential and it is critical to understand how lived experiences for women in STEM impact their overall persistence in the field, supporting the communal goal framework (Dahle et al., 2022; Diekman et al., 2017).

**Why the problem needs to be addressed**

The retention of women in STEM is a concern around the world (Diekman et al., 2015; Syed & Chemers, 2011). This research will focus on this issue as it pertains to Missouri S&T and the State of Missouri. STEM is an integral contributor to the United States economy as it is a growing field that is responsible for many "areas of national need" and is "crucial to national innovation, competitiveness, and well–being" (Goan & Cunningham, 2006, p.1). The U.S. is declining in competitiveness and providing a suitable STEM labor force. Thus, investment in STEM programs in the regional sphere, especially those that promote the recruitment and retention of women, are important to the local community and society as a whole (Diekman et al., 2017).

While women are responsible for 48% of U.S. jobs, they hold only 24% of jobs in STEM (Diekman et al., 2015; Shapiro & Sax, 2011). The need for women in STEM is imperative because:

- Women contribute diversity in ideas and talent.
- The wage gap would be reduced as women in STEM earn more than women not in STEM careers, and women would have greater earning potential.
- More women and future generations would be inclined to pursue STEM careers with greater representation. (Diekman et al., 2017; Shapiro & Sax, 2011)

The issue of retention of women in STEM comes to fruition in postsecondary education. Women account for nearly three–quarters (70%) of college students but less than half of STEM degrees at 45% (Blackburn, 2017). The lack of women in STEM majors is attributed to the deficiency of communal goal congruity in the collegiate environment which impacts women's sense of belonging, self–efficacy, and self–confidence to be retained in STEM (Diekman et al., 2017; Green & Sanderson, 2018; Ramsey et al., 2013).

The authors of this study are hopeful the research we conduct contributes to a larger body of knowledge and furthers higher education practice that increases persistence and retention of females in STEM. As stated, community is imperative to female STEM majors developing the self–efficacy required to persist to graduation. Universities specializing in STEM pathways, like Missouri S&T, must provide opportunities to URM in order to increase student retention.

## Central Research Questions

Based on the review of available literature, 4 research questions were developed to guide our inquiry. The research questions informed the qualitative study, including the creation of interview questions. The research questions allowed the investigators to learn more about successful institutional retention efforts for undergraduate women in STEM and inquired on measures institutions can take to increase the retention of this underrepresented population.

**Purpose of Study and Research Questions**

The attrition rates for females who matriculate through every stage of education towards high–level STEM curricula reveal barriers that prevent retention among women college students. This issue represents more than an individual problem of being retained, rather, it represents an opportunity whereby universities can increase retention by implementing student support for an underrepresented population – women, in targeted fields of study – STEM.

Although we know women in STEM must overcome gender stereotypes and identity threats to be retained by institutions, we are interested in how to cultivate an atmosphere that is inclusive towards women. The purpose of this study is to determine factors impacting the retention of female undergraduate students in STEM fields of study. The research questions that guide this study are as follows:

**RQ1:** To what factors do women in STEM attribute their decision to matriculate through degree completion?

**RQ2:** How does Advanced Placement coursework in high school impact the retention of women in STEM?

**RQ3:** How do extracurricular activities (including student organizations and work study) impact the retention of women in STEM?

**RQ4:** How could engagement in art as a study tool (color coding, listening to music, drawing, etc.) impact the retention of women in STEM?

## Summary of Connections of Actionable Knowledge Reviewed

We endeavor to identify solutions that contribute to increasing the retention of women in STEM majors, which will subsequently lead to better understanding the underrepresentation of women in the STEM labor force and correcting that problem. Women are essential contributors to STEM fields because they can contribute a unique perspective and creative solutions and apply their talents to a field that is essential to the country and the world's economy.

Women in STEM fields encounter demeaning gender stereotypes that imply inadequacies (Ertl et al., 2017; Hand & Greenlee, 2017). Women also lack a sense of belonging in postsecondary STEM programs which leads to poor self–efficacy and self–confidence (Blackburn, 2017; Diekman et al., 2017). A lack of sense of belonging is attributed to gender stereotypes, microaggressions, and gender discrimination in the STEM field and STEM education (Kim & Meister, 2022). Each of these factors has a negative impact on the retention of women in STEM.

Each of the variables that impact the retention of women in STEM involves the learning and working environments rather than the ability and skills to perform STEM–oriented tasks. Women have demonstrated the aptitude equivalent to or even greater than men regarding the successful completion of STEM curriculum (Diekman et al., 2017; Perez–Felkner, 2018; Shapiro & Sax, 2011). The learning environment is a prominent issue. We believe that Advanced Placement programs in secondary education, extracurricular activities (including student organizations and work study), and utilizing art as a tool for study (utilizing music to focus, color coding to organize notes, drawing or doodling to comprehend concepts, etc.) can enhance the learning environment for women in STEM majors. Our study will determine how these influences impact the retention of women in STEM majors.

In the following sections of this dissertation, we will discuss the literature that we have reviewed related to the retention of women in STEM areas of study and potential solutions. As we conclude our literature review, we will identify the issues that have not been adequately addressed and existing concerns. The literature review will further inform our research questions and methodological approach to data analysis. In subsequent chapters, we will share our research findings, identify limiting factors that we encounter throughout the research process, share solutions and answers to our research questions, and conclude our dissertation with suggestions and practical applications to improve the issues that we identify to enhance the retention of women in STEM.

## Review of Knowledge for Action

The problem is that careers in STEM are an integral part of the U.S. economy, yet more and more STEM students, especially women, are choosing different fields of study due to microaggression, isolation, and other discriminatory practices which create a negative environment (Kim & Meister, 2022). Further, the lack of women who pursue STEM majors pose several threats to society (Diekman et al., 2017; Kenney et al., 2012; Shapiro & Sax, 2011). Women account for approximately one–half of the U.S. population, and one concern is that society suffers an economic and scientific loss due to a shortage of women in STEM, as the breadth of subject areas explored is limited with less diversity of personnel (Syed & Chemers, 2011).

**Conceptual Framework**

Issues surrounding the retention of women in STEM majors and the STEM field are largely attributed to goal congruity, which is explained through the communal goal process that comprises the theoretical framework of communal goal congruity. Communal goal congruity as it relates to the STEM field and women suggests that STEM careers do not satisfy communal goals for women (Diekman et al., 2017). The concept of communal goals indicates the need for relatability, altruistic purpose, and collaboration. Communal goals are important to human physiological needs but are even more valuable to women (Diekman et al., 2017). This can be attributed to the traditional roles that women have incurred as caregivers which highlight communal qualities such as nurturing and aiding others (Diekman et al., 2015).

The concept of meeting communal goals for women in STEM is also impacted by gender stereotypes, which affects one's self–efficacy. Numerous studies and research have indicated that gender stereotypes connected to women in STEM suggest perceptions that men perform more effectively in math and science (Diekman et al., 2017). However, studies have revealed that women  are equally capable of  achieving academic success in math and science majors (Diekman et al., 2017; Perez–Felkner, 2018; Shapiro & Sax, 2011). While capable, women are discouraged to pursue STEM by the stereotypes against them as it relates to retention in STEM resulting in poor self–efficacy. A person's self–efficacy regarding academic practice is an influential determinant of their persistence within that field (Diekman et al., 2017; Koch et al., 2022).

Communal goals are fulfilled by the environment in which one is learning or working (Diekman et al., 2015). By emphasizing communal aspects in STEM programs, the retention of women in STEM can be improved (Diekman et al., 2015; Perez–Felkner, 2018). The literature says that this can be achieved with curricular, co–curricular, extracurricular activities, mentor relationships, and community participation (Diekman et al., 2015; Perez–Felkner, 2018). The fulfillment of communal goals can also be achieved by helping others and providing a sense of belonging. The result of achieving communal goals is a feeling of peace, engagement, empathy, and connectedness (Diekman et al., 2017).

The communal goal congruity model suggests that if communal goals can be better addressed, then more women would be inclined to matriculate through their STEM programs and be retained in the field. Furthermore, women would have a greater sense of belongingness and self–efficacy toward STEM programs, which would enhance their desire to persist through STEM programs.

Further, this research is consistent with the goal congruity theory explanation of the gender gap in STEM majors (Diekman et al., 2017), while offering an extension with respect to STEM majors. Although women who do not enroll as STEM majors may be motivated by social impact goals, research suggests that those who are retained also place a high value on those goals. Women across a wide range of majors place importance on helping others (Diekman & Steinberg, 2013). Communal goals may also affect the post–graduate activities of women and explain why a high percentage of women in STEM majors are not employed in STEM fields later in life (Martinez & Gayfield, 2019).

## Review of Research

Our research examines factors that contribute to the retention of women in STEM degree pathways. More specially, our interests included Factors that Contribute to the

Retention of Women in STEM; the impact of Self-Efficacy and Self Belief; and in our research we discovered that additional research was needed to address issues of Social Justice, Intersectionality and other salient examples of progress such as Earning College Credit in a Secondary Setting, the Influence of Non-STEM and STEM specific AP Examinations. Lastly, we discovered what leading scholars in the field posit as important factors for the retention of women in STEM, namely, the consequences of STEM Gender Stereotypes and the benefits of STEM Access in High School.

**Factors that Contribute to the Retention of Women in STEM**

Literature indicates that there are varying external factors which contribute to self–esteem among women who pursue degrees in STEM. Blackburn (2017) analyzed literature during the decade of 2007–2017 in which she discussed factors related to the retention of women in STEM majors in postsecondary education and their persistence toward degree completion. She found that retention can be improved with interactive engagement in classes, mental health resources, and tutoring programs. Persistence and progress are impacted by several variables: internal motivation or commitment, perceived support from advisors, adequate pre–college education, classroom success, resilience towards gender stereotypes, support from family, support from the campus community, and a strong women peer group (Blackburn, 2017). She also determined that some barriers related to the retention and persistence of women in STEM include affordability and availability of programs.

Additionally, unwelcoming learning environments cause women to associate STEM as male oriented majors, which leads to the scarce participation of women.

Unwelcoming environments also can force women to face gender stereotypes, which suggests that men are expected to be more competent in math and science (Ramsey et al., 2013). In their study, the researchers found that women in STEM disciplines who described their environments as inclusive displayed more pride in their major and had more peer role models. The study also found that an intervention program to better support women in STEM decreased “stereotyping concerns and indirect STEM stereotyping” (Ramsey et al., 2013, p.377). This research study draws attention to the learning environment and its importance in the retention of women in STEM majors. The study also suggested that a possible solution for the retention of women in STEM majors could be intervention programs that enhance the learning environment.

**Self–Efficacy and Self–Belief**

Another study also identified self–efficacy and self–belief as variables connected to the impact of students’ learning environments (Green & Sanderson, 2018). The results revealed that ability, self–efficacy, and educational experiences played significant roles in women’s persistence in STEM majors. Self–efficacy was described as “an individual’s belief that he or she possesses the ability to accomplish a goal” (Green & Sanderson, 2018, p. 82) and “confidence in one’s ability to accomplish academic tasks” (MacPhee et al., 2013, p. 348). This concept can be related to Blackburn’s (2017) concept of learning environments affecting internal motivation and resilience towards stereotypes as discussed above. The ideas are bound by intrinsic confidence and self–belief. Green and Sanderson (2018) discuss educational experiences in relation to classroom experiences, a sense of belonging, campus life, and interactions with professors. These suggestions correspond with those from Blackburn, (2017) as she attributed retention and persistence of women in STEM majors to perceived support from advisors, classroom success, and support from the campus community.

Green and Sanderson (2018) utilized surveys administered by the National Center of Education Statistics from 2003–2009 and focused on different variables related to STEM persistence. One of their findings was that participation in school clubs was significant, especially regarding the college persistence of women in STEM majors. There was not any discussion on why this could be significant. However, extracurricular activities generally contribute to increased confidence, sense of community and belonging, and peer support (Foreman & Retallick, 2012; Pascarella & Terenzini, 2005; Ryan & Deci, 2000).

**Additional Research Needed**

Further research needs to be conducted on retention issues regarding women in STEM majors in Higher Education (Campos et al., 2022). Retention issues can be prevented by establishing inclusive and supportive environments. Further, the authors conducted a study utilizing a systematic mapping of literature to address the gender gap in STEM by applying research and educational innovation. The results revealed a gradual trend of published records about the retention of women in STEM from 2011 to 2021. This indicated that there has been a recent focus on keeping women in STEM majors. However, the number of articles and publications found in comparison to institutions in the STEM field was limited. The focal discovery was that while the retention of women in STEM has recently trended upward, there are not enough institutions involved in researching and implementing solutions to this issue.

**Social Justice: Intersectionality in STEM**

Intersectionality is a term used to describe how a person's various identities (i.e. race, sex, gender, etc.) impact lived experiences. For example, while studying the experiences of African American women in STEM, Morton and Nkrumah (2020) found links to their experiences to Critical Race Feminism (CRF), Intersectionality and STEM, a Concept of Resistance, and the Influence of Whiteness as Property in STEM, all of which will be illustrated further in this section. But in summary, they believe that success stories of African American women who persist in STEM disciplines distract from the racism and sexism they endure. Furthermore, the discrimination that they experience is overshadowed by representations of success (i.e. scholarships, fellowships) and illustrates negative realities of acculturation (Morton & Nkrumah, 2020).

As mentioned, Morton and Nkrumah (2020) named theoretical frameworks for resistance that centered Black women's voices, which include Critical Race Feminism (CRF), Intersectionality and STEM, a Concept of Resistance, and The Influence of Whiteness as Property in STEM, each providing voice to lived experiences and how Black women respond to those experiences. For example, the "CRF framework" or resilience against systems of oppression, illuminates the lived experiences of women (or girls) of color, whereas "Intersectionality and STEM" or positionality reinterprets the experiences of Black women through the lens of multiple identities. "The Concept of Resistance framework" (situated in Critical Race Theory) is motivated by social justice and details four types of resistance behaviors which include: reactionary behavior, self–defeating resistance, conformist resistance, and transformational resistance. And finally, The Influence of Whiteness as Property in STEM is a framework that Morton and

Nkrumah (2020) used to illustrate the legacy of white privilege in the academy which normalizes whiteness and systems of oppression that commodifies the other. Their focus remains how women and marginalized groups achieve success in STEM fields.

Rosa and Mensah (2020) discuss how coloniality, which they define as a power system that emerged from colonialism, shapes our understanding of success and its influence on how we assess underrepresented groups in STEM. They "believe it is past the time for academia, particularly STEM fields, to value, recognize, and include multiple ways of knowing and producing knowledge that incorporates Black women's contributions" (p. 502). Analogous to Morton and Nkrumah and other scholars across disciplines, it is customary to compartmentalize scholarly work into frameworks.

Rosa and Mensah (2020) continue to explain that through colonialism the social construct of coloniality was created, a belief that centers on binary systems of being (i.e. White/Black; superior/inferior). For example, in place of learning that from Africa many of the world's greatest scholars and philosophers originated, Black children were taught to believe that they were inferior to whites in every way, both directly and indirectly. And this is poignant because they believe that the feeling of isolation that many women and people of color experience in STEM is a direct byproduct of colonialism and therefore designed with a hierarchy of whiteness as the standard.

In order for women and people of color to thrive in the STEM professions, the discipline must be decolonized (Rosa & Mensah, 2020). Success in STEM disciplines also requires redefining colonial notions of superiority and the inclusion of more women and people of color to the canon while recognizing white heteronormativity (Rosa & Mensah, 2020).

According to Smith and Willison (2021), careers in STEM disciplines across the United States are growing each year, but the number of college students graduating from STEM programs in general is decreasing. They also confirmed that of the students who leave STEM majors, the number of women and minority groups is even higher. They speculate that the rigor of STEM curricula (i.e. amount of material covered, time spent in labs, and the structure of exams) is a factor that impacts STEM persistence. But even under those circumstances, they reached a consensus that peer engagement positively impacts the retention of STEM students (2021).

