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Investigating Gender Diversity, Equity, And Inclusivity And Students' Experiences Within Collegiate Team-Based Learning Environments

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INVESTIGATING GENDER DIVERSITY, EQUITY, AND INCLUSIVITY AND STUDENTS' EXPERIENCES WITHIN COLLEGIATE TEAM-BASED LEARNING ENVIRONMENTS

by

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Marissa Elizabeth Saad
August 2022

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ABSTRACT

As the United States works towards strengthening and diversifying the science, technology, engineering, and math (STEM) workforce, many national charges aim to increase the quantity of female participants, while overlooking how systematic barriers affect the quality of female students' education. Many STEM workforce development programs, such as the National Space Grant College and Fellowship Program, are committed to improving the nation's diversity, equity, and inclusivity (DEI) efforts, enabling technical education through hands-on team-based learning (TBL) environments.

The purpose of this study was to take a holistic approach to assess how gender DEI in STEM team environments influence the quality of female students' learning outcomes and experiences. The socio-ecological framework, guided by feminist standpoint theory, was used to explore how the macro- and micro-levels affect female team members. Through a mixed-methods approach, this work presents two studies: 1) a qualitative document analysis (QDA) that analyzes STEM programs' recruitment documents and assesses how gender DEI is integrated into STEM programs' student-centric policies, and 2) a survey tool that analyzes how gender relates to technical task distribution and individual students' experiences.

Data analysis showed that a lack of gender DEI integration into STEM programs negatively influences students' learning outcomes. First, almost all of the national STEM programs failed to embed gender DEI into the programmatic frameworks and strategic goals. Second, female students were statistically more likely to lead the non-technical tasks on STEM

teams, reinforcing the traditional gender roles found in the literature. Also, although female students reported similar motivation levels as the male students, they were less likely to: (a) conduct technical tasks, X^2 (1, N = 203) = 7.8, *p* = .005, (b) feel like they can lead group work and be effective, X^2 (3, N = 192) = 12.9, p = .005, and (c) feel like they belong to the STEM community, X^2 (5, N = 196) = 10.7, p = .05. Female students were also statistically more likely to (d) feel like an outsider, X^2 (5, N = 196) = 11.8, p = .04, and (e) believe they can effectively coordinate tasks and activities of a group, X^2 (3, N = 192) = 12.9, *p* = .005.

These findings add to a growing body of literature that national efforts are not sustaining a conducive environment that promotes equitable learning experiences. The STEM workforce will fail to see its full potential until systems of inequalities are addressed at all levels of the socio-ecological system.

INVESTIGATING GENDER DIVERSITY, EQUITY, AND INCLUSIVITY AND STUDENTS' EXPERIENCES WITHIN COLLEGIATE TEAM-BASED LEARNING ENVIRONMENTS

INTRODUCTION

Throughout American history, women have been greatly underrepresented in the science, technology, engineering, and math (STEM) fields (NSF, 2019; Rosser, 1998). Fewer bachelor's degrees have been awarded to female students majoring in STEM than their male counterparts: 20.9% in engineering, 19.3% in physics, and 18.7% in computer science, despite more than half of the undergraduate bachelor's degrees being awarded to female students (NSF, 2019). Female students are less likely to enroll in STEM programs, more likely to drop out or transfer to non-STEM programs, and ultimately, less likely to graduate into STEM careers (Zhang, 2021; Tusui, 2007).

These gender disparities exist throughout the collegiate level, specifically in STEM programming that reinforces technical education through hands-on, experiential learning opportunities. One strategy to strengthen technical education is to engage students in a team-based learning (TBL) setting, where classroom knowledge can be applied to an authentic real-world challenge. These challenges allow students to practice their technical and non-technical skills—developing critical skills that are necessary for the STEM workforce.

Collegiate TBL programs also deal with gender inequity issues: female team members statistically perform fewer technical tasks than male team members, missing out on crucial hands-on "nuts-and-bolts" education (Faulkner, 2007, 2011). If the STEM workforce is to receive qualified and prepared individuals, all collegiate team members—regardless of gender—should be trained with both technical and non-technical education.

With different life experiences, female students are able to bring unique perspectives and cognitive diversity to team environments that help create new and innovative solutions, as well as better performances (Nielsen et al., 2018; Maznevski, 1994; Dyson et al., 1976; Hoffman & Maier, 1961; Ruhe, 1978). Without a gender diverse workforce, America will continue to fall behind on the global stage and limit the potential of the future talent pool (Granovskiy, 2018). Until there is systemic change within STEM and all voices have the opportunity to be heard, the United States will be unable to strengthen its economic and national security (Granovskiy, 2018). Brush (2013) summarized this issue by stating: “if a team of three engineers all look alike and think alike, then there are two people on that team that are not needed.” In this dissertation, the author presents two studies that explore gender diversity, equity, and inclusion within TBL settings.

As stated by Iyer (2022), “the goal of DEI policies is to rectify an illegitimate system of social inequality by increasing the representation, status, and power of disadvantaged groups.” Therefore, it is important to recognize the broader need for advancing gender DEI efforts in STEM environments, which attempt to remedy this inequitable social system (Jimerson, 2021). Effective DEI strategies require institutional leaders to acknowledge past DEI challenges and implement evidence-based structural changes that enable growth and more equitable outcomes (Kraus et al., 2022). Strategies may include initiatives that target: (a) recruitment programs to increase participation from underrepresented groups, (b) training mentorships to improve opportunities for underrepresented groups, and (c) preferential treatment for individuals in underrepresented groups (Iyer, 2022). Such efforts may elicit adverse reactions from the public and if not implemented sensitively, these efforts can backfire (Iyer, 2022).

Many groups of individuals disagree about whether DEI efforts are necessary, doubting the evidence-based positive effects (Iyer, 2022). DEI efforts have received negative consequences and connotations in the past, increasing the current apprehension of some organizations (Jimerson, 2021). Organizations that fill unmeaningful quotas are stigmatized and more detrimental to the hard work and accomplishments of other meritorious women (Prieto-Rodriguez et al., 2022).

New DEI policies may threaten the already advantaged groups—traditionally cisheteronormative white male leaders in power—as these policies highlight the salient statuses and advantages this demographic holds within society, and no one wants to believe their group is immorale (Iyer, 2022; Leach et al., 2007). Members within these groups typically do not want the traditional framework of meritocracy to be altered; updating the system would affect the recruitment processes, their career progressions, and the ability to utilize informal recommendations from within the organization (Iyer, 2022). These groups also face resource threats—the fear to lose opportunities or positions of power held previously—and symbolic threats—the perceived attacks on the previous way of life, including values, beliefs, practices, and norms (Rios et al., 2018; Iyer, 2022).

Affirmative action, or the practice to actively include more diversity in a government or organization to remedy the inequities of discrimination, also receives positive and negative reviews (Iyer, 2022). These practices are positively received when people are presented with persuasive evidence of discrimination and evidence-based justification for its implementation (Son Hing et al., 2002; Harrison et al., 2006). When individuals who originally opposed affirmative action learned that the policies were upholding and not violating their own lifestyles, support increased (Reyna et al., 2005). This approach also perpetuates the inequitable status quo while trying to engage the majority group in a non-threatening way; this approach continues to benefit the advantaged groups (Castilla, 2017; Amis et al., 2020; Iyer & Blatz, 2012). As reported by Iyer (2022), 184 *amicus briefs* were submitted to the U.S. Supreme Court in 2013 and 2016, which detailed the negative aspects of integrating DEI through affirmative action. The opponents believed meritocracy and work ethic was threatened (Carter et al., 2019). This affected opinions on implementing DEI efforts within higher education, as many individuals in a position of affecting policy may be apprehensive to enter this controversial arena.

Theoretical Frameworks

This dissertation work is guided by the integration of team dynamics, the issues of STEM, and gender studies. The fabric of this research is created by weaving together theories from all three of these topics. Together, these frameworks help describe and explain the phenomena found within the literature (Hatch, 2002). By integrating these concepts together, this dissertation is able to stand on a solid multidimensional foundation and take an indepth exploration into all students' experiences.

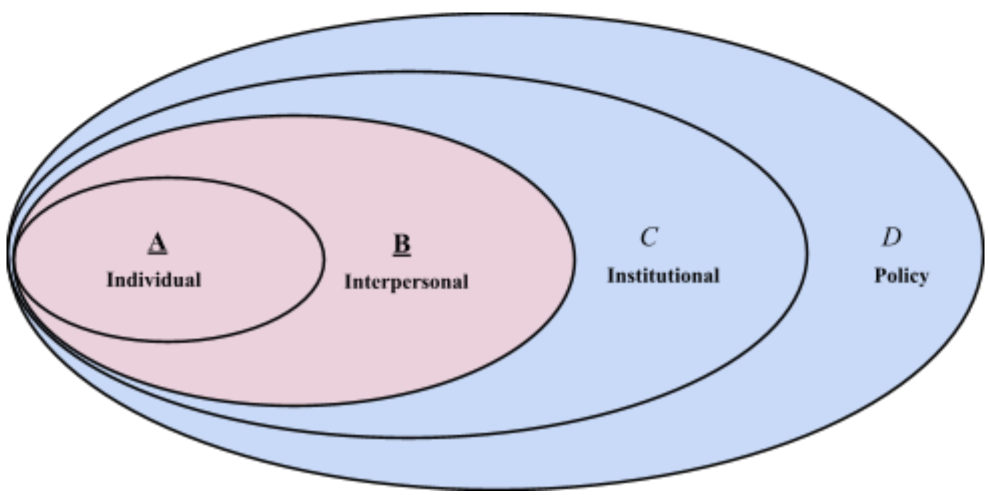
Socio-Ecological Framework

To investigate gender disparities in STEM fields, this research uses the socio-ecological model (SEM), a holistic approach to help explain how individuals interact within a multifaceted social system (Guy-Evans, 2020; Lee et al., 2017; Biglan et al., 2013). Formalized as a theory in the 1980s, the SEM is now commonly used by the Center for Disease Control (CDC) for violence prevention strategies due to its ability to conceptualize the multidimensional areas needed for interventions (Kilanowski, 2017). Many authors and organizations have adapted the model to their fields because of its ability to represent the interdependent relationships between numerous systems. For example, the SEM is used by researchers who are studying agricultural safety and health intervention efforts (Lee et al., 2017; Kelly & Coughlan, 2019), health care and associated behaviors such as obesity research (Ma et al., 2017; Pereira et al., 2019), climate action planning (Pan et al., 2019); and the effects of school environments on students (Lippart et al., 2017; Wilson et al., 2002; Langford et al., 2014).

The SEM is a valuable tool because it assumes ecological systems do not exist in isolation from one another; each dimension is embedded within the other, existing like layers of an onion (Aregu et al., 2016; Dang, 2019). Instead of focusing on how to prevent or treat each problem in isolation, the model helps illustrate how to target environmental circumstances that contribute to all micro-, meso-, and macrosystems (Biglan et al., 2013). Together, the characteristics, similarities, differences, and connections within these layers allow researchers to address a wide-range of societal issues (Xiang, 2021).

Figure 1

The Adapted Socio-Ecological Model (SEM)



The SEM model, illustrated in Figure 1, depicts the nested set of relationships of systems, each displayed as a series of concentric circles. As Ross et al. (2022) describe, the first circle is the microsystem, where interactions between the individual and the environment are bi-directional, influencing the other. The mesosystem (interpersonal and institutional layers) is the interactions between the microsystem and macrosystem; the macrosystem is the culture that influences individuals.

STEM culture is pervasive throughout all layers of the SEM. Example influences include:

1. Individual (Includes students' self-efficacy, motivations, STEM identity, sense of belonging, STEM knowledge, technical skill sets, values, perceived norms, etc.)
2. Interpersonal (Includes students' peers, STEM role models, familial support systems, academic advisors and professors)
3. Institutional (Includes STEM programming and higher education institutions, etc.)
4. Policy-enabling environment (Includes broad societal factors that affect gender inequities such as policies and regulations, STEM culture, gender norms and stereotypes, resources and services, mass media and technology, etc.)

(adapted from the CDC, 2022)

As Townsend and Foster (2013) state, it is important to conduct a multilevel analysis because: 1) behavior affects and is affected by influences found throughout the layers and 2) individual behavior is shaped by the social environment, also known as reciprocal causation. These influences are rooted in predescribed social roles, as discussed in social role theory.

To conduct an in-depth exploration of these relationships, the two studies within this dissertation work target the macro- and micro-systems (see Figure 1). The first study highlights the macro and meso layers C and D, focusing on institutional and policy-enabling levels. The second study highlights the micro and meso layers of A and B, focusing on individual and interpersonal levels. Each layer interplays with the others, and as a result, these two studies address the entire continuum, augmenting and supporting the other.

Social Role Theory

When considering gender-mixed groups and the associated team dynamics, it is important to consider how social role theory impacts all team members, especially female members (Eagly, 1987; Bandura, 1977). Eagly (1987) originally formulated social role theory to explain male and female behaviors, as well as stereotypes, attitudes, and ideologies relevant to sex and gender (Eagly & Sczesny, 2019). Eagly argues that sex differences and similarities in behavior reflect gender role beliefs that represent people's perceptions of gendered social roles in society (Eagly & Wood, 2011). Women are expected to act more communal—acting friendly, empathetic, and emotionally expressive—completing caretaking roles, and men are expected to have more agency—acting assertive, masterful, and independent in authority positions (Eagly & Wood, 2011; Franke et al., 1997).

Social role theory outlines how the division of labor—specifically the distribution of technical and non-technical tasks—is structured in a society that values cultural stereotypes and gender roles, which are then shaped by other constraints (Eagly & Kite, 1987; Valentine & Li, 2012). Individuals use implicit theories about what is expected in a work role to determine if women or men would be better suited for the role (Eagly & Karau, 2002, as cited in Badura et al., 2018). Social roles create socially shared patterns of expectations for behavior, shaping the division of labor (Eagly & Wood, 2011). Women are more likely to hold communal roles in society, such as domestic and caregiving roles, and thus, inferred to possess communal traits such as kindness and warmth (Eagly & Wood, 2012, as cited in Lemoine et al., 2016). Because men have historically served as the "breadwinner" and possess higher status roles than women, they were assumed to be more assertive and dominant (Eagly & Karau, 2002, as cited in Badura et al., 2018). In organizational settings, this division of labor manifests within gender roles and managerial roles: men assume more leadership roles as opposed to women. In mixed-gender settings, these gender stereotypes can become prominent and shape the behavior of the individuals involved (Smelser & Baltes, 2001). Ultimately, socially defined gender roles shape and differentiate women and men's tasks and responsibilities (O'Shaughnessy & Krogman, 2011).

Social Constructionist Framework

A social constructionist lens was applied to this research, which states that all meaning and knowledge is socially constructed through interpersonal relationships (Gergen, 1985). Contrary to constructivism—where an individual's mind reflects reality—constructionism does not illuminate the "truth" (Galbin, 2014). Instead, constructionism outlines how individuals perceive and understand the world, as they form meaning from their experiences (Cojocaru et al., 2012; Galbin, 2014, p.84). Society is socially constructed and it governs how individuals perceive their roles, including the gender roles that are defined on a collective agreement (Andrews, 2012). These roles can change over time, because the way the world is understood is "a product of a historical process of interaction and negotiation between groups of people" (Galbin, 2014, p. 83). The social constructionist framework directly influenced the second study, as the research goals focus on students' perceptions of team dynamics and their learning outcomes.

The social constructionist framework also supports the investigations of social, linguistic, and symbolic practices (Cojocaru & Bragaru, 2012), as highlighted in the first study. Social constructionism reveals the power in communication and language. As described by Galbin (2014), "language is more than just a way of connecting people. People 'exist' in language." This means individuals' realities are constructed through language. The context of how language is used directly affects its meaning, particularly when it is involved in social interactions (Burr, 2003). By utilizing this theory, innovative and diverse practices can emerge (Gergen & Gergen, 2012), as this way of thinking pivots away from the hierarchical and expertise-based models and into the participatory, process-centered models (Galbin, 2014).

Feminist Standpoint Theory

The methodologies developed within this dissertation work were framed through the lens of the feminist standpoint theory (FST). Originating in the 1970s, this theory "centralizes women's experiences in the research process, viewing them as a point of entry for the creation of new knowledge" (Watson et al., 2018). Women are privileged epistemologically because they are members of an oppressed group, and FST asserts women can identify the forces that sustain and perpetuate their oppression (Smith, 2005; Harding, 1987).

Projects within the natural sciences have critically engaged with this framework and developed standpoint themes for decades because of its ability to share women's situations in STEM (Harding, 2004). For example, subject areas such as biological sciences help shape hypotheses and methods to "meet the sexist and androcentric (and often racist and eurocentric) needs of dominant social groups" and ultimately reflect "dominant ways of thinking" (Harding, 2004). When non-dominant ways of thinking are shared within STEM, women's social positions and political struggles advance the growth of knowledge, propelling scientific inquiry (Harding, 2004). This knowledge is created from women's lived experiences as an oppressed group and is shaped by the social conditions under which it is produced (Harding, 1987; Mann & Kelley, 1997).

Collins (1997) interprets FST as a framework that explains how knowledge is crucial to perpetuating and changing inequitable systems of power. By providing a voice to this marginalized group, FST operates free from the patriarchal bias (LeSavoy & Bergeron, 2011). Instead of "studying up"—focusing on dominant social groups' ideologies—it is essential to "study down" and understand the lives of marginalized groups.

STEM subjects have a gendered history and are not a set of objective disciplines (Heybach & Pickup, 2017). These gendered themes range across a spectrum: the math-intensive subjects are more masculine than the social sciences and biological sciences. Despite this gendered range, all STEM fields produce knowledge that is "understood through male-oriented language and worldviews that isolate women from their own realities" (LeSavoy & Bergeron, 2011).

Statement of Problem

In the United States, female college students do not receive equitable technical education as their male counterparts, limiting opportunities for growth and engagement (Smith & Gayles, 2018). Studies show this gender disparity is less to do with the individual learner, and more to do with the academic environments and cultural barriers prevalent in STEM—factors that also affect students' levels of motivation, self-efficacy, and sense of belonging (Smith & Gayles, 2018; Fouad et al., 2016). Many national workforce development programs, such as the National Space Grant and Fellowship Project ("Space Grant"), support team-based learning (TBL) student opportunities (i.e. STEM competitions and challenges), making substantial financial commitments towards the engagement of their students (Ng & Newpher, 2020; Parmelee et al., 2012; NASA Challenges, 2020). Research has not yet explored Space Grant students' TBL experiences and perceptions of TBL, missing out on crucial data to help address gender inequities. As suggested by social role theory, team-based task distribution may be differentiated by students' gender identity, and how this manifests within the STEM TBL settings is currently unknown (Eagly, 1987; Faulkner, 2011). The goals of this study is to analyze the structural policies of STEM TBL programs, assess how well these programs integrate gender DEI into programmatic frameworks, and compare these findings with Space Grant-funded college student participants' experiences. If the perpetuation of gender inequality in STEM is to be addressed, there needs to be an in-depth analysis of the factors that influence female students and technical education.

Purpose of Research

The purposes of this study are to: (a) investigate how well STEM team-based programs' recruitment documentation integrates gender diversity, equity, and inclusivity (DEI) into their programmatic frameworks and (b) to investigate how gender influences students' technical experiences, motivation, levels of self-efficacy, and sense of belonging.

For the first study, a qualitative document analysis (QDA) of public-facing documentation should identify how nationwide programs can reduce gender disparities in STEM. This study aims to explore female representation in text and images, while also exploring how gender is represented in programs' strategic goals. For the second study, the comparative analysis between female and male students' task allocation should identify any statistically significant differences in the distribution of technical and non-technical roles.

Significance of the Study

The literature shows that female students are not receiving equitable technical experiences in STEM fields compared to their male counterparts (NSF, 2022). The purpose of this study is to explore how STEM team-based programs' policies support equitable technical education opportunities. The findings will be compared with students' experiences as they participate in these settings, which will help to identify how gender influences students' task distribution, levels of motivation, self-efficacy, and an overall sense of belonging. This will highlight how institutional barriers may continue to marginalize female collegiate team members. This study will serve as a resource for STEM policymakers nationwide—institutions, governmental agencies, and TBL educational leaders—to influence their future program development and budgetary considerations.

Research Questions

The following research questions, itemized by study, will guide the dissertation:

Study 1:

1. RQ1: How well do TBL programs highlight gender diverse, equitable, and inclusive representation with their recruitment materials?
    a. RQ1a: How well do these recruitment materials use gender-inclusive language?
    b. RQ1b: How well do these recruitment materials promote gender DEI through imagery?
2. RQ2: How well do TBL programs promote equitable student learning outcomes?

Study 2:

1. RQ1: What are the demographics of students participating on STEM teams?
2. RQ2: How does the gender identity of students participating on STEM teams influence students' motivation, self-efficacy, and sense of belonging?
3. RQ3: Is there a relationship between gender and task distribution on teams?

Limitations

A review of the literature shows data are reported through a binary gender construction: male or female. This narrow two-option system can be seen in national reports by the US Census data, National Science Foundation data, NASA-reported data, and others. Because these agencies report only two genders, this assessment is not inclusive of any non-binary or gender non-conforming persons. The exclusion of all gender identities is a limitation for the first survey.

The second study within this dissertation was limited to the extent that all survey participants responded honestly and accurately, as well as they were familiar with their teams' tasks and operations well enough that they were familiar with the questions found within the survey instrument.

Delimitations

To limit the scope of this study, the first and second study in this dissertation focused solely on gender-DEI factors. An intersectional framework was not used for this study, but its importance should not be overlooked or minimized. There are additional critical social identities that influence learners, such as socioeconomic status, race, ethnicity, and disability status.

The second study delimits its investigations to Space Grant-only funded college student experiences. Many students throughout the United States, including those within the K-12 age ranges, participate on STEM teams. This research does not capture data from learners in the younger age ranges. In addition, this study does not account for the large number of international STEM programs that also engage American students.

Research is delimited to the 2021-2022 academic year. At this time, the world was still experiencing the ongoing global health crisis, the COVID-19 pandemic (the highly transmissible Omicron variant was peaking during many of these programs' timelines, directly influencing the potential to hold in-person team-based programming). Despite safety precautions in place, each school across the nation enforced varying levels of regulations and safety precautions. Some STEM programs operated virtually, hybridized, or even paused until the following year. This study did not assess the impacts COVID-19 had on students' motivation to join, especially when some may not have participated due to safety concerns. Studying students' interactions in 2021 could differ from those studied prior to 2020 because of the hands-on tasks and requirements within a group setting.

The second study delimits its reference of gender identities to a binary system, due to the limitations mentioned above. For example, five survey participants (2%) within the second study identified with a gender that lies outside the binary, which provides evidence of how a binary system fails to capture all students' experiences.

Assumptions

It is assumed that students participate on STEM teams voluntarily. If an academic course requires students to compete on a team as part of a degree requirement, it is inferred that these students enroll in that discipline voluntarily. All students would have an equal opportunity to transfer degree programs if they were unsatisfied with their academic path.

Additionally, this research assumes the national STEM programs provide prospective students and current teams with participation documentation (e.g. student handbooks, guidebooks, and technical manuals). This study also assumes that students understand the survey tool questions (including questions that confirmed their age and affiliation to Space Grant) and the associated terminology. It is also inferred that students responded to the survey tool truthfully to provide honest responses.

Overview of the Dissertation

The introduction, literature review, and methodology sections—sections one, two, and three, respectively—precede the two articles. The first article examines gender equity by analyzing public-facing recruitment documents and assessing STEM programs' macro-level policy. The second article examines students' experiences as they participate on STEM teams, exploring the micro-level of how policy affects student learning outcomes. Students' levels of motivation, self-efficacy, and sense of belonging was explored. The fifth section is the dissertation's conclusion.

Conceptual Map

The following concept map (Figure 2) is a visual representation of this dissertation work, outlining how the first and second study both support and influence the other in their goal to investigate gender DEI in STEM programs. The solid connector line represents the first study and the dotted line represents the second study.

Using qualitative document analysis (QDA) methods, the first study will examine public-facing documents that are designed to recruit and engage student team participants. These documents may outline the programs' strategic goals, programmatic objectives, and technical education opportunities for students. The QDA will also investigate the documents' choice of language and image selection, assessing how gender DEI is embedded in the programmatic frameworks.

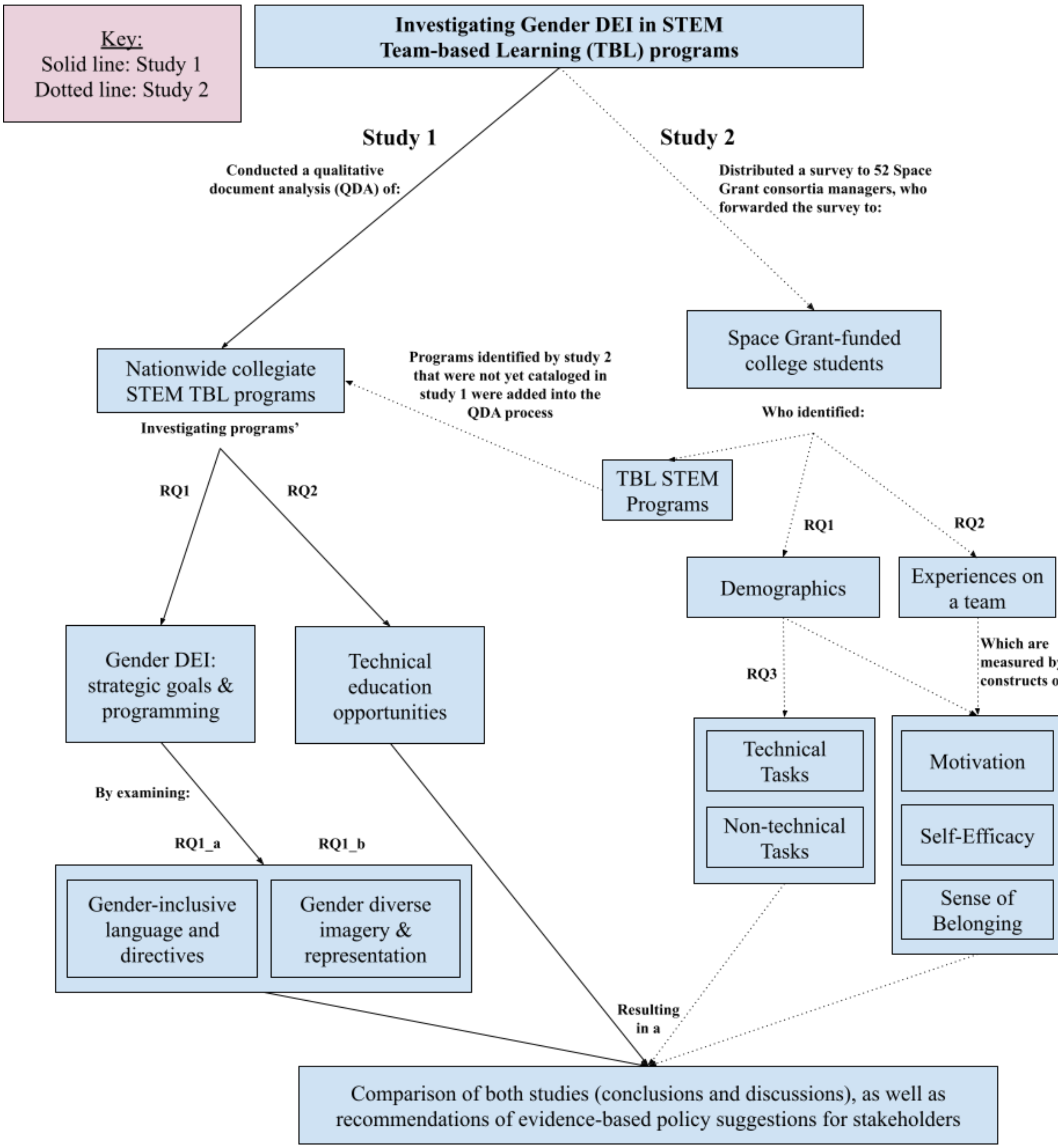
The second study will investigate students' experiences on STEM teams. A survey tool will be distributed to fifty two Space Grant Consortia who will forward the survey to their funded students. These students will identify the name of the STEM program that they participated in, and these program names will be used as reference to expand the list in the first study, increasing validity. The independent variable, gender identity, will be used to investigate the distribution of technical and non-technical tasks, as well as three constructs that directly affect STEM retention and success: students' self-efficacy, levels of motivation, and a sense of belonging.

As defined by Master (2021), motivation, self-efficacy, and a sense of belonging are all motivation-related constructs that affect persistence and retention in STEM fields. *Motivation* is a pattern of cognitions (self-perceptions, beliefs, and goals), affective responses (interest), and behaviors (persistence and academic choices) that energize students in school (Master, 2021; Dweck & Leggett, 1988). *Self-efficacy*, one's belief that they are able to organize and execute the actions required of them and produce effects, helps set expectations and the potential for success (Bandura, 1977; Eccles & Wigfield, 2020; Master, 2021; Vance et al., 2015). Past research has found strong correlations between self-efficacy and academic success, correlating these with strong task performance and persistence (Bandura, 1977; Schunk, 1987). Persistence directly influences students' self-regulated behaviors, such as their efforts, actions, and resiliency towards success (Stewardson et al., 2018). A *sense of belonging* is defined as a student's belief that they will fit in with others and have a positive relationship with the people or environment (Walton & Brady, 2021; Master, 2021). Holvino et al. (2004) describes inclusion as the extent to which participants feel a sense of belonging and are able to influence team decision-making.

Research indicates that gender disparities in STEM are heavily influenced by motivation-related factors, rather than competence (Leaper & Starr, 2019). Understanding what produces a gender gap is especially prominent in STEM team-related research, as these environments foster inequitable technical experiences and these negative experiences undermine female students' motivation. This conceptual map outlines how both studies integrate these concepts into both methodologies, ultimately influencing the discussion, conclusions, and future recommendations.

Figure 2

A Conceptual Map Outlining the Research Goals and the Relationship between the Two Studies.



Definitions

Throughout this research, the following key terms are frequently discussed:

- *DEI*, or *diversity*, *equity*, and *inclusion*, are principles that aim to reduce barriers for all individuals. *Diversity* is "the full participation, belonging, and contribution of organizations and individuals" (NASA, 2022c). *Equity* is the consistent and systematic provision of fair, just, and impartial treatment to all individuals, including individuals who belong to underserved communities that have been denied such treatment" (NASA, 2022c). Equity also means addressing and correcting systemic barriers that prevent the full participation of all. To be *inclusive* is to create an environment in which all are inspired to interact through mutual respect, support, and appreciation of difference. An inclusive environment deliberately fosters a culture of safety and trust" (HHMI, 2021). Inclusivity also "involves the recognition, appreciation, and use of the talents and skills of employees of all backgrounds" (NASA, 2022c). It is important to note that not all diverse settings may be inclusive or equitable. Increased focus on *accessibility* has expanded the DEI acronym to "DEIA" and is a major goal throughout the NASA and Space Grant communities. *Accessibility* provides equitable access to all individuals and makes space for the characteristics of each person (American Alliance of Museums, 2018). Due to the scope of this dissertation research, the author solely focused on DEI, yet recognizes DEIA is an equally important responsibility for educators.
- *Experiential Learning:* A teaching method to enable students to "learn by doing" or becoming participants themselves (McCarthy, 2010).