Chapman et al., (2019) also found that careers in STEM fields are growing, but colleges and universities do not recruit enough STEM majors to keep pace with the demand. Furthermore, while the cost of college rises, fewer students are graduating with degrees in STEM fields. Though again, in order to retain marginalized groups that are underrepresented in STEM fields, colleges and universities are providing support via mentoring, funding, and other resource structures.

Generally, the research on STEM majors focused on different segments of the student population and in some cases narrowed that concentration from underrepresented minority (URM) groups to African American students specifically, however, Park et al. (2021) sought to find the benefit of students who work together in peer groups cross–culturally. They allude that introductory STEM courses are large, instructors have fewer opportunities to aid students internships and other opportunities, but friendships among students become a lifeline for retention. They continue to hypothesize that African American and other URM are already marginalized in society, and because they experience isolation as STEM majors, the likelihood of finding friends in their major is slim (Park et al. 2021).

The researchers attest that students of all races and socio–economic statuses benefit from cross–cultural interactions, but societal stereotypes stifle would–be symbiotic relationships. For example, they notice that male students are reluctant to seek guidance from female peers for fear of appearing weak, and female students are hesitant to solicit assistance from their male counterparts for fear of sexual harassment (Park et al., 2021).

While colleges and universities endeavor to address these and other issues, research validates that culturally diverse friendships on college campuses are healthy. Moreover, those relationships mirror the professional environments that students will encounter in the workplace, and the collegiate environment should be the training ground in which all students feel supported in preparation for their careers.

**Earning College Credit in the Secondary Setting**

A potential explanation for unequal representation among women in STEM fields of study and careers is a decreased enrollment in STEM courses while matriculating as a high school student in comparison to men. As high school students, women take fewer Advanced Placement (AP) courses in STEM subjects (Koch et al., 2022). The courses that students complete while enrolled in high school are strong predictors of persistence toward undergraduate degree completion. Student exposure to rigorous courses aid in the development of the knowledge and skills needed to persist as a college graduate. Evidence suggests that mere participation in the completion of an AP examination, regardless of the score, leads to greater persistence (Ackerman et al., 2013).

AP courses are introductory college courses that students are offered while enrolled in high school. AP courses are  associated with the rigorous standards enforced by the College Board through its use of end–of–course examinations. Performance on an AP examination is evaluated by a scoring system of 1–5, and each score receives a recommendation in relation to earning credit for a college survey course. A score of 1 receives no recommendation for college credit while a score of 5 implies that a student is extremely well qualified to earn credit for a general education survey course (College Board, 2022). Based on policies at the college that a student attends, a score of 3, 4, or 5 will replace the requirement that a student must enroll in and take the survey course as part of their general education requirements.

AP coursework has many possible benefits for college freshmen. Success on an AP exam ensures that student admission to college would be supplemented with college credit. This can be advantageous to precocious students who already know the major that they wish to declare. The state of Missouri recently passed legislation requiring its public universities to accept AP scores of 3 or higher for credit (Missouri SB 718, 2022). The policy measure enacted by the state allows students to obtain an undergraduate degree at an accelerated pace because they accept AP credit that students earn while enrolled in high school (Evans, 2018).

## Influence of non–STEM and STEM Specific AP Examinations

AP STEM exams are disseminated for the following subjects – biology, calculus, chemistry, computer science, environmental science, physics, and statistics. Non–STEM exams are disseminated for the fine arts, humanities, and social sciences. There is a positive correlation among female students who graduate with a STEM undergraduate degree and take STEM AP exams while in high school, including those students who do not achieve a passing score on the AP exam (Diekman et al., 2015). Those who earn a score of 3, 4, or 5 exhibit an even greater likelihood of earning a STEM degree, representing 29% of female STEM degree recipients in comparison to 12% of those who did not take STEM–related AP exams (Smith et al., 2019). Those students who perform exceptionally well on an AP exam, earning the highest score of 5, are more likely to major in the corresponding subject (Avery et al., 2018).

## STEM Gender Stereotypes

The myth which implies that the performance of women in STEM fields is inferior to that of men has been dispelled. Performance on STEM examinations in which test takers scored a three or higher on the AP test was nearly identical when comparing the answers of women and men (Ackerman et al., 2013). Collegiate female STEM students have fewer preconceived notions regarding their ability (Dunlap & Barth, 2019).

Research conducted on women who were admitted to college with the intention of studying STEM indicates that white women are less likely than women of color to declare a STEM major, yet white women are more likely to persist toward completion of a STEM undergraduate degree (Park et al., 2022). This may indicate that racial identity is more salient than gender identity in relationship to undergraduate persistence in STEM fields of study (Boyd–Sinkler et al., 2022).

## STEM Access in High School

There is rich quantitative evidence regarding the lack of female representation in STEM majors and careers. These studies provide information related to the retention of freshmen students, persistence to undergraduate degree completion, and relationships between coursework in high school and possible relationships to persistence (Walczak et al., 2019). There is a dearth of literature related to the qualitative exploration of the retention of undergraduate women in STEM using the voices of those women.

Reducing barriers to AP course access and exams in high school would benefit all students, particularly underrepresented students who pursue STEM career pathways. The positive influence of STEM AP courses on STEM major selection and persistence indicates an increased attention to navigate students towards STEM AP courses in high school (Ackerman et al., 2013).

Missouri has begun the process of developing policy measures at the institutional level to accept a wider range of AP scores for collegiate credit. Policy makers should be cognizant of the financial barriers for families who are making an effort to access AP exams. The cost of AP exams at $97 per exam (College Board, 2022) can be prohibitive and an extra financial burden for families, particularly for families of students from underrepresented groups who have a background with lower socioeconomic status. Policy measures could be further revised to cover exam fees in the state funding formula for public schools which would give those from underrepresented groups in STEM – females, Black, and Hispanic populations—greater opportunity to persist in STEM toward an undergraduate degree.

## The Impact of Extracurricular Activities on Women in STEM Programs

Another potential factor that impacts the persistence of women in STEM–related activities is participation in extracurricular activities. These activities include involvement in STEM student organizations, summer programs and work–study in the form of paid assistantships. Extracurricular activities provide students an avenue to participate in meaningful connections while engaging with students and mentors by means of allowing an outlet for them to learn, grow skills, function as a team, and relieve stress (Almukhambetova et al., 2023; Brown & Johnson, 2018; Buckley & Lee, 2021; Jenkins & Cho, 2013). Extracurricular activity can be defined as an addition to the normal course of study, and therefore, generally, not required by the college.

Palmer and colleagues (2011) argue that on–campus activities which are unrelated to a STEM student's discipline can have negative effects on persistence for underrepresented minorities. There is also evidence that "the 'chilly campus climate' of Predominantly White Institutions (PWI)" (Palmer et al., 2011 p. 493) has been linked to attrition among underrepresented minorities who are enrolled in STEM programs (Palmer et al., 2011). Similar psychological barriers also impact women who also face unique challenges in postsecondary STEM programs (Charlesworth & Banaji, 2019; Perna et al., 2009). Barriers to success include inadequate academic preparation by elementary and secondary schools, inadequate attention to psychological barriers such as stress and anxiety that negatively impact persistence, and inadequate financial support from colleges and universities (Makarova., 2018; Perna et al., 2009). Several issues make the achievement of STEM education and careers for women difficult. Extracurricular activities can help underrepresented minorities overcome adversities despite the barriers that they encounter in STEM programs.

Extracurricular activities enhance learning and student life while improving happiness, belonging, and social connectivity among students, thus leading to retention (Artinger et al., 2006; Fish et al., 2015; Pascarella et al., 1995; Potuto & O'Hanlon, 2007). Additionally, mentors remove some of the barriers when they engage with students in extracurricular activities to enhance their learning environment and campus communal experience (Fuesting et al., 2019; Tinto, 1975). Conversely, when students feel a lack of motivation from either faculty or mentor support, they encounter discouragement within their learning communities (Ryan & Deci, 1990; Tinto, 1975). Thereby, leading to disengagement from activities, and may attribute to factors which lead to disinterest of the college itself (Rocconi, 2010). Extracurricular activities produce levels of intrinsic motivation (Ryan & Deci, 1990) which can enhance the self–efficacy of women in STEM (Almukhambetova et al., 2023).

Extracurricular activities alleviate stress and anxiety which hinder the matriculation of women in STEM programs. However, students involved in activities outside the traditional curriculum, such as clubs or sports, improve their success in college (Astin, 1999; Long & Caudill, 1991). According to a cross–sectional survey of 205 STEM students conducted by Fares and colleagues (2016), extracurricular activities correlated with reductions in stress and an increased sense of community, particularly for women who were more likely to experience burnout. Extracurricular activities assist with the enhancement of the student collegiate experience (Buckley & Lee 2021; Fish et al., 2015; Pascarella et al., 1995; Potuto & O'Hanlon, 2007). For example, a study conducted by Mikulec & McKinney (2014) found how students on the equestrian team relieve stress, while one student stated, "The only thing I hoped to get as a member of this team was a group of friends that I could relate to and who would support me throughout my college career," (p. 98). The participation in such activities provide a sense of belonging which fulfills a component of communal goals (Diekman et al., 2011). These ancillary activities provide women in STEM programs a measure of relief from the rigor of their studies with an outlet to rejuvenate and relieve stress and anxiety (Boucher et al., 2017; Fares et al., 2016; Haverila et al., 2020). Furthermore, these activities offer connections to mentors and peers and alleviate stress (Diekman et al., 2010; Diekman et al., 2011).

In addition to alleviating stress, extracurricular activities facilitate success for women in STEM programs. Researchers Ferguson and Martin–Dunlop (2021) discuss success stories among underrepresented minority women in STEM programs who overcame various forms of racism through experiences and connections gained from extracurricular activities. Many of these women attained scholarships, completed AP courses, and received family support to help them become resilient when they encountered obstacles (Ferguson & Martin–Dunlop, 2021). Extracurricular activities aided these women to persist in STEM programs during the hardships, stress, and rigors of coursework. Furthermore, according to VanMeter–Adams and colleagues (2014), students are more likely to gain self–assurance and passion for STEM programs due to their engagement in extracurricular STEM activities.

**Creating community**

Creating a community allows cohorts of students to share experiences and communicate openly with each other (Diekman et al., 2010; Diekman et al., 2011). Women tend to perform well in environments in which social engagement is frequent (Inkelas, 2011; Perna et al., 2009; Szelényi & Inkelas, 2011).

Research conducted by Diekmann and colleagues (2017) suggests that individuals will seek various paths to fulfill communal goals:

> Individuals might also fulfill communal–goals through extra–role activities – that is, through family or community roles outside of STEM. Individuals whose communal goals are not fulfilled by their careers may increasingly devote time to family or community as a way to fulfill those communal goals. (p. 160)

Clubs that integrate community service needs, student government, tutoring, etc., contribute to the satisfaction of communal goals for women in STEM programs, as women benefit from helping others and receiving help and companionship from like–minded people (Blackburn, 2017; Diekman et al., 2017; Ferguson & Martin–Dunlop, 2021). Diekman et al. (2015) emphasize that extracurricular efforts that integrate communal goals alongside a topic of study are advantageous for women who contemplate enrollment in  STEM programs. Further, extracurricular activities construct an avenue for women in STEM programs to persist, as these activities provide a communal opportunity to restore the leaky pipeline and build self–efficacy (Almukhambetova et al., 2023; Inkelas, 2011; Perna et al., 2009; Szelényi & Inkelas, 2011).

Using a case study methodology, Perna et al. (2009) sought to understand the contextual conditions that sculpt the achievement of underrepresented minority women in STEM fields. They found that minority women in STEM perform better in cooperative relationships with peers. Peer to peer cooperative and competitive culture encourages students to participate in planned activities among friends that strengthen the concept of bonds among students, while faculty encourage study groups that stimulate student success (Perna et al., 2009). Students witnessing their colleagues successfully practicing research encourages them to participate in research as well, which leads to a supportive, cooperative, goal–congruent learning environment (Perna et al., 2009). Using in–depth interview methods for a study conducted a study at a public, mid–size research intensive PWI, Palmer and colleagues (2011) evidenced the importance of the following STEM–related extracurricular activities: “1) involvement in STEM student organizations; 2) becoming a teaching assistant; 3) participating in STEM summer programs; and 4) interacting with alumni and those in professional STEM fields” (Palmer et al., 2011 p. 495).

Palmer and colleagues (2011) found that peer support is essential for success in both social and academic arenas; participants value involvement in STEM–related activities; and the participants of this study believed that STEM programs were successful “when they fostered a sense of community among faculty, students, STEM alumni, and professionals in STEM fields” (Palmer et al., 2011 p. 501).

Student success, as Kuh et al. (2006) pointed out, has two critical features that impact learning opportunities: investment of student time and effort in their studies and purposeful activities and the institution's use of its resources towards organizing the curriculum and support services. Belanger and colleagues (2017) suggest that when curriculum designers fuse communal experience with learning activities, whether inside or outside the classroom, these experiences produce positive effects for underrepresented minority students. Extracurricular activities provide an avenue for the persistence and retention of women in STEM programs (Kuh et al., 2006; Palmer et al., 2011).

Faculty and staff play an integral role  of heightening student awareness of extracurricular activities (Ceglie, 2021). When they help students utilize their peer network, the burden is alleviated for students who are in search of extracurricular activities to keep them engaged. If underrepresented minorities and women are connected to their peers earlier during an academic term, it allows them to forge new relationships that grow as students participate in study groups and STEM–related clubs and organizations (Boucher et al., 2017; Ceglie, 2021). As Hambley (2020) points out, humans feel connected to each other and organizations when the members have congenial thoughts and opinions, therefore, women in STEM programs forge bonds as they understand and sympathize with each other and endure similar experiences (Margolis et al., 2000; Pietri et al., 2019). Women in STEM programs may bond during the hardships previously mentioned, nonetheless extracurricular activities such as team sports, clubs, performing arts, etc. bolster matriculation of women in STEM disciplines (Eccles et al., 2003; Kim & Meister, 2022).

**Impact of Work–Study on Women in STEM**

While extracurricular activities generally support women who are enrolled in STEM programs, they also alleviate various issues pertaining to stress and isolation. Work–study opportunities offer financial support while aiding students in the attainment of communal goals (Carver et al., 2017). For example, Carver et al. (2017) argued that funds, including Federal Work–Study, can be used directly to employ students, increase GPAs, and encourage students to create a community. OpSTEM was created at Cleveland State University to help first–generation college students, underrepresented minorities, and women pass precalculus (Carver et al., 2017). Participants were placed in a summer program in which student mentors were funded by Federal Work Study, two National Science Foundation grants, and Cleveland State University. The program resulted in an increased pass rate (Carver et al., 2017). As stated by Perna and colleagues (2009) and Szelényi and Inkelas (2011), women in STEM programs tend to persist in environments in which they receive support from peers, teachers, family and their respective institution. Women in STEM programs must receive financial support and it must be related to achieving communal goals (Palmer et al., 2011; Perna et al., 2009).

The Federal work–study program was created to promote part–time employment among low–income students (Campus Compact, 2008; Davis & Silverman, 2022). An important feature of this initiative was to prepare individuals for the workforce, community service, various arenas of human advancement, and community enhancement (Campus Compact, 2008; Davis & Silverman, 2022). Students in work–study programs have acquired an improved understanding of technical skills and increased self–efficacy related to their area of study (Carver et al., 2017; Kenny et al., 2015; Lim  et al., 2020; Scott–Clayton, 2017; West  et al., 2021; Zhang & Schmidt–Hertha, 2020).