- *Gender:* Gender is a social construct and social identity (the attitudes, feelings, and behaviors) that a culture associates with a person's biological sex (American Psychological Association, 2012). *Gender identity*, or the person's psychological sense of their gender, which may not correspond to the person's sex assigned at birth, presumed gender based on sex assignment, or primary sex characteristics (American Psychological Association, 2012). The studies within this dissertation discuss gender through a binary lens, to align with the reports of the US Census Bureau, NASA, and NSF national data. It is important to note that not all underrepresented genders identify as women, such as those who identify as non-binary.
- *Motivation theory:* A lens to analyze how students' experiences reflect their engagement and persistence to learning (Jones et al., 2013).
- *NASA:* the National Aeronautics and Space Administration
- *The National Space Grant Colleges and Fellowship Program* (hereafter referred to as "Space Grant") is a Congressionally-mandated workforce development program with the National Aeronautics and Space Administration (NASA), and composed of a network of higher education institutions. Space Grant, established in 1989, consists of 52 consortia (this includes all 50 states, Washington D.C., and the Commonwealth of Puerto Rico), and has over 850 affiliate institutions (NASA Space Grant, 2022). These institutions consist of universities, colleges, industry, museums, science centers, and state and local agencies (NASA Space Grant, 2022). Students surveyed within this dissertation all received funding from one of these 52 consortia.

- *Science, Technology, Engineering, and Mathematics education*, abbreviated by the acronym "STEM", refers to teaching and learning in the fields that use interdisciplinary education to introduce problem solving skills, cooperative learning, and the engineering design process to learners (Granovskiy, 2018; Daugherty & Carter, 2018). The studies within this dissertation use the same list of STEM subjects as defined by the National Science Foundation (National Science Board, 2022).
- *Self-efficacy:* An individual's belief that they are able to organize and execute the actions required of them and produce effects, and sets expectations and the potential for success (Bandura, 1977; Eccles & Wigfield, 2020; Master, 2021; Vance et al., 2015)
- *Sense of Belonging:* A student's belief that they will fit in with others and have a positive relationship with the people or environment (Walton & Brady, 2021; Master, 2021).
- *STEM engagement*, traditionally referred to as *STEM outreach*, is science, technology, engineering, and mathematics opportunities for learners within formal and informal education settings. These learners typically interact with a STEM professional who is actively contributing to the STEM fields, hoping to inspire and educate learners who otherwise may not have access to the service (Engineers of Tomorrow, 2022).
- *STEM Pathway:* In order to strengthen the STEM workforce with diverse and prepared graduates, educators lead students through a course plan that develops their science and math skills (Ellis et al., 2016). This conceptual path, which

includes elementary, secondary, and higher education levels, is frequently called the *STEM pipeline*. In recent years, research shows the use of the “STEM pipeline” is not the best terminology to use in terms of inclusivity and student motivation (Cannady et al., 2014). The “pipeline” analogy conveys that students must meet a sequential set of narrow and rigid benchmarks in order to be worthy of a career in these fields (Cannady et al., 2014). This approach is reductionary and may affect student’s motivation to persevere in STEM when they fail to meet a specific benchmark (Cannady et al., 2014). The “preschool to PhD” path is no longer the only goal; America now needs to create a “STEM-capable” workforce (NSF, 2015). Organizations such as the National Science Foundation, National Academies of Sciences, Engineering, and Medicine, and the Howard Hughes Medical Institute (HHMI) have also replaced “pipeline” terminology with “pathways," which supports a multitude of dynamic, nonlinear approach to STEM literacy (National Academies, 2022; NSF, 2015; Asai & Bauerle, 2016; Langin, 2022). Ranganathan et al. (2021) suggest replacing “leaky pipeline” with “fractionation,” as it quantifies the disproportionate loss of women from academia. Additionally, when the pipeline is described as “leaky,” we fail to recognize scientific literate citizens and all science and math educators (Cannady et al., 2014). Through a cultural lens, the term “STEM pipeline” also assumes a Western viewpoint, perpetuating negative colonialism associations to Indigenous communities (Wiseman & Herrmann, 2019). Throughout this research, the term *STEM pathway* is used instead of STEM pipeline. Although not perfect, this term conveys how there are multiple paths, each with various benchmarks and milestones that still has potential to lead students into a successful career in STEM, while also aiming to be culturally sensitive.

- *Team-Based Learning (TBL):* An interactive and student-centric teaching method that actively engages students in teamwork (Gaber et al., 2020).

Author Affiliation to Space Grant

The author joined the Space Grant community in August of 2011 as a graduate research assistant (GRA) for the Space Studies department at the University of North Dakota. As a GRA, the author received North Dakota Space Grant Consortium (NDSGC) funding to manage the statewide high altitude balloon challenge that engaged middle and high school students, until May of 2012. In 2012, the author joined the UND high power rocketry club, ultimately traveling to Huntsville, Alabama for the University Student Launch Initiative (USLI) (now NASA's Artemis Student Challenge program named "Student Launch").

In 2015, the author's relationship with the NDSGC evolved, as she was hired as the Program Coordinator. One of the many job responsibilities included overseeing higher education programming, such as the pre-college and college competition teams. As Coordinator, she organized and facilitated a statewide conference, hosting dozens of student presenters and team demonstrations. It was at these Space Grant conferences where she noticed there was a gender disparity amongst the STEM teams: there was little to no female representation on these teams. When there were female presenters, the female students generally led the non-technical tasks, such as social media management and photography duties.

The author's level of participation evolved in 2020, as Deputy Director. This change removed her from overseeing the ND competition team program, distancing herself from the program's day-to-day operations. She still served on the review panel for team funding applications at the beginning of each academic year (see the conflict of interest section below for more information on 2021-2022 involvement). Her own experiences with TBL provided a close-up view of the gender dynamics over the years, observing the inequitable gender distributions and more specifically, the imbalance of technical training opportunities for female students. As a product of the Space Grant program herself and an advocate for gender DEI, she decided to dedicate her research goals to these issues.

Summary

Female students are underrepresented in STEM fields that provide technical learning experiences (NSF, 2022). In order to develop a STEM-literate and prepared workforce, all students, regardless of gender, should equitably explore both the technical and non-technical skill sets. Because team-based programs have the power to design their own student engagement policies, they should reflect on their current diversity, equity, and inclusion efforts and be willing to improve their programmatic frameworks to address this national educational deficit. This dissertation work aims to (a) investigate how well STEM TBL programs' student-centric documentation integrate gender diversity, equity, and inclusivity into the programmatic frameworks and (b) to investigate how gender influences students' technical experiences, sense of belonging, motivation, and levels of self-efficacy.

LITERATURE REVIEW

The literature review discusses past research on gendered experiences in the STEM fields. Female students are influenced by a range of impactors across the entire socio-ecological framework: gender gaps, cultural and gender norms, and gender stereotypes that sustain gender disparities. Literature that discusses how gender-exclusive terminology impacts individuals' motivation, self-efficacy, and sense of belonging is also reviewed, as well as the positive and adverse effects of implementing team-based learning into the STEM curriculum. This body of research helps inform the methodology for study 1 and study 2, contributing to a policy analysis of gendered terminology and a comparative analysis of students' lived experiences.

Gender Disparities in STEM

The socio-ecological model outlines the complex relationships among multiple societal systems, including areas that commonly perpetuate gender disparities in STEM. Researchers have analyzed the macro and meso levels, which include K-12 and higher education institutions and the STEM workforce, and found considerable gender disparities within these sectors. These researchers have shown that although women make up more than half of the United States' population, women comprise only one-third of the STEM workforce, which is even less than the 48% of employed women in the workforce (National Science Board, 2022). When women are excluded from these domains, they produce fewer patents, own fewer businesses, and are unable to introduce their own innovations into society (National Science Board, 2022).

Although there was a two percent increase of women in STEM in nine years (growing from 32% to 34% between 2016 - 2019), this growth can be attributed to a proportionally increasing rise of women earning bachelor's degrees (National Science Board, 2022). These bachelor's degrees are awarded inconsistently across occupations. The distribution of women's bachelor's or graduate degrees, arranged from high to low, are made up of: social scientists (65%), life scientists (48%), physical scientists (35%), computer and mathematical scientists (26%), engineers (16%), and civil airmen (8.4%) (National Science Board, 2022; FAA, 2021). These gender gaps perpetuate social inequities that include a discrepancy in salaries. The male-dominated STEM fields, such as physics, computer science, and engineering, yield higher salaries and prestige than psychology and other social sciences (Nassar-McMillan et al., 2011). External factors continue to exacerbate pre-existing socioeconomic conditions; since the start of the COVID-19 pandemic, women in STEM have faced higher unemployment rates than men due to the societal pressures and gender roles placed upon them (National Science Board, 2022).

Many researchers have investigated why high attrition and low retention rates exist for women (NSF, 2019; Dasgupta & Stout, 2014; Kim et al., 2018). Food (2013) argues the low representation of women is "often rationalized as a lack of interest from individual women," placing the blame on the individual level, but in reality, it is a result of a larger systemic process. Gender disparities in STEM are directly correlated to differences in motivation, as opposed to students' competence (Leaper & Starr, 2019). When interpreting the socio-ecological model, these interventions must occur along all strata of the social systems, improving equitable policy, removing institutional barriers, and supporting the individual learner.

Gender Stereotype Threat

Gender stereotypes, or generalized beliefs, are found within the foundation of all these issues, which prevent students from learning new information or transferring the ability to another task (Wang, 2013; Rydell et al., 2010; Diekman et al., 2019). A review of gender stereotypes by Haines et al. (2016) revealed little has changed since women joined the workplace in 1983. Between 1983 and 2014, occupational gender stereotypes remained constant, despite the strong presence of women in the workplace (Glick et al., 1995; Haines et al., 2016; as cited by Bhaskaran & Bhallamudi, 2019). These stereotypes are detrimental and possess the ability to encourage or dissuade students from pursuing a field based on their alignment and association of the stereotype (Eagly, 2013).

Gender stereotypes permeate STEM fields and create a false narrative. Mathematics is internalized as a masculine field, lowering girls' self-efficacy levels and increasing their desire to pursue a non-STEM field (Nosek et al., 2002). As young as six years old, girls judge their abilities for success in math based on their gender (Cvencek et al., 2011). This directly affects their cognitive, social, and emotional development, ultimately influencing their academic STEM identity (Ferrari & Mahalingham, 1998). In particular, math-related gender stereotypes influence girls' self-perceptions and performances on summative assessments (Aronson & Steel, 2005). These stereotypes also affect test scores, as students internalize them. Lewis (2005) demonstrated that girls scored significantly higher on their Advanced Calculus Scholastic Assessment Test (SAT) exam when they indicated their gender after taking the exam, than girls who indicated their gender prior to the start (Wang, 2013).

Barriers surrounding pregnancy and parental leave disproportionately affect women's retention rates in the workforce. Over 40% of women with full-time STEM jobs leave the workforce or transfer to part-time work after having their first child, compared to 23% of men (Hsain et al., 2020). This perpetuates the stereotype that STEM is not for women, especially those interested in starting families (Weisgram & Diekman, 2017).

Lack of Female Mentors

One factor that affects female students' academic performance, persistence and retention, and motivation levels is the presence of female role models (Herrmann et al., 2016). Studies show role models of all genders can help recruit women into STEM fields, but the presence of female role models helps retain female students (Herrmann, 2016). There are limited female role models: the majority of STEM faculty members at universities across the United States are male (i.e. 36% of research and teaching faculty in 2019 were female) (National Science Foundation, 2021). Role models help outline paths of success for female students, indicating concrete examples of how they can achieve their goals (Collins, 1996).

When there is a lack of female role models in the STEM community, female students can feel like they should abandon their feminine traits in the hopes of blending in with its masculine culture (Hatmaker, 2013). Without a role model to look up to, female students can also develop their STEM identity slower (Chachra et al., 2008). By introducing same-gender mentorship programs, institutions can work towards meeting the needs of marginalized groups (Thomas et al., 2015). Female role models help share their own success stories and paths, communicating that the STEM fields are a gender diverse and rich pathway to success; these role models promote STEM identification, interest, and overall sense of belonging (Moss-Racusin et al., 2021). Dennehy and Dasgupta (2017) suggest female STEM students' confidence, motivation, and sense of belonging increased when they were assigned a female peer mentor as undergraduates. Gibson (2004) shows the retention of female students is increased when faculty mentors were actively involved in their learning, offering regular guidance, support, and interactions. However, when mentor programs focus on female students, the message implies female mentees are the problem that needs to change (Thomas et al., 2015). Female mentors should not be expected to change the inequitable STEM culture on their own; female faculty members are already overburdened with more teaching and service workloads than their male counterparts (O'Meara et al., 2017).

Microaggressions in STEM

Although non-traditional classroom environments help foster a STEM identity and increase motivation and success for female students, many STEM disciplines still lack inclusive environments, affecting female students' attrition rates (Seyranian et al., 2018). STEM environments may not be as inclusive to female students as their male counterparts—and deemed "chilly"—due to the environmental, social, and cultural factors that reinforce the masculine culture and gender norms associated with STEM fields (Parson, 2018). Female students navigate a social environment that contains institutional resistance, barriers preventing change, and intransigent masculine-centric disciplines (Bilimoria & Singer, 2019). Drawing on the influences found within the socio-ecological model, research suggests it is not the lack of self-confidence, changing interests, or "fault" of the individual for female attrition in STEM (Fouad et al., 2016). Many obstacles are microaggressions, termed by Pierce (1970), are everyday exchanges that send denigrating messages to certain individuals because of their group membership (Sue, 2010). Migroagressions are the behavioral manifestation of underlying STEM stereotypes, such as the following three examples:

1. Female students' ideas are ignored, yet accepted when repeated by a male student (the microaggression) vs. male students are more credible sources of good ideas than female students (the gender stereotype).

2. Female students are assumed to have been admitted into STEM because of her gender (the microaggression) vs. female students are not skilled in STEM and need special circumstances to be eligible for admission (the gender stereotype).
3. A female engineer is told she doesn't "look like" an engineer (Microaggression) vs. only male students can be engineers (the gender stereotype).

(Sekaquaptewa, 2019)

Gender-Exclusive Terminology

Gendered terminology may appear in advertisements as a subtle way to exclude women out of male-dominated roles (Gaucher et al., 2011). d'Entremont et al. (2015) conducted one of the first studies to explore the impact of gendered wording on female enrollment in engineering schools using a gendered word list from Gaucher et al. (2011). The findings from d'Entremont et al. (2015) suggest having more feminine words in recruitment documents shows a weak negative correlation with the enrollment of female students, but shows a positive correlation with the number of female faculty members (d'Entremont et al., 2015). This may be due to the realization that engineering sustains a chilly climate compared to the welcoming setting the gendered words illustrated in recruitment material, thus increasing attrition rates (d'Entremont et al., 2015).

In addition to gendered adjectives, people use pronouns in everyday language that refer to only one gender, even when they are addressing all genders; this act of exclusion creates linguistic bias and is called gender-exclusive language (Stout & Dasgupta, 2011). Gender-exclusive language is also prevalent in the STEM fields, which causes real and measurable consequences that impact students' success (Harris, 2017). Even when subtle and unintentional, language reaffirms gender stereotypes and gender roles (Santecreu-Vasut et al., 2013). Culture emphasizes these gender stereotypes, which reflect the barriers women regularly face in STEM (Santecreu-Vasut et al., 2013).

Gender-exclusive language may be a passive form of exclusion, but to the listener, is a form of active exclusion and rejection (Stout & Dasgupta, 2011). Although gender-exclusive language may not explicitly attack an excluded group, it still occurs “without explanation” and has a repelling effect (Stout & Dasgupta, 2011). A literature review conducted by Harris et al. (2017) found female applicants were significantly less likely to pursue jobs with masculine suffixes (-man versus -person) (Bem & Bem, 1973). In addition, when researchers explicitly informed participants that a passage with masculine pronouns “he/him” implied the participation by all genders, the participants imagined men; when the gender-neutral “they” pronoun was used, these same participants envisioned fewer men, even though both cases referred to men and women (Harris et al., 2017; Hamilton, 1988).

When female students are aware of negative stereotypes (e.g. “female students lack the ability to do math”), their social identity threat is triggered. This also occurs in situations where female students are not strongly associated with stereotypes (Stout & Dasgupta, 2011). In both situations, gender-exclusive language sends situational cues to female participants, conveying an ostracizing message that they did not belong.

Strategies can be implemented to minimize gender bias in language: (1) use neutral language such as “they” (further research shows the pronoun “ze” may be interpreted as a misspelled “he” (Bradley et al., 2019)); (2) use feminized language such as “female professor” (although this is controversial because it tacitly confirms terms like “professor” are implicitly male); and (3) increase self-awareness and self-critical perspectives, and objectivity (Harris et al., 2017; Santacreu-Vasut et al., 2013; Seaborn & Frank, 2022).

Tokenism in STEM

Females' experiences often differ from their male counterparts because of a concept called tokenism. Introduced by Rosabeth Moss Kanter in 1977, tokenism addresses how a minority individual is perceived as being "different" from their counterparts within the otherwise homogeneous group (Stichman et al., 2010; Zimmer, 1998). Studies show that when less than 15 percent of the overall group is perceived to be the minority, those individuals are at risk of being treated as a token (Kanter, 2008). A token female student may experience higher levels of scrutiny, more stress, and additional problems in the workplace, as they are tasked with representing their entire gender. Tokens may also receive negative treatment because of their social inferiority (Zimmer, 1988; Yoder, 1994). This problem decreases as the underrepresented group's numbers increase over time (Stichman et al., 2010).

Tokenism is discussed further within this dissertation's second study, within the analysis of digital media. As Jean Kilbourne (1977) discusses, it is important to see how women appear in the images. Efforts to feature women and convey a welcoming environment, or feature women as role models in the recruitment process, are all commendable efforts. On the contrary, women who are featured in the background, partially cut out of the frame, not facing the camera, or overshadowed within a large group of unidentifiable (male) faces, are all significant factors. Programs that feature women in images, but lack any gender diversity strategies within their program, limit to "acknowledge the impact of organizational and societal gender-based discrimination" (Yoder, 1994). Tokenism may not be debilitating, but it is detrimental for women. Kanter (2008) states it is up to the organizational structures to hire more women so that the token system will change.

Cultural and Gender Norms in the United States

As described by social role theory and situated within the macro levels of the socio-ecological model, female students' participation in STEM is heavily influenced by sociocultural norms (Eagly, 2013). These norms, which include gender norms, affect students' value systems, motivation levels, and choices to pursue STEM careers (Wang, 2013).

For young students, cultural and gender norms differ for girls and boys, which can directly influence the programs of study they pursue later in life. In the United States, students enter elementary school with a tacit understanding that math is for boys and not girls (Cvencek et al., 2011). These gender norms are perpetuated throughout American society because science and engineering skills are promoted throughout their outdoor leisure activities, toys, television, and video games (Cherney & London, 2006). Even though gender norms are evolving over time, girls have different accepted gender roles. Girls receive positive reinforcement for social play, developing social skills (Cvencek et al., 2011). Boys are socialized to be outgoing, assertive, task-oriented, adventurous, and achievement oriented, while girls are taught to be nurturing, communal, respect male power and authority, and to refrain from being too aggressive or assertive (Eagly & Johnson, 1990; Eagly & Wood, 1991; Fennell et al., 1978; as reported by Neubert & Taggar, 2004). Because of these differences, girls are acculturated with a lack of female role models (Milgrim, 2011). Without an equal opportunity to see professionals who look like them, girls may fail to develop a STEM identity, or a positive feeling of competence, performance, and recognition (Herrera et al., 2012).

Educators are aware that intellectual aptitude is not a result of gender differences (Feingold, 1992), but even so, girls are judged to be less intellectually competent than boys (Smith & Stewart, 1983; Neubert & Taggar, 2004). Girls and women are ascribed lower levels of competence in initial interactions (Wood & Karten, 1986) and assumed to have found luck when successful (Yarkin Town, & Wallston, 1982). When statements similar to this are expressed, it is a reflection of culturally normative excuses (Foor et al., 2013).

Over the last few decades, researchers have become aware that STEM teaching and learning needs to be customized for girls and boys in order to engage all learners equitably (SciGirls, 2022). To accomplish this, educators formed the SciGirls Strategies, which aim to engage girls in STEM at a young age so that they are equally engaged throughout their academic career. This framework presents six main approaches for equitable and effective pedagogy:

1) Connect STEM experiences to girls' lives.
2) Support girls as they investigate questions and solve problems using STEM practices
3) Empower girls to embrace struggle, overcome challenges, and increase self-confidence in STEM
4) Encourage girls to identify and challenge STEM stereotypes.
5) Emphasize that STEM is collaborative, social, and community-oriented.
6) Provide opportunities for girls to interact and learn from diverse STEM role models.

(SciGirls, 2022)

Contrary to boys' development, girls learn best in a collaborative and social setting, compared to a competitive challenge requiring individual tasks (SciGirls, 2022). Some stereotypes convey to girls that STEM jobs require solitary work, that they should be naturally gifted at math and science, and that there is one set STEM path to follow in order to be successful (SciGirls, 2022). Without the visible presence of female role models to envision their own career paths, girls fall back on these gender norms and stereotypes, internalizing them as true. When alternative solutions to STEM challenges are available, girls' interest and confidence rise, allowing them to develop a growth mindset towards STEM learning (SciGirls, 2022). To retain girls in STEM and increase their motivation, educators must approach their education in a different lens than boys, and should consider these teaching strategies.

As more girls and women pursue a STEM field with a positive learning experience, they can serve as role models and examples of success to empower others. One national program that is a positive example is FabFems, a resource for girls to locate local female professionals who are willing to act as a mentor. By utilizing FabFems, girls can visit STEM jobs, see higher education and industry campuses, associated job responsibilities, while engaging in STEM content (National Girls Collaborative, 2022). These community resources attempt to replace harmful stereotypes and improve gender norms with positive STEM experiences and role models.

Motivational Constructs

Although gender disparities are prevalent in STEM fields, a growing number of female students continue to navigate the male-dominated STEM pathway and find success. Students' persistence is positively correlated to motivational constructs (levels of motivation, self-efficacy, and their sense of belonging to the STEM community) and are all critical contributors for retention in STEM (Lytle & Shin, 2020; Young et al., 2018; Simon et al., 2015). Thus, motivational constructs can be used as a lens to assess students' experiences.

Motivation

Albert Bandura proposed that motivation is the notion of personal control and determines students' efficacy expectations and locus of causality (Eby & Dobbins, 1997). As described by Merriam & Bierema (2013), students may fall into the following motivational categories: goal-oriented learners, activity-oriented learners, and/or learning-oriented learners. Goal-oriented learners may be extrinsically and economically motivated to pursue a goal, such as individuals who join a high powered rocketry team to earn their launch certifications or to obtain a salary commensurate with a STEM degree. Activity-oriented learners may be extrinsically or intrinsically motivated, driven by social and need-driven motivation. Students may be interested in joining an extracurricular team to have fun with their peers and socialize. Learning-oriented learners may be intrinsically and cognitively motivated, individuals who are life-long learners and enjoy developing new knowledge. As Merriam & Bierema (2013) concludes, motivation is fluid, and STEM students may identify with more than one style—which can also change in time.

In order to investigate why some female students persist through STEM programs and some drop out or transfer fields, many researchers study how the role of motivation impacts academics (Merriam & Bierema, 2013; Starr et al., 2020; Hernandez et al., 2013; Solanki & Xu, 2018). Some motivational factors, which work cooperatively, include: (a) *establishing inclusion*, or creating a learning environment where students and instructors share mutual respect and connect to each other; (b) *developing a positive attitude*, or creating a favorable disposition toward the activity; (c) *enhancing meaning*, or creating engaging and challenging learning experiences where students values and perspectives are included, and (d) *engendering competence*, or creating an environment where students' intrinsic motivation stems from learning about something they value and are self-directed in authentic experiences (Ginsberg & Wlodkowski, 2019).

Sense of Belonging

Research suggests STEM motivation for female students is strongly influenced by educational experiences independent of the traditional classroom experience (Chang et al., 2014). Learning experiences that were more reflective of authentic science were beneficial in retaining women (Hazari et al., 2013). Research also shows female students benefit from an inviting learning context where they feel a sense of belonging, which improves motivation, attitude, and engagement (Starr et al., 2020). Same-gender instructors impact female student interest and motivations in a subject, positively influencing measures of persistence (Bettinger & Long, 2005; Solanki & Xu, 2018).

Self-Efficacy

Self-efficacy is the psychological construct that refers to a person's subjective evaluation of their ability to reach success (Bandura, 1977). A student with high self-efficacy would be highly confident in their capability to successfully complete the task and would be more motivated to dedicate their effort, even if the task was difficult (Bandura, 1977; Syed 2019). Research shows how TBL programs increase students' STEM proficiency and self-efficacy levels (Kulturel-Konak et al., 2011). Chen et al. (2009) related how efficacy and motivation constructs share meanings and relate to each other, explaining how one construct influences the other. Lent et al. (2017) also explored how experiential learning affected career exploration and decision-making activities. The findings show how students benefit when they are able to use their multidisciplinary knowledge and apply it to real-world situations, developing self-authorship and a deeper understanding of practice applications (Kulturel-Konak et al., 2011). Self-efficacy has been studied in many engineering-based environments (Lent et al., 2013). For example, Cech et al. (2011) focused on professional role self-confidence, finding that men were more confident than women and that lack of professional self-confidence in women was related to not persisting in an engineering major. Students who leave the STEM fields reported difficulty keeping up with the engineering tasks, trouble navigating a work-life balance, and being overwhelmed juggling multiple roles (Fouad et al., 2016).

Active and Experiential Learning

In traditional college courses and seminars, college students are treated as passive receptors, directed to listen to and memorize information from lectures (Hernandez, 2002). Studies show that when students are placed in classroom environments, few participate in discussions (Hernandez, 2002). Karp & Yoels (1987) found that in groups with fewer than 40 members, four to five students account for 75% of all interactions. This approach does not engage all learners equitably and fails to prepare them for the real-world.

To increase student learning, educators implement active learning, a student-centered instructional strategy that strengthens students' communication skills and motivation (Michaelsen et al., 2002; Sari & Husein, 2020). Reflecting Swiss psychologist Jean Piaget, Darling-Hammond (2005) emphasized how learners of all ages are active explorers of their worlds (p. 55). In school, students gain new knowledge by scaffolding inquiry-based experiences onto their prior class and textbook knowledge (Darling-Hammond, 2005, p. 396). Classes that implement active learning also lower failure rates across undergraduate STEM fields (Ng & Newpher, 2020; Freeman et al., 2014). This strategy enables students to deconstruct preconceptions (whether correct or incorrect), explore new concepts, and reconstruct valid conceptions in their place (Cobern, 1991). When active learning methods are implemented students' retention, engagement, and achievement increases (Jeno et al., 2017). Some examples of active learning include the use of flipped-classrooms, interactive lectures and laboratories, and team-based learning.

David Kolb (1984) created an experiential learning model which outlined four dynamic stages of how students effectively learn through active engagements. Based on the research by Lewin, Dewey, and Piaget, experiential learning enables spectators to "learn by doing" or by becoming participants themselves (McCarthy, 2010). As Hawtrey (2007) describes, students remember a majority of what they actively do, contrary to what they passively hear. Kolb's learning process can be described in four stages of a cyclical process: 1) concrete experience, 2) reflective observation, 3) abstract conceptualization, and 4) active experimentation. This is constantly reflected in team-based interactions, as students actively apply their knowledge to solve complex problems. As students develop these higher-level thinking skills, many may develop a higher level of interest in the subject material and other positive outcomes (McCarthy, 2010). These outcomes may consist of enhanced intrinsic motivation to learn, higher retention of the material, the desire to be a lifelong learner, improved communication skills, and team-related skills (problem solving, analytical thinking, and critical thinking skills) (McCarthy, 2010).

Team-Based Learning (TBL)

The application of active and experiential learning theory is manifested in team-based learning (TBL) teaching strategies. Prevalent in the meso levels of the socio-ecological model, TBL enables interpersonal interactions within the social environments that promote STEM learning. This special form of collaboration promotes higher-level thinking of students by engaging them in a group setting (Ng & Newpher, 2020; van Offenbeek, 2001). TBL provides students with conceptual and procedural knowledge, enabling them to apply course content, analyze findings, synthesize new ideas, and practice solving real-world problems (Michaelsen & Sweet, 2008; Ng & Newpher, 2020). Instructors also implement this teaching style to help students reach learning outcomes influenced by interpersonal cooperation, open-ended tasks and develop their collaborative, critical thinking, and problem-solving skills (Michaelsen & Black, 1994). These traits are highly desirable to workforce employers and reflective of real-world expectations (Tiantong & Teemuangsai, 2013; Hernandez, 2002).

Benefits of TBL

As Bock (2022) states, “DEI means making equality a reality; achieving this goal needs diversity, and diversity can only be achieved by being inclusive.” DEI efforts, including those that focus on gender, are best when groups work together, as compared to working independently (Bock, 2022). Team-based learning programs provide a strong motivational framework that supports these desired DEI outcomes (Ng & Newpher, 2020). A good analog to real-world STEM demands, TBL encourages students to demonstrate leadership skills and self-manage their team (Hernandez, 2002). Students can complete their challenges in small groups, use self-directed learning, and reference the instructor as a guide or facilitator (Hernandez, 2002). When students are less likely to feel isolated and alone, they are also less likely to drop out or fail their classes (Jeno et al., 2017).

TBL also enhances educators’ ability to provide quality experiences for their students. Because there are multiple sources of knowledge: the student, the teammates, the instructor, and outside actors (such as industry experts), TBL allows multiple actors to enhance the learning experience (Hernandez, 2002). For STEM competitions, many programs hold their culminating end-of-year missions at a location of significance: a NASA center, a STEM-industry leader’s campus, or a higher education institution. At these locations, students may receive feedback and education from professionals and industry role models who they do not normally encounter at their home institution. Instructors are also able to assess students’ comprehension and mastery of the material through goal-oriented TBL styles, as compared to the traditional classroom summative assessments. Traditionally, instructors have to wait until grading the final exams to see how their students are performing (Hernandez, 2002). This prevents any instructor intervention throughout the semester. Instead, TBL allows instructors and team mentors to conduct semester-long formative assessments, providing direction and intervening when appropriate. Instructors or team advisors are now able to dedicate time more effectively to guide their students and facilitate active and deep learning through their team's activities (Hernandez, 2002).

Fostering a welcoming, safe, gender diverse, and inclusive team environment is critical to ensure the success of female students. Niler et al. (2020) have demonstrated that female participants experience a higher sense of team identification and collective efficacy when there were more female students participating on their team. These authors also revealed that this was not the case for male students, who did not experience a higher sense of team identification, collective efficacy, nor team performance with more male team members (Niler et al., 2020). By fostering an inclusive and welcoming atmosphere, students will feel respected and connected. Then, they will be able to access their experiences, reflect, and engage in dialogue, enhancing their motivation to learn (Merriam & Bierema, 2014).

Inequities within TBL

Despite the benefits of TBL, these strategies do not eliminate gender inequities found within higher education. STEM teams are designed to be competitive, a strategy to enhance productivity and excitement, asking students to meet time-critical deadlines and manage risk (Kulturel-Konak et al., 2011). Pedagogically, this presents an inequitable situation for learners, as both female and male students have different learning styles when it comes to competition. Research shows female learners thrive in collaborative and social settings, where they are able to work together with their peers and male students prosper in competitive environments (SciGirls, 2022; Kulurel-Konak et al., 2011). In addition, female and male students learn differently, which is a result of how they are socialized (Harro, 2000). This socialization directly affects how students act in team-based situations, approaching task responsibilities with differing attitudes.

When comparing team-based organizations to hierarchical organizations, Benschop & Doorewaard (1998) concluded that team-based organizations do not offer a higher quality experience for all genders; gender inequality was reproduced in both settings. Even when both female and male students believed there were no gender inequalities present on their teams, Benschop & Doorewaard (1998) still measured gender distinctions. These authors described how many team members "gradually identif[ied] with the [gender] norms and values" which resulted in the team consenting to these goals, interests, and practices (Benschop & Doorewaard, 1998, p.7).