**Financial Benefit**

A lack of financial aid can hinder persistence for students, particularly underrepresented students (Palmer et al., 2011). In addition, many students suffer academically because they are unable to focus on their academics, as they are overwhelmed with working in order to fund their education. However, overworking is the primary means by which  many non–traditional students can afford to attend school (Perna et al., 2009). Retention increases when financial needs are met (Broton et al., 2016; Olbrecht et al., 2016). The results of a study by Broton and colleagues (2016) evidenced the effect of a grant for students who worked while in college. Students who received increased grant funds worked fewer hours than those who received no grant. Working long hours has been known to have a deleterious effect on GPA and retention overall (Broton et al., 2016; Perna et al., 2009; Ramos et al., 2021; Scott–Clayton, 2011).

There is a financial benefit for students who assist faculty with research projects (Carver et al., 2017; Palmer et al., 2011; Perna et al., 2009). Perna and colleagues (2009) argue for work–study opportunities and undergraduate teaching assistantships for underrepresented women in STEM. Additionally, both Carver and colleagues (2017), as well as Perna and colleagues (2009) have seen success with the use of paid peer tutors to assist students. Perna and colleagues (2009) state that at Spelman College, the faculty nominates high–achieving students for paid tutoring positions. Students can access grants, scholarships, and fellowships to participate in research at postsecondary institutions.

**Art as a Study Tool**

There is not a lot of research on the arts and STEM programs, however, with new approaches to culturally responsive pedagogies, more research may be on the horizon. Students begin their college experience influenced by their lived experiences. STEM fields involve generating ideas, as Waingurt and Sloan (2019) believe that women who find vocation therein bring unique skill sets. They also propose that interdisciplinary pedagogy aid in the persistence of STEM majors. In fact, the researchers explain that "STEAM (STEM + the Arts) is an educational approach to learning that uses Science, Technology, Engineering, the Arts and Mathematics as access points for guiding student inquiry, dialogue, and critical thinking" (p. 13). The researchers acknowledge that interdisciplinary approaches produce critical thinkers who will add to the knowledge base in STEM fields. Furthermore, while discussing interdisciplinary subjects and STEAM, they argued that some of the most innovative thinkers in STEM fields are also creatives, a term used to describe people who have an artistic practice (e.g. painters, poets, dancers, etc.).

Speaking of lived experiences, Beutel and colleagues (2018) believe that there is a correlation between engendered behavior in society and deciding on a major in college. In addition, they infer that societal norms, based on gender, impact student selection of science, technology, engineering, and mathematics (STEM) majors. Specifically for women, gender performance in society (i.e. caregiving, child–rearing, etc.) leads to careers in the humanities that involve caring for others such as English, Philosophy, Social Work and others. These and additional factors contribute to a lack of confidence for women who are interested in STEM.

Beutel and colleagues (2018) also found that for female high school students, standardized test scores, grades, parental education and socioeconomic status (SES) influence decisions related to selecting a major area of emphasis in college. They speculate that female students with a lower SES pursue STEM fields while those from more affluent backgrounds pursue a major in the humanities. This suggests that for female students of color and African Americans from a lower SES background, a career in STEM could provide the lifestyle that leaves poverty in the past while ubiquitously affording opportunities for female students from more affluent backgrounds with careers that enable them to guide others. For women on either end of that spectrum, research supports that there are a myriad of factors that impede student success.

Student success varies from student to student, and societal roles become a barometer by which many students, across disciplines, measure self–efficacy. McKinney and colleagues (2021) report that among the variables that impact women’s decisions to become STEM majors, stereotypes, parental influence, and self–efficacy are the most discouraging. Also influential are societal norms (e.g. boys are better at math) which lead to issues of self–esteem that females experience while learning mathematics during their formative years. Additionally, gender normativity, coupled with math anxiety, shape preconceived notions that discourage women from entering STEM fields. Prior achievement in mathematics attributes to self–efficacy and interest, to which McKinney and colleagues (2021) attest as one of the leading successful factors for female STEM majors. Women who achieve academic success in mathematics develop the confidence to pursue more challenging subjects. Research claims that support for female STEM majors could reduce gender disparities in the field.

Gibson and colleagues (2019) reported that incoming freshmen at a private liberal arts college with an interest in STEM were unprepared, and standardized test scores implied that those students would not matriculate. In response, the college implemented pedagogies to stimulate student success (e.g. first–year seminar courses, learning communities, and bridge programs), to name a few. The researchers determined that colleges and universities have programs designed to support student success, but additional academic support for female STEM majors is needed. Also, the researchers argue that women who pursue careers in science, technology, engineering, and mathematics offer companies necessary holistic perspectives that enrich the lives of everyone, perceptions that include historically underrepresented populations.

With regard to arts and student retention, data from a study by O'Leary and Thompson (2019) suggests that the relationship between drawing a visual image and comprehension may be critical to the function of memory cognition. They theorized that creating a piece of poetry or composing a song or visual art would necessitate that students retain information, naturally leading to elaboration on the information that has been provided (O'Leary & Thompson, 2019). In one study of 55 students that consisted of twenty–eight 5$^{th}$ graders and twenty–seven 6th graders, Rosier et al. (2013) found that drawing activates several regions of the brain which leads to an improved capacity for the reception of information. Not only does art implementation increase learning ability by increasing the brain's capacity to learn art–related extracurricular activities, but extracurricular activities also play a massive role in retention. According to Bovoes–Hammuth et al. (2000), research suggests that students of color learn best in collaborative and supportive educational environments.

As faculty consider efforts to retain female STEM students, interdisciplinary pedagogies have become a viable option in recent years. For example, Kamen and Leri (2019) used field trips to replace lectures and Instagram posts as a substitution for papers for their first–year experience STEM students, which included females and underrepresented students of color enrolled in a liberal arts college in New York. They found that hands–on and artistic approaches to STEM curricula helped female students remain engaged and encouraged to persist. In conjunction with the academic rigor of the discipline, they found that some of the challenges for female STEM majors was a lack of mentorship, sense of community among fellow students, and overall support. The researchers discovered that lack of peer mentorship, in concert with faculty support, aided in feelings of isolation among female STEM students.

Other scholars equally concerned with the persistence of female STEM students, such as Dahle and colleagues (2017), explain the correlation between women who remain

STEM majors and women who remain in engineering fields post–graduation. Analogous to how many female STEM majors feel on campus, unfortunately, the pattern persists for those who become professionals. Moreover, the feeling of loneliness is heightened for African–American female STEM students who are already marginalized in the broader society and are often without peers or mentors to whom they can relate.

As other scholars have surmised, Chapman et al. (2019) disclosed that female students and students of color benefit from instructor mentorship, peer–to–peer relationships, and opportunities to build community among their cohort. Rainey and colleagues (2018) also examined a sense of belonging among students, observing that it has a tremendous effect on persistence for female STEM majors. Among many factors, the intersectionality of students' identities (e.g. race, class, gender, sexual orientation) impacted student experience. For example, an African American female may encounter discrimination in society based on her race and within her own community based on her gender. On a college campus, this student may face similar challenges, yet again, the student may benefit from developing relationships with other female students. To be successful, STEM majors form meaningful friendships.

## Chapter 2: Methods and Design for Action

Women in STEM majors face societal barriers in addition to academic challenges, which prevent many from matriculating into a degree program. More specifically, high school preparation, collegiate academic environments, academic performance, and self–efficacy, are among those challenges; but one of the major factors that affect the retention of women in STEM disciplines is the shortcoming of achieving communal goal congruence (Beutel et al., 2017; Diekman et al., 2017). As previously stated, researchers articulate that successful STEM majors work together in groups, however women are often not included in male dominated groups (Kamen & Leri, 2019). Furthermore, researchers affirm that stereotypes for women directly impact self–efficacy within those fields of study, reinforcing patriarchal societal norms (Beutel et al., 2017; Campos et al., 2022; Diekman et al., 2017; Hand et al., 2017). Given those challenges, when students work together, they achieve success in collegiate learning environments. Membership and belonging are essential, and it is critical to understand how the lived experiences for women in STEM programs impact retention, supporting the communal goal framework (Dahle et al., 2022; Diekman et al., 2017).

## Research Design & Research Questions

Our research is guided by the following questions:

**RQ1:** To what factors do women in STEM attribute their decision to matriculate through degree completion?

**RQ2:** How does Advanced Placement coursework in high school impact the retention of women in STEM?

**RQ3:** How do extracurricular activities (including student organizations and work study) impact the retention of women in STEM?

**RQ4:** How could engagement in art as a study tool (color coding, listening to music, drawing, etc.) impact the retention of women in STEM?

We will utilize a basic qualitative study to discover salient factors that improve the retention of women who pursue STEM pathways. Our research will discover the meaningful experiences that women have in relationship to the factors that improve retention. For example, previous research indicates that rigorous STEM coursework in high school has a positive influence on STEM undergraduate degree attainment, yet there is still a vast underrepresentation of women who enroll in these courses (Ackerman et al., 2013; Krakehl & Kelly, 2021; Wyatt et al., 2020). Women who matriculate in an undergraduate STEM program build community networks and work experience when they actively participate in extracurricular activities (Akos et al., 2022; Simmons & Chau, 2021). In turn, these factors lead to high self–efficacy for women who were retained as STEM majors (Diekman et al., 2017; Guevara–Ramírez et al., 2022). Our epistemological approach is that of a postmodern perspective which seeks to learn how knowledge is constructed (Merriam & Tisdell, 2016; Saldaña, 2011). We have learned that these factors have improved the retention of women as they matriculate in an undergraduate program. We wish to further discover the meaning women attribute to their experiences related to the identified salient factors.

Qualitative research design is a systematic approach to conducting research that seeks to understand and interpret the complexities of human behavior and experiences to further understand phenomena. Qualitative research emphasizes gathering and analyzing non–numerical data, such as text, images, or observations, in order to gain insights into the meaning and context of a particular subject (Merriam & Tisdell, 2016). The researchers are particularly interested in understanding the experiences of undergraduate women in STEM majors, ultimately allowing us to have a greater understanding as to how they construct their experiences in the context of a particular university setting. We are hopeful that this will illuminate the support that undergraduate women in STEM deemed meaningful, which will contribute to the retention efforts that we will recommend to universities in order to increase the amount of women in STEM disciplines.

**Participants**

The participants will consist of 10 to 12 female students who have completed 48 credit hours and also completed four semesters at Missouri University of Science and Technology; many of these students are classified as juniors and seniors. These will be students who are currently enrolled in STEM majors. Missouri S&T academic advisors and admissions staff will suggest potential STEM majors from which we will select our sample. Staff in these positions work directly with female students in STEM programs and toward university retention efforts; therefore, they will have knowledge related to the subject and personal experience with female students. This study will use a homogenous sampling process, as only female respondents who have completed 48 credit hours and four semesters as STEM majors will be selected. This study will not use male students, and the female students can only be selected by advisors and admission staff.

The participants will have similar characteristics. To ensure the credibility of our findings, multiple members of the group will create themes and categorize information from interviews (Gulen, 2019; Palmer. et al, 2011). We will maintain the confidentiality of the names and email addresses of the participants. We will protect all personally identifiable data with computers and digital devices that require passwords. We will delete any email addresses, phone numbers, and names at the conclusion of our research.

**Data Collection and Specific Practices**

We will conduct a qualitative research project that examines the student's perceptions of early access programs, the importance of arts integration, the impact of extracurricular activities, as tools for the retention of women in STEM programs. We will receive student participants from admissions and advising staff at a public university, Missouri S&T.

### *Sample Size*

This study will be a basic qualitative study using a purposeful sampling approach. The objective is to identify and offer potential solutions to the problem of a lack of retention of women in STEM programs. We will use homogeneous sampling to collect qualitative data for our study. Using the homogeneous sampling method that is integrated within the purposeful approach, we will interview students within the STEM programs. Similar to Gulen (2018), our aim with this sampling strategy is to analyze a group with similar features (Creswell & Guetterman, 2019).

### *Instrumentation*

We will consult advisors and admissions staff to identify women who have completed a minimum 48 credit hours and four semesters within STEM majors at Missouri S&T. Qualitative research allows an interviewee to have a voice, expressing and explaining their views on how institutions should retain women in STEM programs (Creswell & Guetterman, 2019). The researchers will interview students who have completed 48 credit hours and four semesters because they have been retained for an extended period of time in their respective degree programs (Palmer et al., 2011). These participants can provide information related to their experiences as a STEM major. This information can infer why their peers have been retained in STEM majors as well (Patton, 2015). We will employ the semi–structured interview format because we would like to invoke participants to discuss the experiences that have aided in their retention (Smith, 2008). We will also use a paired interview style in which one male interviewer is paired with one female interviewer, as our team is composed of two males and two females. We will assign all participants a pseudonym to protect their identity. We will maintain field notes that will consist of identifying information. Analysis of our data will sift out commonalities then reveal content applicable to the retention of women in STEM programs.

We will select students for 45 to 60–minute interviews. We will ask participants 20 interview questions related to early access programs, arts integration, and extracurricular activities and their impact on the retention of STEM majors. During these interviews we will search for themes related to early access programs, arts integration, and extracurricular activities during the coding process. We will record the interviews on Zoom. However, interviews will also be captured with a recording device to ensure that the data is collected.

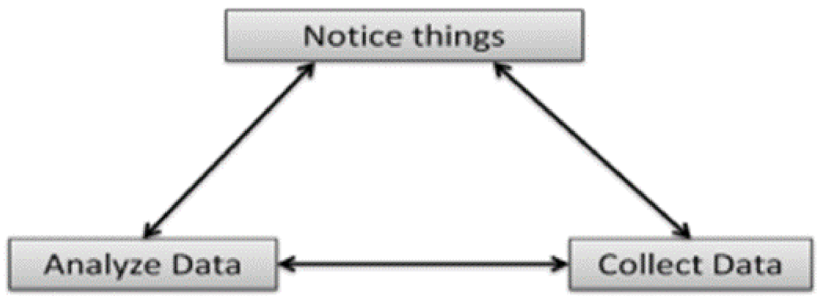
### ***Description of Data Analysis***

Once we have conducted our qualitative study, we will use Zoom and Ottr software tools to transcribe the interview results and analyze our data with Qualtrics. Qualitative data analysis consists of three main aspects: noticing, collecting, and thinking about interesting things (Elliot, 2018; Khandkar, 2009). We will have already noticed and collected the data utilizing interviews. To "think about interesting things" (Khandkar, 2009, p.1) we will apply the practices of open coding, axial coding, and selective coding.

Figure 2.1 shows that data analysis is a continual process. In conducting a qualitative study we will collect data, analyze it, find themes and common concepts ("notice things") and continue the process as we code our interviews.

**Figure 2.1**

*Data Analysis Process*




*Note.* Workflow of Qualitative Data Analysis. Adapted from *Open Coding* by S. Khandkar p. 1. Copyright 2009 by University of Calgary.

Open coding is the preliminary step in data analysis. When utilizing open coding, the objective is to identify similar terms and phrases in order to identify common concepts (Connell and Lowe, 1997; Khandkar, 2009). Common concepts that are discovered through open coding will result in the formation of categories or themes (Vollstedt & Rezat, 2019). Furthermore, open coding can begin to answer questions of what is the phenomenon that is occurring, who is involved, how is it occurring, and why is the phenomenon occurring.

Open coding can be conducted manually by printing the transcribed interviews and analyzing them for common phrases and terms. A less biased, simpler, and more time–cognizant method is to utilize software (Ottr). We will manually code and use software to conduct the open coding portion of our analysis.

Once opening coding has been conducted, we will exercise axial coding. Axial coding involves taking the concepts found in open coding and further developing categories and themes. The main objective of axial coding is to explore and identify relationships between the concepts and categories (Vollstedt & Rezat, 2019). Axial coding specifically considers the causes of the phenomenon, specifically characteristics of the environment, along with the conditions that stimulate its occurrence. Other aspects identified through axial coding are the intervening strategies that influence the interaction between the concepts and the categories developed and factors that can overcome the phenomenon (Vollstedt & Rezat, 2019).