Team advisors should acknowledge the structural, ideological, and social conditions that make up collaborative learning spaces that affect their team (Foor et al., 2013). Despite good intentions to create a welcoming environment, faculty who advise STEM learners are not always trained in women's studies or feminist theories (Rosser, 1998). These advisors and team mentors may have goals to remove barriers and end discrimination for all learners, enabling female students to "have the same access to education and careers in [STEM] as that now enjoyed by their male counterparts" but lack the knowledge of how to achieve these goals (Rosser, 1998). Some of these barriers consist of conscious gatekeeping acts and unconscious microaggressions, both that deter female students from participating (Barzilai-Nahon, 2009). When team mentors manage a team with female participants, they may assume they have an inclusive team atmosphere that enables female participation. Even if a team has female team members in leadership roles, this does not make the team cognizant of gender-related issues and diversity

(Trytten et al., 2015). In addition, this does not necessarily create a team environment that is welcoming to other female students (p. 14).

Gender roles are assumed, reproduced, and used to perpetuate gender inequities (Acker, 2012). Acker (1990) theorized how organizations that have role assignments, including team environments, are not gender-neutral. Before individuals are assigned a job, the position has already been ascribed or associated with a gender as part of a larger structural process. These roles are a social construction that gives men a greater ability to succeed and a better sense of belonging in STEM than women (Cheryan et al. 2017). These gender roles reinforce gender stereotypes, which negatively impact female students' participation rates in STEM. It is also difficult to notice gender when only masculine norms are present (Morton, 2020). These stereotypes obscure the quality of completed tasks, creating false predispositions, and belittling or dismissing female member's competence during male-oriented tasks (Heilman & Haynes, 2005). Organizations should acknowledge these gender biases and work towards clear and irrefutable information about the quality of performance outcomes (Acker, 1998; Heilman & Haynes, 2005).

In summary, many factors, including microaggressions, socially chilly environments, institutional barriers, and cultural factors all influence female students' retention, persistence, STEM identity, and attrition. Future investigations will reveal how such issues manifest on the national STEM team programming stage, revealing if there is a relationship between female students' levels of motivation, self-efficacy, and sense of belonging.

Contextual Background

Artemis: The First Woman

NASA's current human spaceflight program, named the Artemis program, will return humans to the Moon no earlier than 2025 (NASA, 2020). This initiative, named after the twin sister of Apollo in Greek mythology, will bring the first female astronaut and first person of color to the surface of the Moon. In more than fifty years since Apollo 11's first moon landing, NASA is highlighting its continued leaps toward gender inclusivity within its astronaut program and STEM education efforts. By emphasizing gender, NASA communicates to the public that female representation is a core value of NASA, and thus, the Artemis program.

NASA illuminates its gender DEI values by developing resources for students that showcase the first female Artemis astronaut. A graphic novel and interactive experience called *First Woman: NASA's Promise for Humanity* was produced to inspire students, promise gender diversity, and introduce new technologies (NASA, 2022d). By integrating digital platforms with extended reality (XR)—a combination of virtual reality (VR) and augmented reality (AR)—learners can engage in technology and follow the fictitious story of Callie Rodriguez, "the first female astronaut and person of color [to] soon set foot on the Moon—a historic milestone and part of upcoming NASA missions" (NASA, 2022d). Callie's story presents themes of perseverance, passion, overcoming challenges, transformative technologies, and biographies of real-life women who inspired the graphic novel: female astronauts and launch directors (NASA, 2022d). The creation and distribution of this resource is significant because NASA is publicizing its values, goals, and commitment to place the first woman on the Moon.

NASA is also focusing on technology maturation, dedicated to "establish American leadership and a strategic presence on the Moon while expanding our U.S. global impact" and working to "inspire a new generation while encouraging careers in STEM" (NASA, 2020a). These goals are dependent on NASA reinforcing its skilled and diverse workforce with prepared college graduates, who are now called the "Artemis Generation" (NASA, 2020a). By focusing efforts on space research and development, America will improve technological innovations that directly affect all humans on Earth, while also ensuring global and national security, communications, and economic success (Taylor, 2021). In order to develop cutting-edge innovations and technologies needed for human exploration, NASA seeks to recruit the "brightest minds—employees with varying perspectives, education levels, skills, life experiences, and backgrounds" (NASA Inclusion, 2016). These "bright minds" will be found throughout the entire STEM pathway: within precollege systems, undergraduate, and graduate levels.

The National Space Grant Network

To help educate young minds, NASA manages educational programs that serve as workforce development programs, such as the National Space Grant College and Fellowship Program (or "Space Grant"). Established in 1989, Space Grant was created after NASA accepted the Congressional mandate to oversee a national network of colleges and universities in efforts to enhance science and engineering education for American students (Dasch & Ward, 1996). The affiliate membership grew throughout the years: in 1990, there were 86 affiliate members; in 1996 there were more than 550 affiliate members; and in 2022, there are more than 850 affiliates belonging to one of 52 consortia in all 50 states, the District of Columbia, and the Commonwealth of Puerto Rico (Dasch & Ward, 1996; NASA Space Grant, 2022). This dynamic and strategic network of higher education, precollege, and informal education representatives work closely with their students and produce graduates who have engaged in hands-on and experiential learning that is of value to NASA's missions and goals.

The National Space Grant Program has valued equity and inclusion since its conception. In 1989, program directors met and discussed how they would tackle America's systematic challenges that were pervasive in STEM fields (Eisley, 1990). These directors, all based within academia, brainstormed methods to break down the stereotypes—stereotypes that depict STEM as male-dominant fields that lead to masculine careers (Faulkner, 2007). The directors' discussions revolved around increasing the number and visibility of role models, as well as making STEM subjects and careers more attractive to all students (Eisley, 1990). The original 1989 diversity objective stated they would "recruit and train professionals, *especially women* [emphasis added] and underrepresented minorities, for careers in aerospace science, technology, and allied fields" (NASA External Relations, 1989).

More than thirty years later, this fourth program objective still focuses on equity and inclusivity, demonstrating how Space Grant aims to reach additional underserved populations in STEM. The 2022 Space Grant objectives proclaim to:

1) Establish and maintain a national network of universities.
2) Encourage cooperative programs among universities; aerospace industry; and Federal, state and local governments.
3) Encourage interdisciplinary education, research and public service programs related to aerospace.
4) Recruit and train U.S. citizens, *especially women* [emphasis added], underrepresented minorities, and persons with disabilities.
5) Promote a strong science, mathematics and technology education base from elementary through secondary levels.

NASA Space Grant, 2022

All five of these Space Grant objectives are important to help advance STEM literacy and promote STEM careers in America, particularly the fourth objective of the recruitment and training of women in STEM. The focus on gender inclusivity is reflected in national goals outlined by NASA's 2016-2019 Diversity and Inclusion Strategic Implementation Plan. NASA strives to "ensure mission success" by enabling a positive and inclusive environment; NASA states:

> By fostering an atmosphere of inclusion and respect for all, we can continue to value and appreciate the strengths afforded by both the commonalities and differences between us, not only our inherent differences but also in the styles, ideas, and organizational contributions of each person. This in turn will drive innovation, creativity and employee engagement (NASA Inclusion, 2016).

Continued efforts aim to increase DEI efforts throughout the space program. Bill Nelson, the 2022 NASA administrator and highest ranking official within the administration, reflected on the "critical importance and value of DEI for our entire workforce" which will enable America "to recruit and engage the best talent from the full spectrum of our entire workforce"..."with a variety of valuable skills, capabilities, perspectives, thinking, culture, and backgrounds" (NASA & Nelson, 2021). The administrator also elaborated how a diverse workforce will provide unique perspectives, experiences, and ideas that will unite us as a team by mitigating groupthink, confirmation bias, complacency, normalization of deviance, and risk, while promoting safety and optimism (NASA & Nelson, 2021). Only by implementing equitable and inclusive strategies will NASA be able to recruit from a qualified talent pool and reinforce a strong Artemis workforce.

For over thirty three years, millions of federal and state funds have been distributed to the Space Grant program, and thus, the continuous support can be inferred that the program is well-received by the United States Congress. By comparing the funding levels in the inaugural Space Grant solicitation with the 2021-2022 funding levels, a constant and clear increase of funds illustrates the program's success. The base award in fiscal year (FY) 1989 for the first twelve consortia was $75,000 (or $168,630 in 2022 dollars when adjusted for inflation). The "Phase 1 - Designation of Space Grant Colleges/Consortia" document outlined how a base award of $150,000 was awarded in FY90 to each consortium (approximately $320,000 in 2022 dollars) (NASA Space Grant, 1989).

Eisley (1990) documented how the Space Grant directors were more concerned about the quality of students' learning experiences in one of the earliest Space Grant reports. "Any effort made to increase the number of students in science and engineering should also have the purpose of improving the quality of the students, the quality of their preparation, and the quality of programs they enter" (Eisley, 1990, p.5). Space Grant program directors realized students would benefit tremendously from having access to a network of institutions, researchers, and opportunities. Eisley (1990) also concluded that NASA was worried about

> the forecasts of a scientific and engineering manpower shortage, due to a decrease in the number of college age students in the next two decades, a low level of preparation in science and mathematics among high school graduates, plus an apparent decrease in interest in science and engineering as a career.

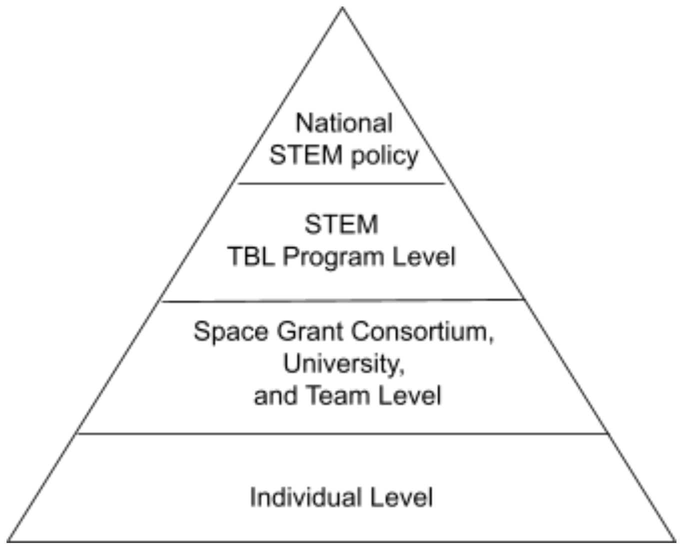
In 2022, Congress—with strong bipartisan support—demonstrated that it values the Space Grant program, allocating a total of $45 million to the national network. The 52 consortia have an equal opportunity to apply for base awards, with each receiving $860,000 during FY22. Through this action, Congress announces to the world that it supports the authentic and experiential learning experiences that are facilitated by Space Grant institutions. Without this funding and Congressional support, these consortia would not be able to sponsor internships, research fellowships, educator professional development, K-12 STEM engagements, STEM team programming, or other STEM efforts.

The Space Grant network is able to support student engagement through programs that promote hands-on experiential learning in the form of STEM challenges and competition programs. Able to set policy that impacts all layers of the socio-ecological model, national STEM programs involve thousands of students and engage them in collaborative, group-based design challenges (Figure 3). Students are able to spend their academic year immersing themselves in real-world projects and formal and informal education STEM engagement efforts, while working with a mentor and developing critical thinking and problem-solving skills. Students are placed in a creative climate, where they are required to trust teammates and support others' ideas (Rickards et al., 2001). These traits are highly desirable to workforce employers and reflective of real-world expectations (Tiantong & Teemuangsai, 2013; Hernandez, 2002). Such challenges allow students to compete with other individuals from all around the globe, practicing critical interpersonal skills required to thrive within the STEM workforce (NACME, 2013). Some of these programs include rocketry and balloon-based missions, robotics and software challenges, and engineering design missions (NASA Challenges, 2020).

Space Grant-funded student teams submit an application to join the challenge. If accepted, the students compete in a regional, national, or global competition. If NASA is the organizing body of these programs, students may be able to visit a NASA center, explore the campus (many feature real rockets, space vehicle engines, historic buildings, and other sources of inspiration), and meet STEM professionals and potential role models.

Figure 3

A Triangular Hierarchy Outlining the Relationship between National STEM Policy and Individual Space Grant Students.



Summary

The literature review section outlined the foundational and historical literature that informed this study. Issues that influence students in STEM, such as gender roles, cultural and gender norms, mentorships and relationships, gender-exclusive terminology, and motivation were explored. Active and experiential learning was explored, including team-based learning (TBL), a teaching strategy that is the foundation of this research. The literature was also examined through a historical context, highlighting how space-based federal programs have integrated DEI policy into their programming for decades. Such programs, such as the National Space Grant Program, and NASA's human spaceflight program, the Artemis program, help direct nationwide STEM engagement policy. The next section will outline the methodology of the two articles embedded in this dissertation work.

METHODOLOGY

The following section describes the methodological approach of the dissertation. The research takes a holistic approach to study gender inequities in the STEM pathway, conducting two sub-studies through a macro-lens (study 1) and micro-lens (study 2). The macro approach utilizes qualitative document analysis (QDA) to assess how policy influences STEM programming. The micro approach utilizes a survey tool to assess how policy influences individual students' experiences on the STEM teams. Together, these approaches work harmoniously to illustrate how the National Space Grant Program could help address inequitable issues in STEM.

Study 1: Qualitative Document Analysis

As guided by Crotty (1998), the approach to this study's policy analysis was framed around the methods used and the methodology employed. Methods are the procedures that are used to collect and analyze data to the research question, and can take many forms, such as participant observation, statistical analysis, interviews, and document analysis. The methodology, or the process and design, may appear as survey research, grounded theory, policy analysis, and case studies. This study sought to analyze the macro levels of STEM team programming, investigating how policy is reflected in recruitment documentation (Crotty, 1998).

The main method of data collection and analysis was qualitative document analysis (QDA), which analyzed public-facing recruitment and student engagement documents of STEM team-based programming in order to assess how well gender DEI was represented within programmatic frameworks. Through iterative explorations of the resources, materials that were available publicly for student team members were identified, categorized, and sorted. The documents were designed for current collegiate teams for the 2021-2022 academic year.

Qualitative document methods were utilized because of how well STEM programs document their learning objectives; they produce accessible and publicly available resources.

As Cardno (2018) warns, document analysis methods may have ethical concerns—documents may be confidential or require an organization's permission to gain access. For this research, all documents were publicly available and included: program manuals, student guidebooks, program websites, and other resource documents. As O'Leary (2004) highlights, public materials are not generated by the researcher and are unobtrusive. This is a critical component of this research, as everything the author accessed was the same materials that were accessible to prospective and current college students.

Through QDA methods, these texts were analyzed as a primary source of research data, through procedural recommendations outlined by researchers (Bowen, 2009; O'Leary, 2004; Wesley, 2010; Corbin & Strauss, 2008). QDA methods also identify documents as a solid source of data, similar to how data is gathered in surveys, interviews, or observations (O'Leary, 2004). Each document is a complex tool that communicates its information to the reader (Marsh and White, 2003).

As described by O'Learn (2004), documentation was primarily utilized from the "public records" category (student handbooks and technical documentation):

1. Public Records: The official, ongoing records of an organization's activities. Examples include student transcripts, mission statements, annual reports, policy manuals, student handbooks, strategic plans, and syllabi.
2. Personal Documents: First-person accounts of an individual's actions, experiences, and beliefs. Examples include calendars, e-mails, scrapbooks, blogs, Facebook posts, duty logs, incident reports, reflections/journals, and newspapers.

3. Physical Evidence: Physical objects found within the study setting (often called artifacts). Examples include flyers, posters, agendas, handbooks, and training materials.

O'Leary (2004)

QDA has the ability to outline the *process* of how conclusions were made, creating an audit trail (Wesley, 2010). This process, which uses a variety of resources, helps paint a broad, overall picture (Bowen, 2009). These reviews are more likely to produce meaningful and trustworthy interpretations of the data (Wesley, 2010; Bowen, 2009). This method also has high feasibility and merit, and it was deemed the best option to satisfy the research goals. The data found within these documents is manageable and practical, while remaining stable and "non-reactive" (Bowen, 2009). In other words, the information found in these public records can always be traced back and confirmed by future researchers (Bowen, 2009). These documents also provide researchers concrete, objective information that helps eliminate bias within the analysis process. This includes the author of the document as well as the researcher and interpreter. As Bowen (2009) states, the researcher should maintain a high level of objectivity and sensitivity in order for the document analysis results to be credible and valid. QDA is "not just a process of lining up a collection of excerpts that convey whatever the researcher desires" and the author was cognizant of maintaining a high level of objectivity and sensitivity to keep results credible and valid (Bowen, 2009).

As Max Weber (1978) reflects (and as noted by Prior):

- Documents form a field for research in their own right, and should not be considered as mere props for action.

- Documents need to be considered as situated products, rather than as fixed and stable things in the world.
- Documents are produced in social settings and are always to be regarded as collective (social) products.
- Determining how documents are consumed and used in organized settings, that is, how they function, should form an important part of any social scientific research project.
- In approaching documents as a field for research we should forever keep in mind the dynamic involved in the relationships between production, consumption, and content (Prior, 2003).

In addition to textual resources that outline team participation guidelines, documents' photographs and visual materials can also serve as records of events (May, 2011). Lindsay Prior (2003) states the modern world is made through writing and documentation (p. 4). As outlined within social constructionism theory, documentation does not simply reflect reality, but is a construction of social reality and versions of events (May, 2011, p. 199). STEM programs' policies may also reflect overarching external or state policies, such as those at the federal level, which determines the need for setting each programs' policy (Cardno, 2018).

Procedure

The QDA method was used on online public-facing recruitment documents of team-based STEM programming in order to investigate how well their programmatic framework supported gender DEI efforts. Through iterative explorations of the resources (e.g. program manuals, student guidebooks, program websites, and other resource documents), materials that were already available to student team members were identified, categorized, and sorted. The documents were designed for current collegiate teams for the 2021-2022 academic year.

In order to be eligible for assessment, the STEM programs must have met two criteria:

1) The TBL program must support undergraduate or graduate student participation (programs inclusive of K-12 students were included if they possessed a collegiate division or sub-category).
2) The TBL program must be hosted domestically.

All internationally-hosted TBL programs were excluded, even if they permitted US students to travel abroad and participate. By setting the study's scope to a review of domestic programs, the number of STEM programs remained at a manageable level. This decision was made because of the study's alignment with the NASA Space Grant program. Space Grant's federal funds are only permitted to be spent on domestic travel, and because the second study's survey participants were all sponsored by a Space Grant program, the author wanted to maintain the same eligibility criteria.

In order to analyze the level of gender DEI within each program, the author categorized programs' documents based on the language used (RQ1a), image selection (RQ1b), and strategic goals (RQ2). Inspired by Nerche (2017), an assessment tool assessed the programs and documents.

Collection of Documents. A list of active STEM programs from the 2021-2022 academic year was compiled into a spreadsheet through a three-step process. The first stage documented STEM programs that were known to the author, such as the seven NASA Artemis Student Challenges and common Space Grant-funded STEM challenges. The second stage incorporated programs from an extensive internet search. Example search terms included: STEM college competitions, computer science competitions, UAS competitions, mechanical engineering competitions, and software competitions. The third stage incorporated data from an independent, IRB-approved study conducted by the author, which surveyed nationwide college students and collected the names of their affiliated STEM programs. This iterative process strengthened the study's validity and helped STEM programs that were omitted within steps one and two. At this stage, three new programs were identified. Ultimately, this study analyzed 40 total STEM programs and 119 associated documents.

As advised by Bowen (2009), the author searched for inconsistent documents and outdated materials. There were many outdated documents, posted online prior to the 2021-2022 academic year. Many programs were postponed due to the global pandemic interrupting their activities. These inactive programs' documents were not included in the analysis. The author saved each downloadable document, such as PDFs and Microsoft Word files. This was to ensure the 2021-2022 documents would not be prematurely replaced by 2022-2023 versions, updated with edits throughout the year, or removed before the author's analyses were complete.

Formation of the Codebook. In order to initiate the document analysis process, a codebook was designed through a priori methods to catalog notes and assessments. The codebook was inspired by the research and publication of Nerche (2017) and Harvard Task Force's (2020) Inclusive Excellence Self-Guided Planning Toolkit. These sources published self-assessment rubrics that measured dimensions of DEI in higher education. The goal of this effort was to produce an assessment tool that administrators could use to help gauge their own institutions' DEI efforts, ultimately locating areas for improvement (Nerche, 2017; Harvard, 2020).

Stage 0 = Start Up: the STEM program does not define any gender DEI strategies nor make them a priority; There is no gender diverse or gender-neutral terminology used within the resources. Programs are at the beginning of their DEI journey.

Stage 1 = Emerging: the STEM program is beginning to integrate gender DEI terminology into its documentation, acknowledging diverse learners. The program lacks gender DEI strategic goals.

Stage 2 = Developing: the STEM program is developing efforts to integrate gender DEI into its strategic goals by providing measurable DEI objectives. Some gender diverse terminology is used.

Stage 3 = Transforming: the STEM program has institutionalized DEI into its strategic goals with specific, measurable, achievable, realistic, and time-bound (SMART) objectives. Many gender diverse terminologies are used in program documentation.

(Adapted from Nerche (2017) and Harvard (2020))

The author added a section into the codebook for documenting direct quotes from the programs' materials. The author was able to refer back to this section to pull direct references of gender-inclusive verbiage. Next, low-level descriptive coding methods were utilized, to identify broad descriptions of the DEI themes (Saldana, 2013). As patterns arose in the data, the author added her thoughts and feedback to an additional notes section to strengthen future analysis and discussion sections. This process captured data that would be used to address the research questions, which investigated the relationship between textual data (choice and selection of language) and gender DEI.

Once the first few STEM programs were analyzed, a pattern started to emerge: even though the majority produced a score of zero and they all lacked gender-inclusive terminology, many programs *did* include images that highlighted female student participation. This data would be used to address the RQ1_b, which investigated the relationship between visual data and gender DEI.

In summary, the codebook grew concurrently throughout the entire process, as data was collected and patterns were observed. The final tool included: four measures to review textual data: *Start Up* = 0, *Emerging* = 1, *Developing* = 2, and *Transforming* = 3; a direct quotation and descriptive codes section; an image evaluation section; and a section assessing how gender DEI was integrated into the programs' strategic goals.

The assessment tool was used to review all 40 programs and the 119 associated documents, and to search for any verbiage indicating gender-DEI initiatives. The measure of gender linguistic variables included: number of genders, sex-based, and gender pronouns (Santecreu-Vasut et al., 2013). Key search terms included female classifiers such as: *she, girl/s, woman/women, female, gender, diversity, equity, inclusion, inclusive, and underrepresented*.

Each document was read through extensively and carefully, as opposed to performing a quick digital term search. The author observed how some programs cited gender-related terms that would have easily slipped through an automatic computer search. For example, some programs supplied recruitment ideas to their participating teams, encouraging students to propose their mission objectives with female student organizations. One organization introduced undefined acronyms. The recommendation was to "[a]sk other organizations like SWE….[and] to make a short presentation about the project". The author was familiar with the term, "SWE", and was able to code this acronym as the "Society of Women Engineers," a registered student organization. Therefore, it was advantageous to the study to carefully examine each document so that all gender-inclusive terminologies and directives were discovered.

Assessing Images. As researchers study photos, they interpret data that can explore and express complex situations through one image. It was important to analyze the images with visual methodologies, which included the review of each image, the classification of its function, the addition of more data within the codebook. The density of information is able to provide and highlight influences not described within the document's text (Parrott, 2019). Thus, images can explore the thinking process of the individuals who created the document (Parrott, 2019). Allan Paivio (1971), an imagery theorist, stressed the importance of dual-coding imagery and verbal (language) data. He argues that textual and visual data can be interconnected, while remaining independent from one another (Paivio, 1971). Together, the data communicates the program's intentions, beliefs, and practices. By integrating an analysis of imagery, the study's trustworthiness also increased (Glaw et al., 2017).

Even though the text is independent of the images, the document's creator intentionally selected these subsystems, interconnecting them to express a concept (Klatzky, 1980). Once selected, these images offer rich data, providing additional layers of meaning and supplementing the text with knowledge (Glaw et al., 2017). Images are used to "capture the thinking process of individuals," enabling the reader to infer which factors, causes, or ideas were implicitly expressed (Bell & Morse, 2010; Berg & Pooley, 2013, as cited by Parrott, 2019).

To categorize documents' images, the author adhered to the following guidelines:

1. If a document did *not* include any images of people, it was not included for assessment. It received a score of zero, where it would be removed from future analysis.
2. If a document *did* include at least one person, regardless of gender, the document was included for assessment.
    a. If no women were featured, the document received a score of one (1).

b. If at least one woman was featured, the document received a score of two (2).

c. If a woman was featured, but served as the program's administrative staff and not as a student participant, the image was not included in the assessment. (According to social role theory, these assistant roles—secretaries and office managers—are assumed to be female-designated roles which perpetuate gender stereotypes).

It is not always appropriate to include images of people on every piece of documentation. Items with no human representation were removed from the image analysis process. Some types of imageless documents included: technical instructions and guidelines, rule books, evaluation criteria, judging sheets, checklists for deliverables, and/or administrative documents that support travel logistics. If a document possessed at least one image with female representation (receiving a score of 2), it underwent further evaluation. This included:

1. Both eyes of the woman must be visible. This was decided after some programs included only one side profile of a woman, or a portion of a woman's head featured out of the frame among a group of men (Kilbourne, 2012).
2. If women are in a group photo, this group must consist of ten or fewer individuals to qualify. This is because many STEM programs featured large group gatherings of 50, 100, or more participants. These types of gatherings are typically photographed at a far distance in order to fit everyone in the field of view, and thus, the impact of having female representation is minimized. Also, as aligned with the national statistics of STEM participation, the majority of these large group photos feature male students, which dilutes the impact of highlighting women (Kanter, 1977).
3. Website headers and footers were not included in the document analysis process, even if they featured a female student. This was due to the headers and footers not always being

associated with the program under review, as the banners represented the parent company or organization. For example, the headers and footers for each of NASA's *Artemis Student Challenges* were identical and reflected the entire Office of STEM Engagement, not the specific program that students could join; the *Microsoft Imagine Cup* program's headers and footers represented Microsoft, the company, not the competition. This approach ensured a more equitable analysis.

Because a document's creator decides on what image to include in the final product, the selection of each image may reveal an unconscious bias (Kilbourne, 2012). For this study, any document that featured an individual—regardless of their gender— was included for analysis. This study assumed each program was in possession of images that featured both male and female participants, producing an equal opportunity—a 50/50 chance—for female students to be featured.

Additionally, gender identity and gender expression are not synonymous. Because the concept of gender is socially constructed, it is impossible to look at an image and accurately assume the individual's gender identity. Despite this, many individuals who identify as women within Western culture express their femininity in a similar fashion: wearing clothing of similar influences, styling hair similarly, and/or longer hair than men. The author used these assumptions, as well as typical feminine physical characteristics (e.g. facial features, outline of body shape) to assess the digital photographs. Lastly, since the author is a product of this Western society, the visual cues she identified in the photographs would be highly similar to the prospective female team members who were also raised in the same society. Lastly, the author's analysis of gender expression was also based on a binary gender system, which is not inclusive of all genders.

Triangulation. This study utilized triangulation, a research process that synthesizes complementary data from multiple data sets in order to prove evidence of validity (Oppermann, 2000). During the document analysis process, additional TBL program names were provided from an independent quantitative research study, conducted concurrently by the author. These additional program names were the product of survey data of college student survey participants, who voluntarily identified the programs they participated in during the 2021-2022 academic year. Many of these program names were unbeknownst to the author. This study, also approved by an IRB board, served as a resource to cross-reference the list of TBL programs, ensuring a comprehensive search was conducted and minimal STEM programs were omitted from the QDA process. Also, all data was dual-coded, assessing its text and image items, which helped triangulate and integrate multiple sources of information into the conclusions.

Researcher reflexivity. Researcher reflexivity is a critical reflection of how the researcher constructs knowledge throughout the research process (Guillemin & Gillam, 2004). Many different factors may influence the study, and a reflexive researcher is aware of their role, ultimately improving the quality and validity of the research (Guillemin & Gillam, 2004).

The researcher acknowledges her biases as a member of the National Space Grant community, a female student and professional in STEM, as well as a prior member of NASA's Student Launch program. These identities provided critical knowledge that assisted the QDA (e.g. many unexplained terminologies were known to the author because of her prior STEM knowledge). This led to a better understanding of the data and experiences of female students in STEM. The researcher acknowledges her past, present, and future experiences all influence this study, even if strong and conscious efforts were made to reduce implicit biases.

Study 2: Quantitative Survey Methods

Participants

This study used a purposive sample of nationwide college students who were involved on a STEM team during the 2021-2022 academic year. The survey was distributed to 52 Space Grant Consortium managers, who then forwarded the request to their funded student team members. A total of 239 students participated in this study, all of whom were enrolled at a higher education institution within the United States and were 18 years of age or older. Almost all of the participants were undergraduate students (96%). The majority of participants were male (68.5%), White (68.5%), and undergraduate seniors (41.2%). Additional demographics of the participants can be viewed in Table 2.

Instrument

Pilot survey instrument. To collect data on student team members' experiences, a survey tool was developed. Eight student team members from a midwestern university's high power rocketry team completed a pilot survey, testing out the first iteration of the research tool in January of 2022 through the Qualtrics survey platform. This pilot survey collected information from this convenience sample, providing valuable feedback on the survey's flow and perceptibility. A few questions were revised, such as the question about students' majors (Q4), which was updated to separate astronomy, physics, and astrophysics fields into three choices.

The development of the survey tool's measures were derived by conducting an extensive survey of the literature. Validated scales from three peer-reviewed studies were used to measure constructs of motivation, self-efficacy, and a sense of belonging on the STEM teams. Each construct was detailed in peer-reviewed and validated surveys (Guay, Vallerand, & Blanchard, 2000; Nostrand & Pollenz, 2017; and Eby & Dobbins, 1997) and integrated into the survey tool.

For the purpose of this study, a “team” was defined as a collegiate student group that participated in a year-long STEM program. To be included in this study, the STEM program must have concluded in a high-level challenge or competition, yet did not need to be held at a NASA center. In-person and virtual involvements were also eligible to be analyzed. Additionally, student participation must have been supported by a Space Grant Consortium, regardless if the students engaged in an institutional, regional, national, or international competition.

Final survey instrument. Participants were asked to rate their level of agreement on a 6-point Likert-type scale with: 6 = strongly agree, 5 = agree, 4 = somewhat agree *(all some form of agreement)*, 3 = somewhat disagree, 2 = disagree, and 1 = strongly disagree *(all some form of disagreement)*. In order to avoid biasing participants towards gender-related responses, survey questions focused on general experiences to ensure the validity of the instrument (Patridge, 2014).

Procedure

The purposive sampling method was used due to its ability to align the research goals with the specific target population, ultimately strengthening the rigor of the study and trustworthiness of the data (Campbell et al., 2020). Nationwide survey participants were instructed to respond as honestly as possible, as all feedback would be anonymous.

To increase the validity of the data, the survey was distributed using the double-blind method. Each individual—including Space Grant managers and survey participants—was informed that the research goal was to investigate students' general experiences on STEM teams and was not informed of the sub-research goal of investigating gender dynamics. By using the double-blind method, the author was able to eliminate bias that may have influenced responses.