Axial coding will be performed by our research team. We will analyze the results of open coding. We will identify linkages in the concepts that form themes related to the phenomenon of the shortage of the retention of women in STEM programs. The goal of axial coding is to begin to identify the common cause for the phenomenon and factors that impact those causes.

Following axial coding, we will conduct selective coding which is similar to axial coding but it assesses additional details. Selective coding utilizes an abstract perspective, and our team will think in terms of theorizing the phenomenon (Vollstedt & Rezat, 2019). Selective coding will lead us through the process of choosing a core category and linking it in conjunction with the categories identified during the axial coding process. The core category is described as “the central phenomenon around which all the other categories are integrated” (Strauss & Corbin, 1990, p.116). Upon completion of the selective coding process, we should identify the main causes of our phenomenon and begin to develop solutions.

Selective coding will also be conducted by our research team, and we will analyze the results on an abstract and theoretical level. Our objective will be to condense our results as we identify explanations for why women are not retained in STEM programs and develop solutions.

### ***Developing Themes***

The themes that we will use to code and analyze our data will emerge from two sources: -the concepts that are identified through open coding and the concepts related to the Communal Goal Congruity conceptual framework (Diekman et al., 2017). Studies have shown that many of the issues surrounding the retention of women in STEM programs are derived from the need for women to fulfill their communal goals (Diekman et al., 2015; Diekman et al., 2017; Koch et al., 2022; Martinez & Gayfield, 2019; Perez–Felkner, 2018). We anticipate that our phenomenon will revolve around concepts and terms related to communal goals. Communal goals include relatability, altruistic purpose, selflessness, and collaboration (Diekman et al., 2017). Achieving communal goals enhances women's self–efficacy, which is their belief in themselves and their confidence to accomplish tasks/goals (Green & Sanderson, 2018; MacPhee et al., 2013). Communal goals also result in feelings of peace, engagement, empathy, connectedness, and a sense of belonging (Diekman et al., 2017).

Previous studies have indicated that satisfying communal goals will result in the retention of women in STEM disciplines. Based on previous research, we hypothesize that participation in advanced placement classes in secondary education, extracurricular (and work–study) programs in the postsecondary setting, and utilizing art as a learning tool will enhance the achievement of communal goals for women, thereby providing opportunities that can enhance the retention of women in STEM programs. As we conduct our coding analysis process, we will use the concepts that are discovered in the open coding process and we will also identify concepts relating to communal goals. We will evaluate additional connections related to these terms and themes in order to determine which factors impact the retention of women in STEM.

### ***Criteria Used to Define Improvement***

Upon the completion of the coding process, we intend to have several themes that will provide clarity and answer the research questions. We will refer to our conceptual framework of communal goals to identify relationships between our data and our research questions. Furthermore, we will also ground our data in the literature that we have previously discussed regarding the retention of women in STEM programs and the varying factors that can contribute to improving the retention of women in STEM.

After we complete our study, we will be able to identify trends in our research to answer the research questions and determine an improvement plan for the retention of women in STEM programs. We will identify trends and common themes as we code our participants' interviews.

## **Summarize Connections of Actionable Knowledge Reviewed**

In summary, female STEM majors endure varying levels of adversity on college campuses, more specifically within their major fields of study. Our research has supported that there is much yet to be done in terms of policy, learning environments, and curriculum development to aid female STEM students (Diekman et al., 2017). Our objective is to advocate for female STEM students. We hope to discover the strategies that students used to navigate cultural border crossings and communicate that information to future students. More specifically, we believe that if learning in groups (Communal Goal Congruence), participating in extracurricular activities and work–study programs, and using art as a learning tool aids in student retention, that data should be made available to administrators. We recognize that the curriculum in STEM fields is and should be rigorous, but our research supports that female STEM majors also manage the rigor of their programs in hostile learning environments (Gordon, 2018). To address the aforementioned barriers, we would like senior–level administrators to understand where additional support is needed because as administrators, they are the policy makers in academic institutions and are most likely to advocate for institutional reform.

Our research is also intended for future and current female STEM students who will encounter some of the same challenges as the population studied in our project. The application of our research will provide a litany of resources and best practices for administrators who institute policy for current and future female STEM majors. Our approach is to publish a practical learning guide that will contain sections that document student experiences and best practices for retention (see chapter four) for administrators and future and current female STEM students.

## Chapter Three Overview

Chapter three will feature our research that will be conducted at Missouri Science & Technology but in a condensed and analyzed format. Portions of the questionnaire, coding with explanation, responses to questions, and discussion surrounding those questions will follow in chapter three of this dissertation. We will base the following off of our data:

- justify an applied inquiry plan to carry out the improvement initiative
- inform the research questions
- document impacts of the improvement initiative
- makes strong case for how methods and designs of study address research questions by describing: the people involved the methods used the practices monitored and evaluated the criteria used to define improvement

**Chapter Four Overview**

What sets the practitioner's doctorate apart from the doctor of philosophy is the application of theory put into practice. In most cases, doctors of philosophy or PHD's conduct original individual research and then publish that research. Their works are often found in academic journals and other peer reviewed materials. For practitioners, in this case a doctor of education or Ed.D. the scholars also conduct original research, but are often set into research teams who publish their research in academic journals and peer reviewed materials, with the added feature of putting their theory into practice; an application of theory that constituents can use in real time, (e.g. books, learning models) and other materials.

As practitioners, we will create a guide for administrators and future or current female STEM students to use in real time. Set into two sections, one for administrators and one for female STEM students, our guide will be a conceptual framework based on the experiences reported and the successful strategies of the female STEM students that participated in our study. *EmpowHer: A Steminists Guide to Cultural Border Crossing* will be either independently published or published by an educational textbook publisher in the year following our research and will be the application of three + years of research and rigorous coursework.

The audience for our guide is robust, with STEM globally being a growing field and more specifically in the United States of America. We believe that more students will pursue STEM degrees in the coming years and at least half of those students will be women. So we endeavor to market and promote our guide to those students and to the administrators who govern policy on colleges and universities across the country. We have not developed a marketing plan, but to market our guide any member on our team of four researchers can attend conferences individually, or we can present collaborative work in hopes of helping more administrators, students, and parents understand the value of a holistic approach to learning.

## Chapter 3: Actionable Knowledge

Women account for approximately half of the country's population and one concern is that society suffers an economic and scientific loss due to a shortage of women in STEM as the breadth of subject areas explored is limited with less diversity of personnel (Syed & Chemers, 2011). Data suggests that women account for approximately 47% of the total workforce but only 29% of the STEM labor force (U.S. Department of Labor, 2021).

As previously stated, women continue to be undervalued as wage earners, and the wage gap continues to expand (Kenney et al., 2012; Gartsetein & Hancock, 2021). Furthermore, this is a societal issue whereby women and girls have historically been stereotyped to pursue work in fields such as education because, as teachers, women also serve as nurturers to their students, similar to the role of a mother. The stereotyping of women as only caregivers is part of the problem.

If more women were encouraged to pursue careers in STEM, there would be more diversity in research and development and women would have greater earning potential. Women contribute diversity in ideas and talent. The wage gap would be reduced, as women who pursue careers in STEM earn more than women who do not. An additional result is that the lack of women in STEM careers will negatively affect social expectations. If women are not represented in STEM, girls and young women are less likely to consider those occupations (Diekman et al., 2017).

Research indicates that girls who were exposed to women who have pursued STEM careers while in grade school, were more likely to pursue STEM as a career option, in part because those girls perceived the opportunity to work in STEM as a reality. Representation matters, especially for women and underrepresented minority groups who learn that their chosen fields of study are dominated by white males. The homogeneity of whiteness and maleness in STEM fields deters women and those in minority groups in the pursuit of those fields, so representation in STEM fields provides hope for women and minority groups to pursue STEM careers as part of the solution.

## Data Collection and Instrumentation

The process of data collection began after approval from the Institutional Review Board of the research proposal (Appendix A). Our objective was to conduct 10–12 interviews with female students who have completed 48 credit hours towards a STEM major and four semesters at Missouri University of Science and Technology (Missouri S&T). We interviewed 13 women who met the criteria. The participants' majors ranged from chemical, civil, aerospace, electrical, computer, and ceramic engineering to biology. The participants included white, Hispanic, Chinese, and women of mixed race.

To acquire our participants, we emailed professors and advisors from the following departments: Biology, Chemistry, Mathematics, Business – Information System Technology, Aerospace/Mechanical Engineering, Civil Engineering, Chemical Engineering, Petroleum Engineering, Computer Engineering, and Electrical Engineering. We felt that these areas of study would provide a quality representation of varying majors and opinions. The professors and advisors forwarded our information to students who fit our criteria and they believed they would be willing to participate in our study. The participants were then asked to read and sign the consent form to participate in the research study (Appendix B). Of our 14 respondents, we had 3 aerospace engineering majors and because we endeavored to interview a variety of female STEM majors, we decided to interview students from other fields within STEM.

Two researchers, one male and one female, conducted each interview. Interviews were conducted via Zoom and they were recorded. We asked 20 open–ended questions (Appendix C), and interviews ranged from 25–40 minutes in duration, depending on the answers. When we finished the interview process, we coded the interviews using Ottr and manually. We used the process of open, axial, and selective coding to identify themes and findings to answer each of our research questions.

### Analyzing Data and Emerging Themes

The process of data analysis took place while interviews were conducted and following their completion. We conducted interviews using ZOOM video conference technology and each was recorded and transcribed. During the interviews, we created analytic memos as participants answered questions. Those analytic memos served as an open coding system for reporting on developing themes prior to researchers transition to axial and then selective coding.

Following the interviews, we coded them, and the codes served as descriptive labels which highlighted participant answers to interview questions relevant to our research study. Themes and sub–themes began to emerge throughout the coding process. Based on initial codes, we were able to identify multiple emergent themes (early introduction to STEM, outreach programs, self–efficacy, the impact of COVID, and communal goals).

#### *Early Introduction to STEM*

A common theme that was emergent among research participants was an early introduction to STEM disciplines. This was described by the majority of participants as key to the identification of STEM as possible career pathways. Participants were introduced to STEM at a young age by family and K–12 institutions. In many instances, parental figures served as role models. These role models extended their influence to participant choice of profession. Participants described their exposure to STEM disciplines through coursework that was offered as early as middle school grade levels.

***Outreach Programs***

Many of the participants explained that they had participated in STEM–specific corporate partnerships. Multiple companies offer educational experiences that are aimed at the inclusion of women in STEM careers. Respondents described opportunities in which they had been selected to participate, both as secondary and undergraduate students. These programs were identified as major influences in the decision to enter STEM fields of study.

***Self–efficacy***

Participants revealed factors that positively impacted their self–efficacy in relationship to their ability to achieve academic success in STEM fields of study. These factors affirmed their scholastic abilities within their majors.

***The Impact of COVID***

An unexpected sub–theme that revealed itself was what participants referred to as “the COVID year.” The COVID year refers to the spring of 2020 when much of the world went into isolation to avoid the spread of COVID–19 at the beginning of the pandemic. Elementary and secondary schools and higher education institutions used online learning platforms instead of face–to–face learning. Participants repeatedly referred to COVID, whether it was used as a demarcation of time or as a factor that negatively affected their self–efficacy in relation to educational endeavors. Multiple participants related decreased levels of motivation. Participant 7, who was particularly high achieving while in secondary school, described her experience in relationship to COVID: "But then COVID kind of, you know, like, trickled into my senior year... And I took, I think, six AP classes that year. One of them was AP Calculus, and I got an A first semester, and then I transferred to an online class. And I got an F because I didn't do any of the work."

Participant 2 described the consequences of COVID–19 during her senior year of high school and how it affected her academic trajectory: "I failed every single one of my classes." This participant continued to describe the completion of coursework at a community college in order to subsequently transfer to Missouri S&T. These statements indicate that students experienced adversity related to their academic self–efficacy.

### ***Communal Goals***

As expected, communal goals are a major theme. Research participants discussed in great detail the importance of communal goal congruity in relation to their retention as undergraduate students. Participants described collaboration with other students via study groups, design teams, and laboratory work as central to their development as STEM students. In addition, many participants joined extracurricular groups, including the Society of Women Engineers and sororities, in hopes of finding a sense of belonging while enrolled as undergraduate students. As a component of extracurricular involvement, participants volunteered to aid the community in which they reside and this evolved into a sub–theme that served to reinforce the idea of altruism as key to retention at the university.

**Research Question 1: To what factors do women in STEM attribute their decision to matriculate through degree completion?**

Our research indicates that the women at Missouri S&T attribute their decision to study within STEM disciplines to several factors. Most of the women with whom we spoke shared that they discovered STEM programs while enrolled in K–12 schools. Some women have family members who are engineers and doctors, which influenced them to follow similar paths. In contrast, others were introduced to STEM by their teachers, visitors from STEM companies, or outreach programs dedicated to enhancing the educational opportunities for underrepresented minorities. Regardless of how girls discovered STEM disciplines, early exposure played an integral role in their choice to pursue STEM majors and careers.

The participants chose STEM majors because of early introduction; however, other factors, such as exposure to the field, led to their decision to be retained within STEM majors. These factors largely depend on the learning environment, finding friends, and supportive faculty and mentors. Each of these factors (exposure, a supportive faculty and learning environment, and peer to peer comradery) all relate to communal goals. The participants did share some of the challenges that they have experienced in the postsecondary environment, such as microaggressions from male peers and faculty, but most have been combated by the fulfillment of their communal goals.

**Family Background as Introduction to STEM**

A few participants indicated that their childhood experiences influenced their decision to study STEM in college. For example, 1 participant grew up in rural Missouri and shared a story about caring for the family's chickens. A chicken was caught in a raccoon trap, and she faced her fears of getting near the trap to help free the chicken and to care for it. This incident influenced her to focus her studies in the direction of caretaking via biological sciences and a pre–med track.

The career paths of parents or families also influenced other participants decision to pursue STEM. For example, 3 of the engineering participants said that one or more of their family members were engineers; this made them aware of the career path and STEM educational pathway.

**Introduction to STEM in K–12 schools**

While some participants were influenced by experiences in their households, others were exposed to STEM within their pre–college school systems. For example, some participants were introduced to STEM in middle school and high school. Of the participants interviewed, 2 mentioned that because engineering companies visited their middle and high school class their awareness of engineering as a career pathway was strengthened. The chemical engineering major said that she was lured by free pizza to attend an information session with the Kansas City engineering consulting firm, Burns & McDonnell. She was captivated by the female presenters who explained the day–to–day operations within the company. The chemical engineering major's appreciation of the presentation, coupled with her competency in math and science guided her decision to major in engineering. Participant 8, a mechanical engineering major, was encouraged by her female high school math teacher to pursue engineering as a potential area of study because she excelled in mathematics, which illustrates a benefit of representation in the formative years of a student's education.

**Outreach Programs**

Participant 4, who is currently an electrical engineering major, said that she wished she had more exposure to the engineering career path at an earlier age. This student also referenced a few challenges as a first–generation college student and an underrepresented minority (Hispanic). She expressed that earlier exposure to STEM fields would have made her transition as a STEM major easier. During her sophomore year of high school, she learned more about STEM programs when she participated in a TRIO program, with added emphasis in math and science. TRIO programs were designed to assist disadvantaged, underrepresented minorities, and 1st–generation students to enroll in and complete college (Graham, 2011).

In lieu of her experience, there were several examples of how outreach programs provided exposure for many of our participants. Two participants stated that because various businesses conducted presentations during their middle school and high school years, respectively, they each acquired an early interest in STEM fields.