The survey's data collection window was selected for April 1, 2022 to April 20, 2022—specifically at the end of the academic year. By waiting until April, the survey gathered rich feedback from students, as they would have more experiences to share. This information would better reflect students' year-long understandings, responsibilities, and perceptions about the team processes.

Data was analyzed following the close of the survey with SPSS software. The survey gathered information regarding students' demographics (i.e. ethnicity, gender, year in school, majors, etc.), STEM team responsibilities, and perceptions about their motivations, self-efficacy, and sense of belonging. A chi-square test of independence was conducted to examine if there was a relationship between gender and the dependent variables. This study was approved by an Institutional Review Board.

ANALYZING GENDER DEI IN RECRUITMENT DOCUMENTATION OF COLLEGIATE TEAM-BASED LEARNING PROGRAMS

Marissa Saad, University of North Dakota

Abstract

The purpose of the study was to analyze how well national STEM team-based learning (TBL) programs (a) integrated gender diversity, equity, and inclusive (DEI) policies into recruitment documentation and (b) supported gender equitable technical learning outcomes in their programmatic frameworks and strategic goals. Qualitative document analysis (QDA) methods were used to review 40 STEM programs from the 2021-2022 academic year. Programs were sorted into one of four categories: *Stage 0:* Start Up, *Stage 1*: Beginning, *Stage 2*: Developing, and *Stage 3*: Transforming. The majority of STEM programs referred to student participants with gender neutral or female-inclusive wording, as there were no references to students using only masculine pronouns. The majority of programs included at least one image of female representation on at least one document, and the majority of programs did not introduce gender DEI directives into their strategic goals. The study concluded with a set of evidence-based recommendations to help policymakers address gender disparities in STEM.

Keywords: gender diversity, equity, and inclusion (DEI); technical education; science, technology, engineering, and math (STEM); team-based learning (TBL); document analysis

Introduction

In order to develop a STEM-literate and prepared workforce, all students, regardless of gender, should equitably receive technical and non-technical educational experiences. Female students are underrepresented in STEM fields that promote these technical experiences, and STEM team-based programs have the ability to design structural policy that promotes gender DEI integrated outcomes (NSF, 2022). The purpose of this study is to assess how well STEM programs integrate diversity, equity, and inclusivity (DEI) into their recruitment documentation. Nationwide programs have the power to affect entire generations, setting the learning outcomes for the future workforce. This study conducts an in-depth exploration into how the current DEI frameworks encourage and foster a welcoming, gender-diverse environment through the programs policy and promotional materials. The findings will be shared with program and team sponsors to provide policymakers with critical information that is necessary to make evidence-based policy changes and DEI enhancements.

Gender Disparities in STEM

Throughout American history, women have been greatly underrepresented in the science, technology, engineering, and math (STEM) fields (Rosser, 1998; NSF, 2022). Fewer bachelor's degrees have been awarded to female students majoring in STEM than their male counterparts—20.9% in engineering, 19.3% in physics, and 18.7% in computer science—despite more than half of the undergraduate bachelor's degrees being awarded to female students (NSF, 2022). Female students are less likely to enroll in STEM programs, more likely to drop out or transfer to non-STEM programs, and ultimately, less likely to graduate into STEM careers (Tusui, 2007).

These gender disparities exist throughout the collegiate level, specifically in STEM programming that reinforces technical education through hands-on, experiential learning opportunities. One strategy to strengthen technical education is to engage students in a team-based learning (TBL) setting, where classroom knowledge can be applied to an authentic real-world challenge. These challenges allow students to practice their technical and non-technical skills—developing critical skill sets that are necessary for the STEM workforce.

Collegiate TBL programs also deal with gender inequity issues: female team members statistically perform fewer technical tasks than male team members, missing out on crucial hands-on "nuts-and-bolts" education (Faulkner, 2007). If the STEM workforce is to receive qualified and prepared individuals, all collegiate team members—regardless of gender—should be trained with both technical and non-technical education.

With different life experiences, female students are able to bring unique perspectives and diverse characteristics to team environments that help create new and innovative solutions, as well as better performances (Maznevski, 1994, p. 534; Dyson et al., 1976; Hoffman & Maier, 1961; Ruhe, 1978). Without a gender diverse workforce, America will continue to fall behind on the global stage and limit the potential of the future talent pool (Granovskiy, 2018). Until there is systemic change within STEM and all voices have the opportunity to be heard, the United States will be unable to strengthen its economic and national security (Granovskiy, 2018). Brush (2013) summarized this issue by saying: "if a team of three engineers all look alike and think alike, then there are two people on that team that are not needed."

Recruitment Documentation

STEM programs announce their policy and procedural information in official documentation—student guidebooks, reference manuals, rule books, and/or technical instructions. This publication helps share the programs' goals and objectives of the challenges to the programs' prospective and current team members. To increase accessibility and convenience, documents are available to the students online to reach a nationwide audience. These documents frequently included textual and image data, which, if not assessed for implicit biases, may perpetuate inequities within STEM. Assessment of recruitment materials are beneficial, as these documents may be interesting for what content creators leave out, as well as what they contain (May, 2011). Photographs, videos, and textual information help illustrate an exciting, welcoming, collaborative, and fun atmosphere, used by content creators to attempt to recruit additional team participation in the future. When prospective students look at these digital media, they may find answers to questions such as: *Would I fit in here?* Research also suggests that documents may include gender-exclusive text that influences female students' experiences (Seaborn & Frank, 2022; Stout & Dasgupta, 2011; d'Entremont et al., 2015; Gaucher et al., 2011). Document analysis helps investigate if gendered pronouns perpetuate or dismantle STEM stereotypes, or if STEM-related tasks refer to a single gender, targeting specific gender roles (Gaucher et al., 2011).

Documents are a critical resource for analysis because they are the sedimentation of social practices; these resources refer to and describe places and social relationships (May, 2011, p. 191). Most importantly, team documentation has the potential to inform and structure the social climate that students will engage in on a daily and longer-term basis (May, 2011, p. 192). Pertinent to this study, documents can help identify the link between the programs' DEI policies and students' learning outcomes, highlighting areas for improvement (Kulig et al., 2015). Policymakers implicitly or explicitly communicate the DEI climate to the students through the use of text and imagery (Chrobot-Mason & Aramovich, 2013). Students form an initial perception before they join the program, which is why the documents' impact is significant.

If TBL programs seek to foster an inclusive and diverse STEM culture, then these documents are an ideal method to publicize their "commitment to eliminating barriers for those students who are disadvantaged and disempowered so that they can fully participate" in the program (Dhillon Brar & Milenkiewicz, 2021). Documents are an important tool to engage female students—a demographic underrepresented in STEM and technical education—because the resources communicate the diversity climate (Buttner et al., 2012). Buttner et al. (2012) also conclude that female students compare their perceived expectations of the program to their actual experience, making "psychological contracts" with the organization, and deciding if the two narratives align. This is significant because of the documents' power to influence retention rates and persistence (Buttner et al., 2012).

STEM Team-based Learning Programs

Team-based learning (TBL) environments, specifically collegiate group settings that reinforce the iterative engineering design process and scientific method, promote higher-level learning in students (Bloom, 1956). By redirecting students away from the traditional classroom and into TBL environments, these learners experience new opportunities to practice higher-level thinking. This form of andragogy also encourages college students to create, evaluate, and analyze issues critically.

After students join a STEM team, they are directed to work together to complete a set of goals and mission requirements, propelling their team along the engineering design process or scientific method. These goals should be met by completing STEM-related tasks, which may range from technical to non-technical tasks. Task distributions are not equitable for all genders, as performance, participation, and stereotypes are inseparable domains.

Significance of the Study

This study may serve as a resource for educators, administrators, TBL facilitators, advisors, and mentors, as well as any other interested persons who wish to eliminate gender inequities in collegiate team-based learning environments. As seen in the literature, there is a critical need to recruit female students into STEM education programs, especially programs that promote critical thinking, problem solving, and teamwork skills (SciGirls, 2022; Cooper, 2013). This study investigates programs' strategic goals and procedural operations, examining the methods used to encourage female participation and equitable task distribution.

Research Questions

1. RQ1: How well do TBL programs highlight gender diverse, equitable, and inclusive representation with their recruitment materials?
    a. RQ1a: How well do these recruitment materials use gender-inclusive language?

b. RQ1b: How well do these recruitment materials promote gender DEI through imagery?

2. RQ2: How well do TBL programs promote gender equitable student learning outcomes?

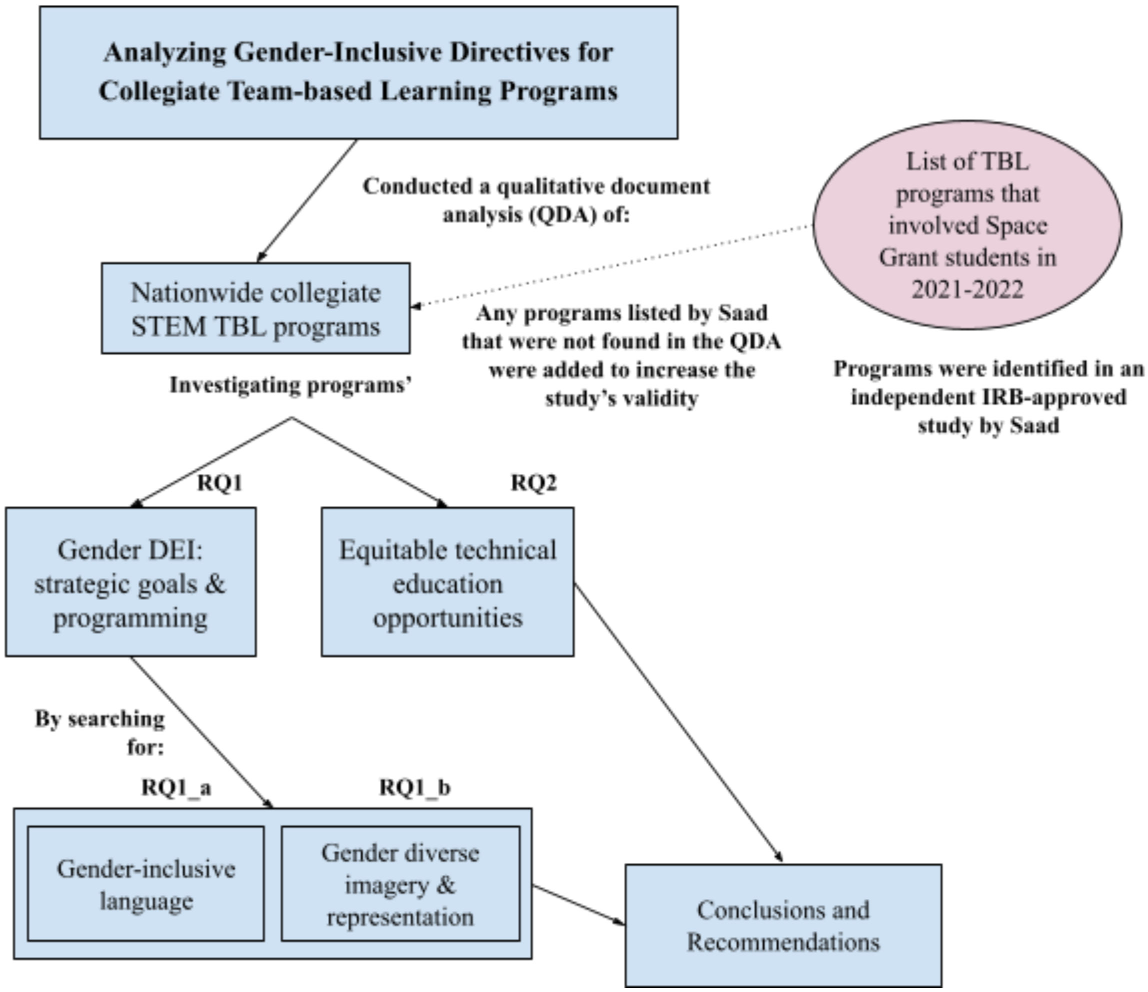
The first research question (RQ1) investigates how well gender DEI is integrated into the program's recruitment materials. A sub-research question (RQ1a) examines the documentation and searches for gender-inclusive terminology that demonstrates DEI has been implemented into the program's strategic goals. The second sub-research question (RQ1b) examines how female representation is portrayed in the same public-facing documentation within imagery. The second research question (RQ2) investigates how the STEM programs integrate technical education equitably in their strategic goals. To address these questions, a taxonomy of TBL programs was constructed and their documents were investigated using qualitative document analysis (QDA) methods.

The study's hypotheses were that the 1) majority of TBL programs would not possess any gender-related DEI initiatives; 1a) the majority of programs would lack gender-inclusive language; 1b) the majority of programs would not include gender-diversity within their documents' visual media; and 2) the majority of programs would not include any programmatic guidance or directives that encourage all genders to participate in technical tasks.

Conceptual Framework

Figure 4

Conceptual Framework of Study 1



Gender Inequality

Women continue to remain underrepresented in STEM fields, and many institutions work to remedy this disparity by offering STEM-focused training programs that project a welcoming and inclusive environment to attract female participants. Some diversification strategies consist of promoting diverse recruitment materials, highlighting gender diverse images, and messages (Kroeper et al., 2020). Institutions project diverse, heterogeneous messaging through visual cues to send signals of its DEI values, regardless of the actual composition of the institutions' demographics (Miller & Triana, 2009). These environmental cues can extend positive messages that the institution values gender DEI, identifying an intent to build a gender-balanced workforce (Lu, 2019).

On the contrary, these programs are not always a welcoming and inviting setting for women. Women are required to overcome institutional barriers as they continuously navigate the complex male-oriented STEM pathway, collecting personal situational cues that indicate which environments are more hostile and which are inclusive (Gaucher et al., 2011). Such situational cues influence the level of social identity threat, which impacts women's perception and internalization of stereotypes or stigmatized identities (Murphy et al., 2007). Many cues present themselves as textual and imagery communications that identify the numerical representation of like/same-gendered participants, and depict performance (Murphy et al., 2007). Many advertisements' documents have a discriminatory effect even when gendered wording is not deliberately integrated (Gaucher et al., 2011).

When programs are non-diverse, but exaggerate gender diversity in recruitment advertisements in hopes of reaching an aspirational diversity level, the program is perceived to have counterfeit diversity (Kroeper et al., 2020). Both women and men perceive counterfeit diversity levels as insincere, which decreases overall interest in participation and manifests identity threat issues for women (Kroeper et al., 2020).

Gender-Exclusive Terminology

Gaucher et al. (2011) argue that gender inequality in male-dominated fields is perpetuated by the inclusion of masculine wording in advertisements, which ultimately decreases women's sense of belongingness and interest in the opportunity. For example, Gaucher et al. (2011) found that advertisements for male-dominated jobs contained more dominant masculine wording than those in female-oriented jobs. In accordance with Gaucher et al. (2011), Zhao et al. (2018) developed an artificial intelligence (AI) program that measures the frequency of gendered pronouns in reference to occupations. While testing the AI with documents from the US Department of Labor, they discovered that 80% of the references with male pronouns were linked to a male-dominated occupations (Zhao et al., 2018).

Gendered wording affected women more than men, as women prefer jobs that include words that match their gender (Gaucher et al., 2011). Men were slightly more likely to find masculine-worded jobs more appealing than femininely worded jobs, and men's sense of belongingness was not affected with these gendered wordings (Gaucher et al., 2011).

Gendered terminologies still emerge through individuals' motivational biases, dissuading women's interest in jobs that feature masculine wording (Gaucher, et al., 2011). As social role theory posits, the selection of occupations and gendered roles are determined by socialized systematic factors (Eagly & Johnson, 1990). Instead of tailoring each advertisement to specifically men—as was the norm in the 1960's—modern day programs have goals to create advertisements that help diversify their workplaces (Gaucher et al., 2011). Although, when individuals act on behalf of governments and institutions, their biased beliefs can unintentionally reinforce institutional barriers already present for women as supporting documents are created (Gaucher et al., 2011). Such barriers are difficult to dismantle, and content creators should self-reflect on ways to enhance the programs' levels of gender DEI.