Burns & McDonnell provided outreach to many of the middle and high schools that our participants attended. Participants described corporate partnerships with their middle and high schools as access points for exposure to STEM career fields. For example, 1 participant discussed a presentation from a Kansas City engineering firm, Burns & McDonnell, as integral in her decision to enroll in Project Lead the Way (PLTW) engineering courses.

**Self–Efficacy**

Multiple women identified positive self–efficacy in STEM disciplines as a factor that influenced their decision to major in a STEM field. In relation to the choice to study electrical engineering, Participant 4 expressed, "... and then I considered doing circuits as a kind of emphasis because it was pretty easy. I was pretty good at that". Another participant described parental influence in relation to discipline–specific positive self–efficacy: "But I definitely excelled in math as a kid, and I think my parents encouraged that because not everyone excels in math and some people really struggle...and it was just something I always enjoyed,". Statements like these suggest that the participants perceive themselves as excelling in an academic discipline, which leads to an increased interest in their chosen field.

As illustrated, self–efficacy is a factor that contributes to the confidence needed to succeed in the classroom. Confidence in a subject builds interest and may develop into a life–long profession. With proper tutelage from faculty and staff, coupled with mentorship and access to real world applications of careers in various professions, students gain skills that can be used for a lifetime.

Many participants expressed an interest in STEM at an early age and the confidence to engage in science. Participant 5 stated, "I've always felt very comfortable learning about science and like, I guess learning about it and then being able to communicate it to other people". Various participants expressed a belief that they could succeed. Participant 1 discovered that she was good at math and science as early as middle school, which motivated her to pursue chemical engineering. Participant 2 stated, "I've proven myself in that lab time and time again". Participant 13 stated that her experience gave her the confidence to work successfully and complete classes. She stated, “Now that I'm older, I feel like, I find sometimes I have seniority. So now I don't feel bad”.

Participants also revealed factors that negatively impacted their self–efficacy. These external influences were often described as factors that impeded their success in relation to academic achievement. Participants describe resilience in order to overcome these external influences, which threatened their self–efficacy.

While most participants experienced different moments of encouragement and affirmation from their teachers or personal performance, Participant 2 had a different experience. She stated that “a lot of my counselors and everything steered me (away) from college. Especially whenever I told my counselor that I'd be taking classes with dual enrollment students, she refused to sign the paper that allowed me to do that for three weeks”. Participant 2 believes she experienced these hurdles due to her family’s poor financial situation. Her parents also had not attended a 4–year college, and her high school did not express encouragement in her pursuit of this. Fortunately, there were two teachers who encouraged this participant to pursue college and her dreams of studying biology.

Another example was Participant 4, who struggled in high school, but through self–efficacy and communal goals, was able to manage the rigor of her program. This student felt supported by the faculty. She acknowledged the challenge in the rigor of the program and found success in the midst of those courses through communal goals. It was encouraging to learn that the faculty were supportive and encouraging. For her, it was her male peers from whom she experienced microaggressions. She shared an example of microaggressions from a male student who arrived late to a study session:

There were only so many math problems. So you would be standing at the board, but you'd have to like, share your problem. But you didn't have to work together. And I was doing it. I just remember he was like, really working himself up and was like, I have this amazing method I learned in high school, you're gonna love it. Like, they don't teach it here. But it's gonna change your life. And he was like, solve it without the numbers first, and I was like, Okay, thank you. Wow, like, solve it symbolically as if that's not something that most people know how to do.

The male counterpart thought his ordinary idea was superior to the female student's method. This example showed how male students can create hostile learning environments for their female peers.

### Communal Goals

All participants were positively affected by communal goals, and all participants showed an interest in achieving them. Having communal goals helped many participants to be retained. One way for women to fulfill the need for relatability, altruistic purpose, and collaboration is through study groups. Participant 5 stated, "... I'd say forming study groups has been my biggest tool. I('m) still (in) my friend group. Now, we are all biology majors. And we all take the same classes and study together". For many participants, it was important to study and associate with individuals who were in the same classes. Furthermore, in regards to communal goals, another participant added that, "having a community of people that are all passionate about a similar way, similar thing, and meeting friends and just spending time with people who you wouldn't have normally met." The opportunity to study in groups of like–minded individuals with similar goals in similar classes gave them a stronger sense of community.

Many participants enjoyed being in the company of and working with other women. Participant 1 stated that she enjoyed working at the company with several other women, stating:

> I feel like I've had a great support system, and I don't know if it's just because, my last co–op, I didn't really have a mentor, and I was the only intern there, and it was a smaller company if that's why I didn't like it so much. But it is kind of refreshing to know there are more women in STEM now.

**Research Question 1: Conclusion**

Factors that attributed to the retention of women in STEM programs included communal goal congruence, self–efficacy, and support from faculty and staff. We found that women studying in the classrooms together succeeded. Furthermore, we should note that female students achieved success, through communal goal congruence, whether they knew one another or not, prior to taking that class. In our study, many of our participants shared that there was safety and comfort in sitting with other women in male–dominated spaces. Also worth mentioning is the notion that in order to achieve communal goal congruence, many women joined sororities and other interest groups. In these groups, women did homework together but also spent time socially with one another on a peer–to–peer level, which contributed to their retention.

Self–efficacy was evident among female students who achieved success in STEM–adjacent subjects in grade school and high school. Additionally, with motivation from female teachers and other educators, they believed that a career in STEM was a viable option because they not only enjoyed the subject matter but achieved success as evidenced in grades and praise from teachers.

Among the most important factors that contributed to the retention of women in STEM was support from faculty and staff and their university. At Missouri S&T, there were several campus–wide programs designed to help women in STEM achieve communal goal congruence. One of those programs was the Society of Women Engineers (SWE), which empowers women to pursue careers in engineering. This program is unique because it was not limited to only those who are engineering majors, but other women who are STEM majors. SWE serves as one of the support systems for women at the institutional level that is designed to encourage women in STEM majors to network and cultivate relationships.

**Research Question 2: How does Advanced Placement coursework in high school impact the retention of women in STEM programs?**

Participants shared that programs like Advanced Placement (AP), dual enrollment, Project Lead the Way (PLTW), and the A+ Program assisted their retention in STEM in several ways. These programs prepared our participants for the rigor of college, assisted in developing study habits, which in turn enhanced their self-efficacy towards STEM coursework.

***Advanced Placement and Dual Enrollment***

All participants shared that they completed AP and dual enrollment classes. Several participants shared that the rigor of their AP coursework prepared them for the challenges of STEM classes at Missouri S&T. Participant 9, a computer engineering major shared, “I want to say sophomore year (in high school) and on, I had at least one

AP or dual enrollment class. So I came into S&T and I think with my credits I was technically like a second semester sophomore… It (high school) was just more rigorous… I will say S&T was easier than my high school." It should be noted that this participant attended a private school in the St. Louis area, which was described as having an increased rigor in comparison to other participants who attended public high schools.

Two of the participants indicated that they preferred dual enrollment classes because a student's credit is dependent on the completion of coursework and is not reliant on a single test, as it is with AP classes. Participant 3 said that she preferred dual enrollment:

> She (student's teacher) said that it would have been better for students to just take dual enrollment, because if you take it, you pay for the class through the university that it's like partnered with, and you would get the credit, whereas the AP exam that would all like all the studying, and everything that you'd need to do to prepare for, it would just be evaluated on that day. And if you feel like you're not, you don't know what you're doing. Or like, if you're not confident on that one day, like it could really change, or it could just really affect how you score. And then if you don't get a three, you don't get college credit. But if you do, then you do. But she actually encouraged me to take dual credit, or dual enrollment. So I did that.

Participant 13 shared a similar perspective, stating that she did not feel confident in receiving college credit just because she was in AP classes. She found dual enrollment classes through a local community college to be advantageous in the achievement of early college credits.

A few participants discussed that they could bypass humanities and history classes in high school, which enabled them to take classes more relevant to their major at a more efficient pace. Participant 1 shared that she was not passionate about English or US History, so it was beneficial to complete those courses in high school and transfer the credits into Missouri S&T through dual enrollment.

### ***Additional Programs***

In addition to AP coursework, interview participants indicated enrollment in other secondary programs as influential to their decision to complete their undergraduate degree in a STEM discipline. Also, interview participants reported that the ability to complete general education coursework prior to enrollment at Missouri S&T allowed them to focus on the degree requirements for the completion of their major.

### ***Project Lead the Way***

Another program that the participants discussed was Project Lead the Way (PLTW). PLTW is a curriculum designed for K–12 students to make learning applicable to STEM career pathways. Students in grades 9–12 can complete PLTW coursework in the disciplines of computer science, engineering, and biomedical science (Stebbins & Goris, 2019). Of the 13 participants interviewed for our study, 5 reported that they had completed PLTW coursework while in high school, while one reported that she began PLTW coursework as a middle school student. The participants reported participation in Introduction to Engineering and Computer Science. One participant completed advanced PLTW coursework in civil and aerospace engineering as well as robotics. Participant 13 said that she took Introduction to Engineering and Civil Engineering and Architecture classes through PLTW. She also shared: “So (in middle school, I took) a little bit of robotics, a little bit of coding. And then in high school, I took the intro to engineering course and then the civil engineering and architecture course. And that's kind of where I ended up enjoying civil engineering.”

Research participants who enrolled in PLTW coursework reported positive self–efficacy related to PLTW coursework as evidenced by feeling they were ‘good at’ a PLTW subject, which then led research participants to choose a major within a STEM field of study. Participant 4 shared:

> I took one of the PLTW intro courses in engineering. And I was really good at learning the software. I thought that it was creative enough, but still not, you know, sucking the fun out of something that I've already enjoyed... And I thought, well, there's a pretty easy thing for me right now. And I think it'll turn into a good career, so I might as well do it.

She developed confidence and found enjoyment in taking PLTW intro courses to engineering which influenced her to follow the engineering career path.

Participant 7 discussed the rigor of her PLTW program and also discussed how it benefited her:

> We had PLTW classes. They had like computer science, engineering and like biomedical classes that were like a different structure from like normal classes. It was like an outside kind of organization that was giving us the curriculum. So I took the engineering route. I took an introduction to engineering principles of design… that was horrible, but it did help me in physics here at S&T. And then the final one that I took was digital electronics. And that's where we kind of got to

> work with the electrical stuff. And it was really useful to like work with breadboarding and like learning about circuits and stuff like that. So that was very useful. And then meeting people there, so like my high school friends like Tyler and Nora, they also go to S&T. So it was really nice to have that kind of support group that was also going into engineering.

While the PLTW classes were challenging, this student was more prepared for coursework at Missouri S&T and from those classes, she was also able to establish a support group that would evolve into college. This type of early introduction and exposure to STEM coursework through K–12 schools, inclusive of female students, could increase the number of women who declare a STEM major as undergraduate students.

### ***A+ Program and Community College***

A civil engineering student shared that she took advantage of Missouri's A+ Scholarship program. The A+ Scholarship program is "a merit–based scholarship that provides scholarship funds to eligible graduates of A+ designated high schools who attend participating public community colleges or vocational/technical schools or certain private two–year vocational/technical schools" (A+ Scholarship Program, 2023). Participant 13, a civil engineering student utilized her dual enrollment coursework to attend a community college on a full scholarship for her first year of postsecondary work. She also went to a community college prior to attending Missouri S&T and finished her associate's degree in three semesters. Community college was a more cost efficient option for this student, "that's why I went to community college. I had my 1st year there for free because I completed that A+ program." A+ also helped her get on track academically, "I did not get an associate's (degree), but I did that just to get my general education credits. And then I transferred here to Missouri S&T to complete my last 2 years for my undergraduate bachelor's (degree)." She is now set to graduate earlier than her peers whom she started college with.

***Study Habits Impacted by AP and Dual Enrollment Courses***

While participating in AP and Dual Enrollment courses was beneficial in the completion of coursework at an accelerated pace, it also assisted in the development of quality study habits. Participant 1, a chemical engineering participant said that she was in her AP classes with friends, and they collaborated in their studies. She stated, "I did a lot of study groups. Me and my friends were all in the same classes, so we would hang out at a friend's house, and we would do group study, and I've kind of brought those habits to college". The study habits that students developed in high school translated to the ability to overcome rigorous coursework in college. The participant elaborated, "Study habits have helped because now I have group projects. You have to work with a team and lead a team. So I've developed leadership skills through that as well."

Whether AP, Dual Enrollment coursework, or other academic programs, each has contributed to the establishment of study habits that prepared them for success in preparation for studying STEM courses in college. The participants learned how to take notes, dissect reading, create flashcards, study in groups, and prioritize materials while taking AP and Dual Enrollment classes.

***Research Question 2: Conclusion***

Based on our research, participation in AP classes has a positive correlation with the retention of women in STEM majors. Women who participated in AP classes experienced rigorous classes which prepared them for the rigor of college STEM classes at Missouri S&T. Furthermore, the structure of the AP classes required many of our participants to learn study habits that would aid them in college. They also learned to work in collaborative study settings, as is also required in college. These aspects of AP coursework prepared our participants for Missouri S&T, which enhanced their self–efficacy. These women had experienced and succeeded in challenging classes and had confidence in their ability to succeed at the next level.

While AP classes play a significant role in the retention of women in STEM, we should also consider Project Lead the Way (PLTW) and dual enrollment courses as significant secondary educational measures to retain women in STEM. PLTW courses provided our participants an early experience with STEM coursework and the ability to consider majors such as engineering, computer science, biomedical science, etc. The participants who took these classes in high school found that they liked the idea of STEM majors and also found that they could have success in such classes, which again enhanced their self–efficacy.

Dual enrollment classes seemed to have provided a great advantage to our participants and is something that should be strongly considered for high school students. Our participants were able to finish high school with college credits, which enabled them to begin their collegiate careers more prepared than their classmates or colleagues who had not. Furthermore, they also had enhanced self–efficacy because they had already completed college coursework. Some students shared that dual enrollment was better for them since it was not dependent on a single test, as were AP classes.

The conclusion and answer to Research Question #2 is that AP classes do impact the retention of women in STEM, and it makes a positive impact. However, PLTW and dual enrollment coursework also make a positive impact, and it can be argued that PLTW and dual enrollment courses make an even greater impact than AP classes. Women, specifically, greatly benefit from PLTW because they have exposure to STEM classes at an early age. PLTW, AP, and dual enrollment classes all enhance women's self–efficacy by preparing them for the rigorous coursework of the collegiate environment.

**Research Question 3: How do extracurricular activities (including student organizations and work–study) impact the retention of women in STEM programs?**

Our research showed that participants benefited from the participation in extracurricular activities, student organizations, work–study, and other student groups. The participants found like–minded people while participating in these activities and built bonds and friendships which has enabled them to have success and support through their STEM studies.

***Extracurricular Activities***

Through our study we discovered that extracurricular activities were one of the most impactful areas in achieving communal goals for women in STEM. Missouri S&T offers a variety of clubs and organizations, including several that are specifically for different demographics. For example, one of the participants said that she is in the Asian American Association and that while she is not extremely involved in it, she can count on that organization if she needs something or wants to have a group that is more relatable for her. Another minority participant said that she benefits from her involvement in the Society of Hispanic Professional Engineers. This group is important to her, as other members are also 1st–generation college students, and she says that the organization is more like a familial community. They can share their challenges and also find points of encouragement to matriculate to degree completion.

A popular organization that nearly all of the engineering participants mentioned was the Society of Women Engineers (SWE). SWE is a national organization in which female engineering majors and professional engineers can be involved. SWE's goals include enhancing the sense of community, self–confidence, and mentorship among women in engineering, technology, and computer science (Thompson, 2003). The SWE organization at Missouri S&T collaborates with the Women's Resource Center and according to Participant 2 strives to "create a safe space for women in science to be able to talk and have fun and just be able to feel like they're in a more safe environment". The participants from the study expressed that SWE will extend beyond their time in college and into their professional careers.

While student groups have served as support systems, they also serve as a point of social release and companionship. A chemical engineering participant shared that if it were not for her social sorority, she might not have made it to this point in college (she is a senior currently). She coordinates social events for her sorority, like senior celebrations, family formal day, community service events, etc. Participant 2 is a member of Phi Sigma, which is a biology honor society that enables her to collaborate and socialize with other like–minded women. Participant 5 said that she has gained a sense of community from the participation in different organizations, and the majority of her college friendships have stemmed from participating in various activities.

### *Time Management*

Many participants referenced the importance of time management to be involved in various groups related to academics and extracurricular activities. Participant 13 indicated that her participation in the American Society of Civil Engineers and the Society of Hispanic Professional Engineers was “a huge time commitment”. She also stated that it was challenging to find the time to participate in the various committee meetings, general meetings, and e–board meetings each week. Participant 13 stated that these meetings took  “a big chunk of time”. While time management is challenging, some participants found it worth the effort. Participant 6 expressed that extracurricular participation helped her meet new people and improved her time management skills because she had to plan events with her student organizations while keeping up with her classes. Participant 4 explained that participating in too many organizations was overwhelming, especially after the COVID–19. Participant 4 stated, “So time management is when you're joining all those at once, you could burn out pretty quickly. And if you're trying to do officer roles and all of those, which I was, that was a big issue. But I still enjoyed it. I definitely would probably recommend doing things one at a time.”

### *Work Study*

Work study has had a beneficial impact on many of our study's participants, as Participant 2 stated, “I think work study has been probably one of the most life–changing things here”. Participation in work–study positively impacted several participants' attainment of career skills. In addition to this, scholarships met financial needs of students who otherwise would not have had the opportunity to obtain those skills. Work study provided a flexible environment in which students could achieve academic and professional goals.

Work–study had a beneficial impact on Participant 2 who explained that her department assigned her various important projects. For example, her department put her on their Department Chair search list. She highlighted her importance to the department: "My professors prioritize me a bit just because I am the work–study there, and I help them out a lot." Participant 2 also stated that "it's gotten to the point where whenever I run out of work–study hours, they pay me to be there because I've been such a beneficial addition to the office there".

A few of our participants shared that they conducted research in exchange for monetary compensation, while others received academic scholarships. Conducting research permitted them to attain work and learning experiences and helped to meet their financial needs. Participant 9 highlighted that a scholarship that required research with a specific lab on campus, which she did from her sophomore year to the end of her senior year, provided her with necessary financial support. Participant 9 stated that this research helped her transition into her future doctoral research. Additionally, her original motivation behind applying for the scholarship "was the money because it was quite a bit of money. And I'm not going to say no to that. It was, I think, $20,000 for 2 years".

As a part of Participant 7's National Merit Scholarship, she explained that she received payment for her work as an intern with one of her professors in the electrical engineering department. While Participant 7 was not financially compensated well, she highlighted the benefits of receiving such an experience, stating, "And I got paid, it wasn't great pay, but it was something, and it was a great experience as a freshman, you know, like, most kids don't get to do this". Participant 7's testimony aligns with research that states that students in work–study programs have acquired an improved understanding of technical skills and increased self–efficacy related to their study area. The benefits of work–study and research in compensation for scholarships served an integral role in the attainment of career skills for many participants. Participant 10 detailed how a summer opportunity as a contractor working with NASA allowed her to work on the Artemis program's Orion spacecraft:

So the Orion spacecraft, part of the Artemis program, will be the first manned spacecraft to go in space, and eventually, I think, onto the moon. And so they had the outside material built perfected, all of that ready to go. However, it was made by a private company. It was made by Lockheed Martin... So NASA didn't actually know what was in the material or how exactly it was made. So last summer, my job was to do some characterization on the material, look under the microscope, try to understand some of the materials that were inside of it and how they reacted to tests and stuff like that.

While Participant 10's experience with off–campus research seemed to positively impact her self–efficacy, her financial need, and her capacity to meet communal goals, Participant 3 encountered some negative experiences with off–campus work. She talked about how, while she needed financial support, she was not allowed to study. According to Owen et al. (2018), this is called work–study conflict. Work–study conflict occurs when workplace responsibilities hinder the student's ability to meet academic obligations. For Participant 3, off–campus work was stressful and inflexible, while on–campus jobs recognized the needs of the student. According to Participant 3, "I think work study on campus was a little bit nicer just because they knew you were a student, whereas off–

campus jobs, they didn't really care for that". This is consistent with research stating that many students suffer academically because they cannot focus on their academics, as they are overwhelmed with working to fund their education (Perna et al., 2009).

One way to combat work–study conflict is with work–study facilitation. Work–study facilitation occurs when there is an improvement in the student's ability to perform academically because of their participation in work (Owen et al., 2018). When students are given more control in their work environments, they see improved academic success and career readiness (Marx & Wilson, 2020; Owen et al., 2018; Aikos et al., 2021). Some participants stated that having a flexible workspace on campus allowed them to work on academics. Participant 2 stated:

> I can just sit there. I can clock in when I want, work a little bit, study for an hour, work some more, and if I don't have anything to work on there, like work purpose–wise, I can just sit there and study until I needed, and that has been one of the nicest things I have ever had.

For Participant 3, work–study did not negatively impact her ability to study; she stated, "I don't think it really did much because I knew that I would have to work during that time period, but it was nice to get like an extra, like, amount of time just to like, study."

Many participants tended to perform well in work environments with frequent social engagement. Participant 2 discussed the benefits of working in the same department where she was a student:

> But being able to be in that work study and, I'm emphasizing in my own department because not many students are fortunate enough to get a job in the room department. But being able to be there I can just email my professors and

> like just go up to their office most times if I have questions, and I think that a lot of other students don't have that, and I've come to realize especially like last semester, that if I have questions, my professors prioritize me a bit just because I am the work study there and I help them out a lot. So that was just fortunate for me.

All women who participated in work–study alluded to the importance of financial support and a flexible community–oriented environment in which support is easily accessed. All of the women who participate in work–study and extracurricular activities alluded to the importance of balancing their time in one way or another. They also are all fulfilled by their extracurricular activities, but to maintain their studies and additional activities, they must be organized and efficient with their time.

### *Research Question 3 Conclusion*

Collectively, participation in extracurricular activities, including student organizations and work–study, has played an intricate role in the retention of women in STEM. Extracurricular activities provide an outlet to discuss school–related concerns in safe environments. They also allow the participants to take a break from their studies and find comradery with others who have similar interests. These aspects of participation in extracurricular activities help women to achieve the communal goals of relatability, collaboration, and a sense of belonging by bonding with other classmates who have similar interests. In addition, it builds self–efficacy as women hold leadership positions and have the autonomy to accomplish goals within their organizations.

Furthermore, the various clubs and activities that our participants have joined provide resources for success as a student at Missouri S&T and beyond. For example, SWE and the varying ethnic organizations extend beyond college and into professional organizations. Extracurricular activities enable the participants to develop their soft skills such as communication, conflict resolution, and leadership, which are valuable in their transition into the workforce.

Through our conversations with the participants, we discovered that work–study was an advantageous avenue for the utilization of spare time. While the majority of our participants did not have experience with work–study, the students who did had positive remarks. They were able to work jobs or perform research that would be applicable to their future careers. The students shared that they were gaining career–related experience as they learned more about their area of study, or they developed soft skills by interacting with others or in the fulfillment of leadership positions.

In addition to providing comradery and the enhancement of soft skills, participation in extracurricular activities has enhanced our participant's’ ability to manage their time and prioritize their commitments. While managing their time was a challenge at times, all of the participants shared a variety of positive perspectives with regards to their participation in extracurriculars. The benefits of extracurriculars far outweighed the challenges.

Based on our research, extracurricular activities might be one of the most impactful areas for the retention of women in STEM. Women are able to fulfill their communal goals, which in turn encourages them to work through more challenging aspects of their field of study.

**Research Question 4: How does art used as a tool of study impact the retention of women in STEM programs?**

Our research determined that art can serve as a tool to assist in learning, comprehending, and applying academic lessons. Art such as music, color coding, and utilizing drawing of diagrams are examples that participants shared can assist them with their study habits and retention of information.

***Note Taking Aids***

Several participants expressed that they use different art–related study tools such as color coding their notes, listening to music while studying, drawing figures in the margins of notes, and drawing illustrations as study tools. Students reported that using different colored highlighters gives them a visual aid when recalling specific information. A couple of the engineering students shared that they also utilized sticky notes of varying colors to assist their memorization and comprehension of information.

Participant 1, a chemical engineer, said that she finds it easier to memorize things if there is a visual representation. While she said that she is not artistic herself, she does benefit from seeing others' drawings of diagrams and other class materials. Participant 2 utilized drawing to help her understand concepts and explained by saying, "I would sketch out things for anatomy I would sketch out like chambers of the heart (and) I would pretty much write in my notes and annotate those drawings." Participant 7 expressed that drawing was helpful to understand the concepts in her calculus class when she stated, "For calc 3, that was really important because it's all like three dimensional stuff. So having those kinds of, like, visual aids to draw them or highlight the different sides…the shading was really useful", which supports that using art was helpful for this student.

Additionally, Participant 3 found that people were against using art as she expressed:

> I think I know a lot of people are against it. But I think whenever I color, or use different things like highlighters or different pens to write out my notes, it's really nice because I'm able to create smaller sections of each PowerPoint slide.

She went on to infer that with proper guidance, more students could benefit from using art as a way to organize ideas:

> I think that art, like I don't think there's a lot of exposure to it on how to like, really use it, but it can be very soothing and it could calm you down, while also just being able to like make sure that you're organized because I like color coding things and that's been helpful for me to like organize and make sure that things are kept in a like tidy way and I think that's probably like very beneficial.

Another participant expressed that she used art to illustrate her notes by saying, "I take pretty quick notes in class, but then when I review them outside of class, I definitely make them look a lot nicer. Like on my iPad, I have all those little drawing tools and stuff." In addition to using art to illustrate her notes, she also utilizes it as a learning tool, listening to music while she studies. She stated, "And when I do listen to music, I find that sometimes I don't like really busy music. So I listened to instrumental music, just to fill the space but not distract from, like, if I'm reading something."

As other participants have affirmed, listening to music and using different colors to highlight and annotate notes are common uses of art as a learning tool. However, one participant used art while "taking orbits." While enrolled in an aerospace mechanics course at Missouri S&T, one participant expressed it this way:

> We had to do a lot of work where we had to draw, like, an orbital diagram. Where you could see where in the orbit the thing is that you're modeling is and that's something that actually takes a lot of focus to draw a good diagram. Because if you draw a good diagram and label everything right, then I guess it's easier to understand what's going on.Whereas if you're a little bit more sloppy and not as, I guess, clean with your lines and where exactly everything's labeled, then things could get confusing really fast. So having that artistic, I don't know, I guess just spending a little bit more time and trying to be more artistic and colorful with it can be helpful, for sure.

***Using Art to Study***

An electrical engineering student said that she uses music to help her study. She will even correlate the genre of music to which she is listening with the subject that she is studying. An aerospace engineering student said that she also likes to listen to music when she studies, but she prefers instrumentals because the lyrics can become distracting while reading.

Participants expressed a myriad of ways in which art can be used as a study tool. Whether color coding or annotating notes with pictures, listening to music to study, or using visual art to capture complex diagrams, the female STEM students in our research not only used art to retain material, but they also saw the value in using art as a methodology for retaining information. For example, while discussing art as a learning tool with our participant, she verified, "I definitely am a big color coder. I use different colors for each of my classes to keep it organized in all my notes”. She continued to explain the benefits of using art as a study tool:

> I think it's a great visualization. I know I'm more of a visual learner. Definitely. I like to have pictures if I can have pictures. Like I said, math classes don't always allow for that. But I also do a lot of visualization with my hands, as you've probably seen. I talk a lot with my hands, but if I'm memorizing anything, visual arts, like using your hands, also help me a lot.

Similarly, Participant 5 also used different art–related techniques to assist with her coursework, stating that:

> Big concepts will have a color and then littler, like smaller details will have a different color and especially in things like anatomy, I draw a lot in my notebook. It helps, definitely helps to visualize and using a bunch of different colors makes it a lot easier to see what I just drew. Many of our participants used color coding and drawing to visualize and better understand concepts in their STEM courses.

While listening to music and color coding aided most of the participants in our study, using art in that way to study was not helpful for everyone. In fact, Participant 9 expressed that while she understands the benefits of the aforementioned methodologies, she preferred to study in silence. She explained that when she does use art as a study tool, it is usually in the form of a diagram:

> I taught a class this past semester, a computer networking class to some undergraduate graduate students, and I used figures quite a bit in that. Because if you think about it, networks are a very visual concept. Computer networks and networking in general is very visual. And so it's hard to teach the subject and teach it to an understanding that they're going to grasp without utilizing diagrams

> or images of what is actually happening to just be able to map it out. Because if you try to put that in a paragraph, nobody's understanding that.

While Participant 9 utilized art to visualize concepts, another participant concurred and added more information regarding the benefit of using art to conceptualize ideas. When asked about how art can be used as a learning tool, Participant 10 expressed:

> I think it's a great reinforcement tool, especially when you are forcing yourself, I guess, to recall and not just regurgitate the exact words that you've heard. So, again, doodling like a concept or something. Right now we just started in mechanics of materials. We're talking about stress and strain. And so you can say that. Let's see, what was the example here? Okay, so we know that stress is the intensity of internal forces. Okay, but what does that look like? And so sometimes drawing a diagram, and even if it only makes sense to me, what the symbols mean is sometimes very helpful. So I think that a good way to incorporate art into studies is to draw concepts. I think that's kind of like an elementary thing, but it really is useful.

Participant 12, who also listens to music while studying, uses art to visualize concepts and stated, “I know like right now actually taking a statistics class. So we use Venn diagrams and stuff to help represent the Functions and Formulas”. When asked about how art could be used as a learning tool, she affirmed that “I think it's just a good way to focus your attention on things. Like I said, with the music. I use that to just kind of focus myself”.

Participant 13 also contributed to the notion of using art as a learning tool, and similar to her colleagues, she too used music to study and identified as a visual learner.

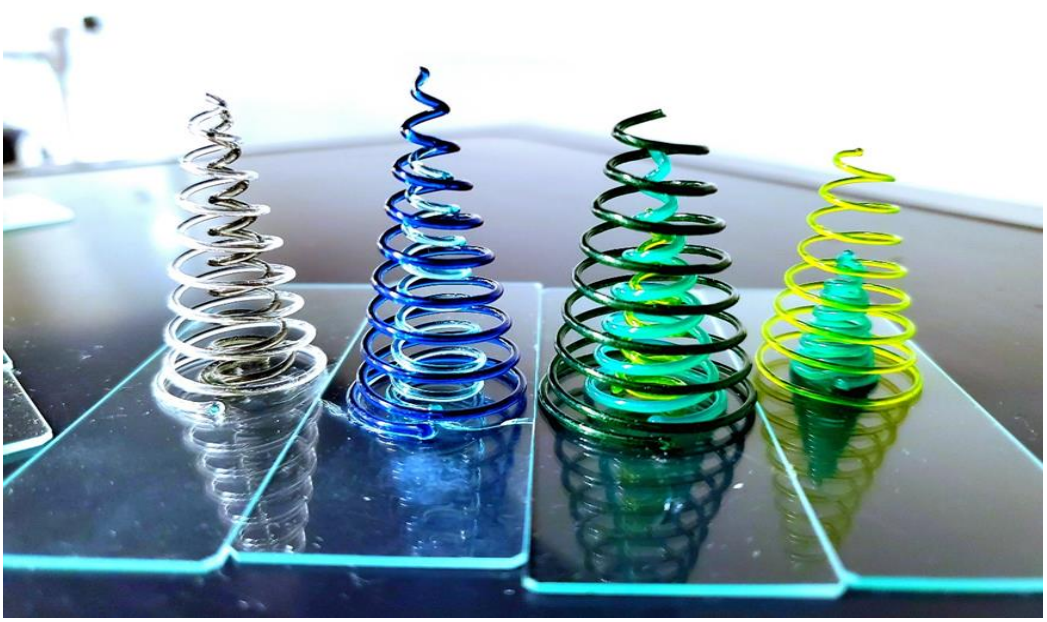
When asked about the benefit of using art, she expressed that "I know people use a lot of visuals like drawings. So I think people who kind of like me, but in a different way who really do learn visually. Art and drawings tend to help a lot".

***Research Question 4 Conclusion***

Participant 7 described an elevated interest in her discipline due to her incorporation of art as a product of her study. She is an undergraduate student who is a double major in computer science and electrical engineering. Part of the research that she conducts as a computer science major is centered around glass additive manufacturing, which is the 3–dimensional printing of glass structures. The structures in her research require creativity for testing the manufacture of unorthodox glass shapes (see figure 3.1).

**Figure 3.1**

*Examples of Glass Additive Manufacturing*



*Note.* Photograph of additive glass manufacturing provided by Participant 7.

In conclusion, there was not a lot of previous research regarding art as a learning tool for women in STEM programs, but our findings affirm that art aids with mood, the organization of notes, and the visualization of complicated concepts. Perhaps in future research, more scholars will seriously consider how music and visual art can help students with memory and the contextualization of concepts. Further, music and visual art meet the conceptualization of ideas as both a didactic and pleasurable exercise in learning and retaining information.

## Criteria for Improvement and Limitations

Limitations within our research are related to the external validity of the study. The study was conducted with 13 students from Missouri University of Science and Technology. Participants included representatives from STEM majors, including a myriad of engineering disciplines (aerospace, civil, chemical, electrical, computer, and environmental), as well as biology, physics, and math. While this is inclusive of multiple STEM disciplines, it is limited to those stated above.

Furthermore, our sampling methodology relied upon student responses to their department chairs' request for interviews and unfortunately, no Black women responded during the participant outreach process. Interviews were conducted with participants that represent Hispanic, Asian, and white communities. Our research suggests that both women and underrepresented minorities (URM) experience microaggressions, we hoped to hear the perspective of their experiences, including Black women. More research needs to be conducted to discover how historically marginalized minority groups are retained in STEM programs.

**Participant Challenges in STEM**

Participants shared positive and challenging perspectives as women in STEM majors. By understanding these perspectives we can enhance women's experiences as students who study STEM curricula. Participant 1, a chemical engineering student, shared many positive perspectives as a woman in a STEM major, but she would like to see continued development in the field. She thinks the engineering field could use more diversity. She also suggested that people should not solely be hired just because they "check a box," but some efforts could be made to hire a more diverse selection of people.

Participants provided evidence related to microaggressions that they have experienced as women in STEM fields of study. One participant shared a story about her lab partner, a fellow woman in STEM. Their instructor redistributed lab partners, and her partner was paired with a male student. Participant 2 provided an example of a microinsult she experienced when upon learning the identity of his new partner, a male student asked for another partner because "...she wasn't smart enough to be his partner". She further explained this by stating:

Some of my male classmates have this high horse that they're on. They know everything and that they can answer any question... I've noticed that a lot of the men in my classes also have to drag a lot of people down in order to do that...I have to fight to get a word in half the time, especially in my cell biology lab.

Participant 1 said that she was working an internship, and there was a big spill, and all of the engineering men went to help clean it up. She tried to assist, and their reply was, "This isn't a woman's job. Why are you here?" She said that they were well–intended; however, she wanted to fulfill all of the duties of her job.

**Participant Recommendations in STEM**

In addition to discussing their challenges, participants also discussed positive programming at Missouri S&T directed towards inclusion. Their comments should be considered for continual growth at Missouri S&T and other universities that would like to retain more women in STEM. Participant 1 was complimentary of the university and its strategies aimed at supporting women in STEM. Participant 2 said:

> One way that our university has been combating this (microaggressions) is having a safe space for just more women only like movie nights so on and so forth, having that safe space to just enjoy being there without having to be ridiculed or criticized.

Participant 2 also said that the Career Center has been helpful in reviewing her resume numerous times. She also added, from a personal perspective, that she benefited from the comradery and companionship that she experienced as a member of her sorority. Participant 11 shared:

> I actually thought it was really cool that a thing they are doing now is this Women's Welcome Brunch for the freshmen. And it was just like there were panels where you could go to your degree program and you could talk to the female professors that are in your degree program; talk to them about classes, anything you really want to know. And then there was, like a Q and A session with the Student Health Director and the Minor Oasis director, people like that. So you could ask them questions about that, too. And I think that was, like, a good step in the right direction because coming here to a male dominated campus is scary. So it's nice to know that they are doing stuff like that for the younger

> generation, so then they feel more comfortable and they get acquainted with people in their department.

She said that she really enjoyed being a part of this event and is hopeful that S&T will continue with these kinds of initiatives.

Participant 2 also mentioned that while Missouri S&T currently has a multitude of options for programming to support women, students did offer a few other recommendations. Participants 2, 12, and 13 mentioned a women's resource group, but students would like a dedicated facility or area within a building for spaces to converse with professors and staff regarding their challenges and learn about tools to manage their frustrations. These students said that while they are aware there are resources to support them, they would like them to be more openly publicized and more easily accessible. They acknowledge that the Student Diversity Initiatives department does make an effort with outreach programs, but more programs within specific majors, especially male–dominated areas, can be implemented.

## Summarize Connections of Actionable Knowledge Reviewed

Based on what we have learned from other scholars in the field and from our participants, we surmise that there are connections to representation, self–efficacy, and communal goal congruence in STEM fields. Many of the women in our study found success in STEM–adjacent subjects like math and science, but we also found that early exposure and/or seeing women in those fields helped students see themselves as successful.

We realize that part of the problem is that societal norms of women as nurturers perpetuates the social stigma that STEM fields are not inclusive towards women.

Moreover, the notion that women should only pursue careers in fields like education, social work, and others that support these ideals is in direct contrast to the data, which supports two things – that not only are women capable of successful careers in STEM, but the idea that because of their gender, they should not pursue this career is sexist and supports homogenous and outdated ideals rooted in heteronormativity.

For many of the participants in our study, the representation of women in STEM was a key factor. For example, there were several participants who, because STEM companies and organizations presented the possibility of a career in STEM for women, became attainable. For others, having women, and in some cases, people of color as professors, also supported our claim that representation in STEM fields is of great importance. For the women in our study, the representation of women in their fields of study supported their self–efficacy.

It's also important to note that the participants in our study found success in their K–12 learning environments, in STEM–adjacent fields like math and science. For some, it was the support at home from parents and other family members, but it was also life experiences that inspired the women in our study to pursue STEM. Earning good grades in math and science, in conjunction with familial support, also aided the participants in our study to pursue STEM. Whether the field of choice was biology or engineering, the women in our study had experienced success in and outside of their classrooms, which bolstered their self–efficacy in STEM fields.

Finally, one of the factors that contributed greatly to the retention of women in STEM majors was communal goal congruence, which manifests differently, person by person. Many of the women in our study identified  a sense of belonging due to their involvement in sororities, while others found similar success via STEM–specific student organizations. Still other women who did not belong to a sorority or participate in student life found comfort from physically sitting near other women in class or finding women within their majors.

In summary, communal goal congruence is a support system of like–minded individuals. Whether the women were in sororities, student organizations, or even for those who did not participate in student life, they all found safety in groups.

Furthermore, we want our research to illustrate how women can be retained in STEM programs, both for the girls who will become future STEM majors, but also for those who are currently enrolled in college and are in need of a support system. Our study is also intended for college and university administrators. We discovered that while Missouri S&T has support systems for female STEM students, more can be done to enhance the retention of women in STEM. The retention of female STEM students depends not only on the broad support of a post–secondary institution, but also in the day–to–day practices of faculty and staff. For example, training for faculty and staff could mitigate some of the microaggressions experienced by our participants, as mentioned in our study.

We believe that with more training for administrators as well as best practices for incoming and current female STEM students, students will be supported and ultimately matriculate with degrees in STEM at higher rates. If the goal is for colleges and universities to prepare students for professional roles in their respective fields, equitable practices are required to ensure that more students enter the workforce prepared.

Chapter four will discuss our deliverable, a manual, that we have composed based on our research for college and university administrators that will better equip STEM departments to meet the needs of their female STEM students. The manual, *EmpowerHer: A Steminist Guide to Cultural Border Crossing* (Appendix D) will serve as both a tool for college and university faculty and staff, and best practices for female STEM students to aid in their retention.

Our manual will consist of two sections. The 1st section, “Seek to Empower More” will be for administrators and will provide an overview of our research and our findings in an easy–to–read manual style format. Included in this section will be several examples of scenarios that participants mentioned that had a profound impact on them, both positively and negatively. Administrators can expect to read about the key components of diversity context, admissions outreach, student affairs and student organizations, work–study, and diversity, equity and inclusion as it relates to women in STEM. Each of these components are tied to the foundational framework of communal goals and their ability to enhance women’s self–efficacy. Administrators' ability to apply these concepts at universities can contribute to increased retention of women in STEM.

The 2nd component of our manual, “Find the Power Within”, which is intended for future and current female STEM students, will provide an overview of the experiences of participants in our study and a list of best practices.

Students can expect to learn from other students' experiences and learn how they were able to matriculate through the STEM curriculum despite being a minority in their major. Key components discussed in this section include outreach within the school district, coursework in the school district, extracurricular activities, and work study. We understand that our list of resources for female STEM students will not be exhaustive, but it will be a comprehensive list to provide information to guide students in the right direction for additional aid and resources.

Ultimately, our goal is to provide a guide for administrators and students alike to understand the challenges that female STEM students face and how to combat such obstacles. In the manual, *EmpowerHer: A Steminist's Guide to Cultural Border Crossing*, we aim to heighten awareness of the challenges female STEM students endure and solutions for the faculty, staff, and administrators who are positioned to offer those students a chance to earn their degrees.

# Chapter 4 Implementation and Dissemination

The inspiration for our research on the retention factors for women in STEM programs derives from the issue of women choosing fields of study other than STEM due to microaggressions, isolation, and other discriminatory practices that create a negative environment (Kim & Meister, 2022). Further, the lack of women in pursuit of STEM majors poses several threats to society (Diekman et al., 2017; Kenney et al., 2012; Shapiro & Sax, 2011). Women account for approximately one–half of the U.S. population, and one concern is that society suffers an economic and scientific loss due to a shortage of women in STEM, as the breadth of subject areas explored is limited with less diversity of personnel (Syed & Chemers, 2011). The academy's research affirms that the specific problem is that careers in STEM are an integral part of the country's economy.

In reviewing scholars' previous research, the importance of achieving communal goal congruence and self–efficacy was described as a significant factor for women to matriculate to graduation in STEM programs. For example, researchers affirm that successful STEM majors work together in groups; however, women and minority groups are often not invited to participate (Kamen & Leri, 2019). Another aspect relative to communal goal congruence is gender normativity in college majors, and researchers argue that societal norms and cultural beliefs impact student decisions in fields of study (Beutel et al., 2017).

Concerning societal norms for women, researchers also support a correlation between caregiving behaviors and the choice of major. For example, a societal norm of women as caregivers suggests that careers in education are preferred over those in engineering (Beutel et al., 2017). Additionally, researchers affirm that stereotypes for women directly impact self–efficacy within those fields of study, reinforcing cultural normativity (Beutel et al., 2017; Campos et al., 2022; Diekman et al., 2017; Hand et al., 2017).

With our work, we will address how women in STEM majors navigate academic learning environments that are non–supportive and encourage competition instead of cooperation. We will examine how recognition from mentors and working with peers contributes to levels of confidence, which impacts career potential. Finally, we will remain solution–focused in our examination of how membership and belonging are essential to success and how critical it is to understand how lived experiences for women in STEM impact their overall persistence in the field, which supports the communal goal framework (Dahle et al., 2022; Diekman et al., 2017).

**Implementation**

Our research supports our position to create a manual for administrators and potential female STEM majors to understand the social underpinnings of microaggressions and how to address those issues. *EmpowHer: A Steminist's Guide to Cultural Border Crossing* is a manual that aims to normalize issues women experience as science, technology, engineering, and mathematics (STEM) majors. We designed the manual for administrators who govern policy at the university level and current and future female STEM majors. We hope to share and articulate the challenges of the women who participated in our study, not as case studies but as part of a larger discussion on implicit bias, sexism, and marginalization across higher education learning environments.

We divided the manual into two parts: *Seek to Empower More: A Guide for University Administrators Retaining Women in STEM* and *Find the Power Within: Convergence of Women in STEM K–12 to Post–Secondary Education.* The sections discuss initiatives that university admissions, student affairs, and diversity, equity, and inclusion groups can incorporate to grow their STEM retention efforts. We used the research conducted with students from Missouri S&T to construct our manual. We found Missouri S&T to be a supportive environment for women in STEM. Missouri S&T's initiatives can be used as a blueprint for other universities that want to incorporate similar programs and additional measures discovered through our research to enhance the retention of women in STEM.

**Improving the Retention of Women in STEM: Introduction**

The manual's content is based on our study's results, which involved interviewing 13 women from Missouri S&T who have achieved junior status or higher in a STEM field. Furthermore, this section describes the goal of the manual as providing guidelines for administrators who govern policy at the university level, K–12 administrators, and girls interested in pursuing STEM degrees.

The next portion of the introduction describes the definition of retention that we have utilized for our research. For this study, retention is defined as continuing study within a major or discipline. The research is most relevant to the concept of degree completion for women in STEM, which coincides with definitions that Hagedorn (2006), Oseguera and Rhee (2009), Levitz and Noel (2008), Tinto (1993), and Seidman (2016) provide.

Two additional terms that we discussed are communal goals and self–efficacy, which are the keys to our foundational framework and serve as the connection between our research and the retention of women in STEM. Communal goals are the need for relatability, collaboration, and the ability to help others, stimulating relationships, the human need for belonging, and self–efficacy (Diekman et al., 2017). Communal goals are important to human physiological needs (Maslow's Hierarchy) but even more valuable to women, which can be attributed to the traditional roles that women have incurred as caregivers, which highlight communal qualities, for example, nurturing and aiding others (Diekman et al., 2017). Communal goals are fulfilled by the environment in which one is learning or working and can be achieved through curricular, co–curricular, and extracurricular activities, mentor relationships, and community participation (Diekman et al., 2015; Perez–Felkner, 2018).

The achievement of communal goals enhances women's self–efficacy. While capable, women are discouraged from the pursuit of majors in STEM by the stereotypes against them; as this relates to retention in STEM, the result is poor self–efficacy. A person's self–efficacy regarding academic practice is an influential determinant of their persistence within that field (Diekman et al., 2017; Koch et al., 2022). The communal goal congruity model suggests that if communal goals can be better addressed, then more women would be inclined to matriculate through their STEM programs. Furthermore, women would have a greater sense of belongingness and self–efficacy toward STEM programs, which would enhance their desire to persist through STEM programs.

The introduction segment of our manual will provide background information that will prepare readers for the remainder of the two–part manual: *Seek to Empower More: A*

*Guide for University Administrators Retaining Women in STEM* and *Find the Power Within: Convergence of Women in STEM K–12 to Post–Secondary Education.*

**Seek to Empower More: A Guide for University Administrators Retaining Women in STEM**

This section of the manual offers guidance for university administrators interested in the retention of women in STEM. The critical components of this section assist our readers in understanding the diversity context, admissions outreach, student affairs – student organizations, work–study, diversity, equity and inclusion, and art as a learning tool in relation to the retention of women in STEM.

The diversity context says that historically, society has characterized females as nurturers and people of color as uneducated; in addition to gender stereotypes, research supports that women in STEM fields encounter many forms of gender and, among URM (underrepresented minorities) groups, race–based discrimination throughout their careers such as identity threats, microaggressions, cultural border crossing, and Critical Race Feminism (CRF) (Kim et al., 2022; Morton & Nkrumah, 2020). Based on our research and understanding of the diversity context, in order to recruit and retain women and increase diversity in STEM, administrators should focus on measures that achieve these students' communal goals and enhance their self–efficacy. Historically, URM have faced biases and microaggressions of being a minority in STEM. If administrators want more women and minorities in STEM programs, they will have to make efforts towards increasing students in these demographics.

Another area that administrators can use to increase the amount of women in STEM is through admissions. Based on our research, admissions departments can partner with STEM companies when they go to high schools for recruiting visits. Companies can explain what they do, and universities can share how students can obtain STEM careers through the STEM education at that particular university. Also, while visiting schools, admissions departments can inform high school students and counselors about the importance of A.P., dual enrollment, and PLTW classes for students who want to pursue STEM coursework.

One of the most significant areas administrators can focus on is student affairs. Our research showed that participation in extracurriculars like sororities, interest groups, affinity groups, student organizations, athletics, and student recreation is integral to meeting women's communal goals and building their self–efficacy while in college. Missouri S&T has 247 student organizations from which students can choose. The participants we interviewed are all involved in multiple extracurricular activities and have achieved a sense of belonging through participation. Other universities that want to retain women in STEM should consider incorporating clubs and organizations that will reach women and URM.

Similar to extracurricular activities, women in STEM have benefitted from work study. Work–study aids in the attainment of communal goals. Work study helps women's need for relatability, altruistic purpose, and collaboration. Work study helps STEM departments with limited staff meet departmental goals. Both compensated research participation and work–study help women acquire an improved understanding of technical skills and an increased self–efficacy related to their area of study. The benefits of work–study and research in compensation for money or scholarships were crucial enablers to the attainment of career skills for many of our participants. If administrators can include work–study opportunities on campus, the retention of women in STEM can also be positively impacted.

Another important aspect that administrators should consider to increase the retention of women in STEM is diversity, equity, and inclusion. Our research supports that the function of STEM education is to prepare students to work in careers that are integral to the U.S. economy; however, women, specifically, are severely underrepresented in these career fields. Regarding retaining women in STEM programs, we affirm that successful cultural border crossing into the microculture of STEM contributes to female student retention. Our research supports that women and underrepresented minorities (URM) account for 70% of college students but less than 45% of STEM degrees (Blackburn, 2017). Therefore, due to the lack of representation of URM in STEM, the discipline requires redefining colonial notions of superiority and the inclusion of more women and people of color in the field. While colleges and universities strive to address these and other issues, our research validates that culturally diverse friendships on college campuses mirror the professional environments that students will encounter in the workplace. Furthermore, our research suggests that women and minorities benefit from seeing people of their gender and ethnicity in leadership and teaching positions. As administrators work to increase the retention of women in STEM, the growth of diversity, equity, and inclusion should be at the forefront of strategic planning.

The final consideration in this section is art as a learning tool. This aspect is different from the others. However, it is a measure that can be included in a cost–efficient manner, assist in meeting women's communal goals, and enhance their self–efficacy.

Over 90% of our participants expressed the use of different art–related study tools, such as color coding their notes, listening to music while studying, drawing figures in the margins of notes, and drawing illustrations, aided with comprehension. While listening to music while studying was not helpful for everyone, our research affirms the work of O'Leary and Thompson (2019), who found that the relationship between drawing a visual image and comprehension may be critical to the function of memory cognition. Administrators can use this information by including colored pens, highlighters, markers, colored note–taking paper, and music in campus study rooms and resource centers.

The *Seek to Empower More* portion of the manual concludes with a flowchart that summarizes the section and demonstrates how university administrators can implement our research findings. Administrators could implement all of these concepts, or they could select the measures that they find most beneficial for their specific university in an effort to increase the retention of women in STEM.

**Find the Power Within: Convergence of Women in STEM K–12 to Post–Secondary Education**

The second half of the manual, *Find the Power Within: Convergence of Women in STEM K–12 to Post–Secondary Education,* is intended for K–12 districts, administrators, and parents of young women who want to encourage STEM as a career path. The key components of this part of the manual are outreach in your school district, coursework in your school district, extracurricular activities, and work–study. These concepts are applied in a similar manner in this section as they were in the *Seek to Empower More* section. However, this section can serve as a suggested prerequisite to being a collegiate woman in STEM.

The first consideration for K–12 districts and administrators is outreach in your school district. School districts can facilitate guest speakers from STEM companies and STEM college fairs. Our research revealed that most of our participants who chose STEM majors had early exposure to STEM as a career option while in middle or high school or their family members worked in STEM careers. K–12 school districts can influence young women by providing engagement with guest speakers and college career fairs.

The second consideration is the coursework in your school district. Most of the participants we interviewed had taken AP, dual enrollment, and/or PLTW classes. AP and dual enrollment coursework allow students a head start on their collegiate journey. Consider taking courses offered in the humanities to lessen the amount of general education coursework required as a traditional undergraduate student. This choice will allow access to specialized courses within a STEM major at an earlier date. PLTW coursework offers a hands–on, project–based approach to learning, fostering creativity and problem–solving skills. Enrollment in PLTW courses provides a supportive environment at the secondary level for young women to explore their potential to excel in STEM fields of study. By enrolling in this kind of rigorous coursework, students can learn to be successful in challenging classes and develop stronger self–efficacy. Furthermore, students learn to study and develop organizational and time management skills that translate to success with collegiate STEM coursework.

The next component discussed in the manual is extracurricular activities. Like the extracurricular section in *Seek to Empower More,* participation in extracurricular activities establishes a sense of belonging. Young women in K–12 should be encouraged to join clubs and participate in activities so that they can bond with other like–minded people, find support from peers with similar goals, and find support groups. Participation in extracurriculars for K–12 young women will establish interests that can be further developed in college.

The final consideration for K–12 districts and administrators is work–study. While work–study is not as common in K–12 as it is in college, it is something that could be implemented as a measure to increase the retention of women in STEM. K–12 districts could form their own version of work study by offering credits to complete jobs within the school, conduct extra research, or additional projects. There are several benefits to work–study related to meeting communal goals and enhancing self–efficacy. When students are given more control in their work environments, they see improved academic success and career readiness. Flexible workspaces in school allow women to work on academics. Work–study also aids in attaining career skills, meeting financial needs, and providing a flexible environment where many participants can study, thus allowing many participants to meet communal goals. If students can practice habits of work–study in K–12, it will assist in their transition to college.

The final page of this part of the manual is another flowchart that summarizes the section and demonstrates how K–12 school districts and administrators can implement our research findings. Districts and administrators could implement all of these concepts, or they could select the measures that they find most beneficial for their specific university in an effort to increase the retention of women in STEM. The manual concludes with a short summary of the contents of the manual.

**Dissemination**

We plan to disseminate our research by distributing our manual to enrollment management, student affairs, admissions, and diversity, equity, and inclusion at Missouri University of Science & Technology, University of Missouri–St. Louis, and Harris–Stowe State University. In addition, we will share our manual with area Missouri high schools, specifically, the school counselors and teachers of STEM curricula at Rolla High School, St. James High School, and Francis Howell Central High School.

In addition to disseminating our research to the aforementioned institutions of higher learning and area Missouri high schools, we will also submit our research to two journals: *Holistic Education Review* and *The Norton Guide to Equity – Minded Teaching*.

We endeavor to have our research appear in the Spring 2025 issue of the *Holistic Education Review*, their upcoming theme is "Education for Holistic Wellbeing: Exploring intersections and common purpose with social justice and equity which focuses on social justice, equity, and healing as intentional outcomes of holistic education." On our research team of 4 scholars, 3 identify as people of color and this issue amplifies the voices of authors and scholars who are from or work in communities of color, diverse language and cultural groups, LGBTQ+, neurodivergence, ability/disability, and other marginalized communities. We believe our research would align with the theme of this forthcoming issue.

In addition, we were invited to submit our research to *The Norton Guide to Equity – Minded Teaching,* written by renowned teaching and learning experts, this guide offers concrete steps to help instructors strive to ensure that all students – and, in particular, historically underserved students –have an equal chance for success (W.W. Norton &

Company). We believe female students are among those who have been historically underserved and given that our research centered on factors that improve the retention of women in STEM, and that our audience are college administrators, faculty (e.g. instructors), staff and students, we hope that this journal would be suitable for publication.

Broadening our scope, we will also share our research on 2 podcasts, one of which is The Nerdacity Podcast with Dr. DuEwa Frazier, who is an award winning poet, educator, TEDx & keynote speaker, children's / YA author and digital creator (Nerdacity, 2023). DuEwa also holds an Ed.D. and is excited to hear about our research.

The other podcast we have been invited to share our research on is The Poet & The People with Gregory Maurice. The Poet & The People is a platform for influential artists, creatives, activists and community advocates and people on the edge of Saint Louis culture. The Poet & The People podcast provides intimate conversation around creativity, art, social issues and authenticity with people who make Saint Louis culture what it is today (The Poet & The People, 2023). The issue of sexism is a social issue and we hope to raise awareness concerning this societal norm. Gregory is also interested in changing the narrative in society and is excited about helping us promote our research beyond the halls of academe and into the broader community.

We would like our research efforts to lead to the empowerment of women considering STEM majors and careers. Further, we want to encourage women to pursue STEM and support them with the varying resources that we have found to be impactful through our research. Our hope is to change the narrative that suggests that STEM fields are not for women. Through the publication of our research we hope to enlighten our peers within the field of education on the benefits of women pursuing STEM fields, but not only for future female STEM majors, but also for the administrators, faculty and staff that will work with them. We hope to guide these institutions on how to strengthen retention efforts at their institutions.

Additionally, through candid discussions on podcasts, we aim to heighten awareness and advocate for girls and women pursuing STEM.  Through community dialogue, we hope to stimulate interest among females in society. Moreover, for males and females to remain in conversation with each other about the issues women face while pursuing their degrees. Much like issues of racism have become topics of discussion among those of various ethnicities, we believe sexism also needs to be part of the conversation among university professionals, students, and the general public to de-stigmatize the notion of women pursuing degrees in STEM. Ultimately, our goal is to seal the leaky pipeline between women and men in STEM at the collegiate level while also broadening perspectives in society at-large.

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**Appendix A:** IRB Approval Letter

UMSL | Research
University of Missouri–St. Louis

June 30, 2023
Principal Investigator: Jason Nicholas Vasser-Elong
Department: Dean Honors College
Your IRB Application to project entitled Steminism : Analyzing Factors That Improve Retention for Women as STEM Majors was reviewed and approved by the UMSL Institutional Review Board according to the terms and conditions described below:
IRB Project Number 2096278
IRB Review Number 391168
Initial Application Approval

Date June 30, 2023
IRB Expiration Date June 30, 2024
Level of Review Exempt
Project Status Active - Exempt
Exempt Categories (Revised

Common Rule) 45 CFR 46.104d(2)(ii)
Risk Level Minimal Risk
IRB Exempt Consent
Approved Documents
This document details our research questions, interview questions, and probing questions.
recruitment_email.pdf

The principal investigator (PI) is responsible for all aspects and conduct of this study. The PI must comply with the following conditions of the approval:

1. Enrollment and study related procedures must remain in compliance with the University of Missouri regulations related to interaction with human participants at https://www.umsystem.edu/ums/rules/collected_rules/research/ch410/410.010_research_involving_humans_in_experiments.

2. No subjects may be involved in any study procedure prior to the IRB approval date or after the expiration date.

3. All changes must be IRB approved prior to implementation utilizing the Exempt Amendment Form.

4. The Annual Exempt Form must be submitted to the IRB for review and approval at least 30 days prior to the project expiration date to keep the study active or to close it.

5. Maintain all research records for a period of seven years from the project completion date.

If you are offering subject payments and would like more information about research participant payments, please click here to view the UM Policy https://www.umsystem.edu/ums/policies/finance/payments_to_research_study_participants

If you have any questions or concerns, please contact the UMSL IRB Office at 314-516-5972 or email to irb@umsl.edu.

Thank you,

UMSL Institutional Review Board

**Appendix B:** Informed Consent for Participation

**Consent to Participate in Retention of Women in STEM Study**

## University of Missouri–St. Louis

## Informed Consent for Participation in Research Activities

**Project Title: Steminism : Analyzing Factors That Improve Retention of Women in STEM**
**Principal Investigator: Jason Vasser-Elong**
**Department Name: Education**
**Faculty Advisor: Dr. Shawn Woodhouse, Dr. Marcus Long, Dr. Rebecca Jones**
**IRB Project Number: 2096278**

1. You are invited to participate in a research study. The purpose of this research study is to identify factors relevant to the retention of undergraduate women in STEM majors.

2. Your participation will involve an interview lasting approximately 45 minutes. The interview will be conducted
remotely via video conferencing software, Zoom. The Zoom interview will also be recorded and transcribed as to be reviewed by the researchers in the group. If a participant would not like to show their face on camera, we will conduct the interview without the video feature. Please rest assured that your privacy and information will be kept confidential or anonymized in the final dissertation.

3. There is a loss of confidentiality risk associated with this research as identifiers including your name, gender, ethnicity, area of study, amount of credits completed, and hometown will be requested. This will be minimized by utilizing pseudonyms. Associated risks could include discomfort in responding to questions, however, if the participant is not comfortable with any of the questions, they may choose to "skip" or "pass" the question.

4. The possible benefits to you from this research are assisting in discovering factors to create better learning environments for women in STEM majors and enhance college programing that benefits women in STEM majors.

5. Your participation is voluntary and you may choose not to participate in this research study or withdraw your consent at any time. You will NOT be penalized in any way should you choose not to participate or withdraw.

6. We will do everything we can to protect your privacy. As part of this effort, your identity will not be revealed in any publication that may result from this study. In rare instances, a researcher's study must undergo an audit or program evaluation by an oversight agency (such as the Office for

Human Research Protection) that would lead to disclosure of your data as well as any other information collected by the researcher.

7. If you have any questions or concerns regarding this study, or if any problems arise, you may call the Investigator, (Jason Vasser-Elong, 314-327-0799) or the Faculty Advisor, (Marcus Long, 605-661-7776). You may also ask questions or state concerns regarding your rights as a research participant to the University of Missouri–St. Louis Office of Research Compliance, at 314-516-5972 or irb@umsl.edu.

**Appendix C:** Interview Questions

1. Please share your gender, year in school, and where you are from.
2. What degree program are you enrolled in?
3. Tell us about your educational background.
4. What motivated you to choose a major in the STEM field of study?
5. How did experiences as a high school student influence your decision to choose a STEM major?
6. Describe your high school experiences related to Advanced Placement (AP) coursework or Dual Enrollment coursework.
7. Tell us about the study habits you developed as an AP student.
8. How have your study habits evolved to suit your needs as a STEM major?
9. What extracurricular activities do you participate in?
10. How have your experiences with extracurricular activities impacted your college experience?
11. What are some challenges of participating in extracurricular activities?
12. What have been the benefits of you participating in extracurricular activities?
13. Do you utilize art in your study habits? i.e., study with music, use color coding for notes, draw or paint to visualize concepts. Please explain.
14. In what ways do you think art can be used as a learning tool?
15. What has your experience been with work-study?
16. How has your participation in work-study impacted your learning experience?
17. How has your participation impacted you as a STEM major?
18. As a woman in a STEM major what challenges have you faced?
19. How can the aforementioned challenges be improved?
20. Can your university do anything to be more supportive of you as a woman in a STEM field?

**Appendix D:** EmpowHer: A Steminist Guide to Cultural Border Crossing