Changing ways is a complex and difficult task, as individuals regularly demonstrate injunctification—a tendency to defend the status quo and support the action because it has been accepted and the normal way things have operated (Gaucher et al., 2011). Diekman & Eagly (2000) discuss how these dynamic constructs surround women's positions, and how the constructs need to change if role divisions and stereotypes are to diminish. To do this, policy-makers and institutions should remain cognizant on how their program integrates masculine wording in a domain where male-oriented themes are the expected norm. These actions will support a diverse recruitment process, help dismantle gender stereotypes, and lead to more women pursuing traditionally male-oriented STEM opportunities that offer critical training (Gaucher et al., 2011).

Team-based Learning Opportunities

Research shows that female students thrive in collaborative, social, and group-based settings as early as elementary school (Capobianco et al., 2017). Team-based environments are analogous to the expectations of the real-world, where scientists and engineers work together towards a common goal. Carlone and Johnson (2007) described how women make meaning of their own experiences, as well as societal experiences. These authors concluded that social interactions on teams directly influence students' ability to identify with STEM careers (Carlone & Johnson, 2007).

Niler et al. (2020) revealed how female participants experience a higher sense of team identification and collective efficacy when there were more women participating on their team. These authors also revealed that this was not the case for men, who did not experience a higher sense of team identification, collective efficacy, nor team performance (Niler et al., 2020). Team managers can integrate this information to increase their team's female participation, boost team morale, and performances. By fostering an inclusive and welcoming atmosphere, students will feel respected and connected. Then, they will be able to access their experiences, reflect, and engage in dialogue, enhancing their motivation to learn (Merriam & Bierema, 2014).

The NASA project life cycle is a critical paradigm for these programs, as it guides students from the formulation stage to the implementation stage (NASA, 2019). Before each team applies and submits a proposal, students read the Call for Proposals (CfP) or similar application guidelines. These resources outline the objective's constraints, establish guidelines, discloses the assessment standards, and communicate the deliverables (Capraro et al., 2013). By completing these entry requirements, students then start the engineering design process of designing, creating, reviewing, calculating risks, testing, analyzing, retesting, and forming conclusions. Major milestones include the mission definition review (MDR), preliminary design review (PDR), critical design review (CDR), and system integration review (SIR) (NASA, 2019).

Student team environments are composed of a wide-range of college students: traditional and non-traditional students of various ages, academic backgrounds, and majors (both STEM and non-STEM content areas). Students may also participate in these TBL programs to satisfy formal "for-credit" coursework, such as senior design classes or capstone courses. Alternatively, students may also form a team through extracurricular efforts, recruiting through an informal "not-for-credit" approach, such as a registered student organization (RSO).

Also, STEM teams may promote a sense of community, teamwork, and help women relate to their disciplines, as compared to the individualistic nature of the conventional classroom (SciGirls, 2022). Efforts like these may increase female retention in STEM.

During the 2020-2021 academic year, many of these programs were held virtually due to the global pandemic. Students were able to explore the campuses virtually, meet STEM professionals online, and ultimately compete from their home institution and attend competition ceremonies virtually. Many opened their campuses for the 2021-2022 academic year, although not quite at “normal” operations or capacity.

Within TBL settings, students are required to use a higher-level thinking, which stimulates their application, analysis, synthesis, and evaluation levels (Hernandez, 2002). Traditional college courses ask students to memorize or recall information, all reflective of the lowest cognitive levels found within Bloom’s Revised Taxonomy of learning (Krathwohl, 2002). By incorporating all levels of the taxonomy within STEM team-based challenges, students are required to understand concepts, problem-solve, and think critically to propose solutions to challenges (Gomez et al., 2010). By replacing passive lectures with experiential learning and active learning opportunities outlined below, students have the opportunity to develop their higher-order thinking skills.

Methods

Qualitative Document Analysis

The qualitative document analysis (QDA) method was used on public-facing recruitment documents of team-based STEM programming in order to investigate how well their programmatic framework supported gender DEI efforts. Through iterative explorations of online resources (e.g. program manuals, student guidebooks, program websites, and other resource documents), materials that were already available to student team members were identified, categorized, and sorted. The documents were designed for current collegiate teams for the 2021-2022 academic year. No individuals were contacted for additional communications.

Selecting STEM Programs

In order to be eligible for assessment, the programs must have met two criteria:

3) The TBL program must support undergraduate or graduate student participation (programs inclusive of K-12 students were included if they possessed a collegiate division or sub-category).
4) The TBL program must be hosted domestically.

A list of active STEM programs from the 2021-2022 academic year was compiled through a three-step process. The first stage documented STEM programs that were known to the author, such as the seven NASA Artemis Student Challenges and common Space Grant-facilitated STEM challenges. The second stage incorporated programs from an extensive internet search. The third stage incorporated data from an independent IRB-approved study conducted by the author, which surveyed nationwide college students and collected the names of their affiliated STEM programs. This iterative process strengthened the study's validity and helped capture STEM programs that were omitted within steps one and two. Ultimately, this study analyzed 40 total STEM programs and 119 associated documents.

Formation of the Codebook

In order to initiate the document analysis process, a codebook was designed through a priori methods to catalog notes and assessments. The codebook was inspired by the research and publication of Nerche (2017) and Harvard Task Force's (2020) Inclusive Excellence Self-Guided Planning Toolkit. These sources published self-assessment rubrics that measured dimensions of DEI in higher education. The goal of this effort was to produce an assessment tool that administrators could use to help gauge their own institutions' DEI efforts, ultimately locating areas for improvement (Nerche, 2017; Harvard, 2020).

Stage 0 = Start Up: the STEM program does not define any gender DEI strategies nor make them a priority; There is no gender diverse or gender-neutral terminology used within the resources. Programs are at the beginning of their DEI journey.

Stage 1 = Emerging: the STEM program is beginning to integrate gender DEI terminology into its documentation, acknowledging diverse learners. The program lacks gender DEI strategic goals.

Stage 2 = Developing: the STEM program is developing efforts to integrate gender DEI into its strategic goals by providing measurable DEI objectives. Some gender diverse terminology is used.

Stage 3 = Transforming: the STEM program has institutionalized DEI into its strategic goals with specific, measurable, achievable, realistic, and time-bound (SMART) objectives. Many gender diverse terminologies are used in program documentation.

(Adapted from Nerche (2017) and Harvard (2020))

The assessment tool was used to review all 40 programs and the 119 associated documents, and to search for any verbiage indicating gender-DEI initiatives. The measure of gender linguistic variables included: number of genders, sex-based, and gender pronouns (Santecreu-Vasut et al., 2013). Key search terms included female classifiers such as: *she, girl/s, woman/women, female, gender, diversity, equity, inclusion, inclusive, and underrepresented*.

To categorize documents' images, the author adhered to the following guidelines:

1. If a document did *not* include any images of people, it was not included for assessment. It received a score of zero, where it was removed from future analysis.
2. If a document *did* include at least one person, regardless of gender, the document was included for assessment.
    a. If no women were featured, the document received a score of one (1).
    b. If at least one woman was featured, the document received a score of two (2).
    c. If a woman was featured, but served as the program's administrative staff and not as a student participant, the image was not included in the assessment.

It is not always appropriate to include images of people on every piece of documentation. Items with no human representation were removed from the image analysis process. Some types of imageless documents included: technical instructions and guidelines, rule books, evaluation criteria, judging sheets, checklists for deliverables, and/or administrative documents that support travel.

If a document possessed at least one image with female representation (receiving a score of 2), it underwent further evaluation. This included:

1. Both eyes of the woman must be visible (Kilbourne, 2012).
2. If women are in a group photo, this group must consist of ten or fewer individuals to qualify (Kanter, 1977).
3. Website headers and footers were not included in the document analysis process, even if they featured a female student.

For this study, any document that featured an individual—regardless of their gender—was included for analysis. Additionally, gender identity and gender expression are not synonymous. Because the concept of gender is socially constructed, it is impossible to look at an image and accurately assume the individual's gender identity. Despite this, many individuals who identify as women within Western culture express their femininity in a similar fashion: wearing clothing of similar influences, styling hair similarly, and/or longer hair than men. These assumptions, as well as typical feminine physical characteristics (e.g. facial features, outline of body shape), were considered within digital photographs. Lastly, because the research was written under the influences of Western society, the visual cues identified in the photographs would be representative of the visual cues fellow team members would also identify.

This study utilized triangulation, a research process that synthesizes complementary data from multiple data sets in order to prove evidence of validity (Oppermann, 2000). During the document analysis process, additional TBL program names were provided from an independent quantitative research study, conducted concurrently by the author. These additional program names were the product of survey data of college student survey participants, who voluntarily identified the programs they participated in during the 2021-2022 academic year. This study, also approved by an IRB board, served as a resource to cross-reference the list of TBL programs, ensuring a comprehensive search was conducted and minimal STEM programs were omitted from the QDA process. Also, all data was dual-coded, assessing its text and image items, which helped triangulate and integrate multiple sources of information into the conclusions.

Summary

Quantitative document analysis (QDA) methods were able to capture an objective and detailed historical account of the STEM programs' student-centric policies. By systematically reviewing and evaluating these documents, the author was able to "elicit meaning, gain understanding, and develop empirical knowledge" about how these programs integrate gender DEI into their strategic goals and program objectives (Corbin & Strauss, 2008). An assessment tool was designed and used to measure the gender DEI criteria within each program. Documents were reviewed to assess how well gender DEI was integrated into the strategic goals, through an in-depth exploration of the text and imagery.

Results

A qualitative document analysis was conducted on 40 STEM programs that were active during the 2021-2022 academic year. These programs supplied data as public records (e.g. public websites, student handbooks, and policy guides) and provided a wealth of information within their program solicitations, requests for proposals (RFPs), team guidelines, and social media advertisements. A total of 119 program documents were analyzed.

As seen in Table 1, the 40% of programs categorized in *Stage 0* presented the most room for improvement, as no gender diverse terminologies were used in any documentation. The lack of gender inclusive terminologies was also coupled with a lack of gender DEI strategies. The 52.5% of programs that met the criteria for *Stage 1* acknowledged their student participants with diverse terminology such as, "person; women; she; female; they; and girl." *Stage 1* documentation also presented gender DEI recruitment and engagement strategies as suggestions for teams with, "SWE (Society of Women Engineers); and #GirlPowered grants". The three programs (7.5%) that met the criteria for *Stage 2* developed broad DEI goals that were integral to the teams' operations. Such DEI efforts were strongly encouraged or mandatory efforts that affected teams' final scores. *Stage 2* policies required teams to document their strategies for "equity, diversity, recruiting, training, [and] working together" and required the integration of a female driver in engineering vehicle challenges.

There were no *Stage 3* programs. Eligible programs could have demonstrated a commitment to embed gender DEI into their programmatic frameworks. For example, programs could have required student teams to propose how DEI influences recruitment strategies, prolonged engagements, and assessment. Programs could encourage teams to intentionally set gender DEI-related SMART goals for the competition year.

Table 1

Results of the Qualitative Document Analysis

	RQ1a				RQ1b		RQ2			
	STEM Programs		Documents		Programs with images of female representation		STEM Programs		Documents	
	n	%	n	%	n	%†	n	%	n	%
Stage (0): Start Up	16	40%	86	72.3%	*13*	*81.2%*	37	92.5%	116	97%
Stage (1): Beginning	21	52.5%	30	25.3%	*7*	*33.3%*	0	0%	0	0%
Stage (2): Developing	3	7.5%	3	2.52%	*3*	*100%*	3	7.5%	3	3%
Stage (3): Transforming	0	0%	0	0%	*0*	*0%*	0	0%	0	0%
Total items:	*40*	*100%*	*119*	*100%*	*23*	*57.5%*	*40*	*100%*	*119*	*100%*

†Percentage within the stage.

Discussion

A qualitative document analysis (QDA) was conducted on public-facing STEM materials and resources that were available to college students nationwide. The documents were reviewed through a feminist standpoint lens, assessing if policies integrated DEI within its program strategies and goals. This search would address the research questions of how well the STEM programs equitably support female STEM students, who are members of a minority group (Harding, 2004). It was important to investigate what the documents conveyed—or lacked to convey—to prospective and current students. As May (2010) states, all documents have deeper intentions and meaning, and this analysis conducted an in-depth examination into the technical requirements and operational procedures to see how well they conveyed an inclusive environment.

Research findings

The purpose of this study was to analyze STEM documents that targeted TBL participants and assess how these documents' integrated gender DEI into their programming. An analysis of the textual data was conducted and the first finding was that the majority of STEM TBL programs referred to student participants with gender neutral or female-inclusive wording, as there were no references to students using only masculine pronouns. This was a positive discovery in terms of gender inclusivity, as Zhae et al. (2018) presented evidence for a higher percentage of male-associated terminologies and Gaucher et al. (2011) discussed the implications of projecting gender biased information. However, 40% of the total programs did not include any terminology—neutral, feminine, or masculine—that referred to gender. These programs met the criteria for *Stage 0: Start Up*, which was defined as possessing no documentation with gender inclusive text. This large percentage indicates a lack of inclusive recruitment, failing to advertise the STEM opportunity to prospective female participants. This may seem trivial, but as reflected in the national STEM demographics and statistics, STEM is already male dominated; the process of injunctification—or individuals assuming the status quo—plays a role and perpetuates the gender stereotypes of role expectations and technical task allocations (National Science Board, 2022; Gaucher, 2011).

The omission of female-inclusive or gender neutral text does not imply malintent or ignorance on the programs' content creators. It is possible that this omission was an intentional effort to not use male-serving terminology. Programs may also become gender blind, failing to acknowledge diverse learning styles and participants and sustain injunctification tendencies (Gaucher et al., 2011). When complacency prevails, injunctification leads to more of the status quo: male-dominated STEM domains.

Unexpectedly, 80% of *Stage 0's* documentation depicted female participation through the use of images. There are various explanations for why this may be the case. It may be that these programs *do* value gender-inclusive messaging, but they may be expressing them through imagery as opposed to text. Conversely, the high percentage of female representation in imagery could also be due to programs attempting to exaggerate the participants' heterogeneity—known as "counterfeit" diversity (Kroeper, 2020). Counterfeit diversity is often implemented because it can be good for business and public relations, but it is an insincere effort to increase diversity (Kroeper, 2020; Özturgut, 2017). If the same programs that lack gender-inclusive text also feature a high percentage of female participants in images, then these minimal efforts could contribute to the tokenism of female participants (Kanter, 2008). Ultimately, the programs that met *Stage 0* did not demonstrate efforts towards improving female students' underrepresentation in these technical fields.

Sixty percent of the STEM programs possessed documentation that referenced some form of gender-inclusive terminology, meeting the criteria for *Stage 1* and *Stage 2*. The programs in *Stage 1* (52.5%) included terminology that acknowledged female students. Programs in *Stage 1* expressed this terminology in various ways. The most common expression was through the use of binary pronouns. For example, document creators used “he/she,” “Boy/Girl Scouts,” and “boyfriend or girlfriend.” Binary pronouns were not only used to refer to student or abstract concepts, but also to refer to faculty members. One program stated, “regardless of the number of teams he or *she* [emphasis added] supports…,” and another program requested students seek a Space Grant director’s signature approval on a proposal form, stating, “the letter needs to clearly state that he/*she* [emphasis added] has reviewed the proposal.” Referring to female faculty members acknowledges the possibility of a female role model for students which has been shown to increase female students’ retention in STEM (Olsson & Martiny, 2018).

The use of gender binary phrases demonstrates that programs are gender-aware, but they make minimal efforts to acknowledge the presence of female participants. Similar to Özturgut’s (2017) research on the intentions of promoting gender diverse imagery, gender binary pronouns may be intentionally-placed environmental cues designed to promote the appearance of a welcoming and inclusive setting using heterogeneous messaging (Miller & Triana, 2009). This, too, is an insincere and ineffective strategy to increase diversity (Kroeper, 2020).

Additional programs within *Stage 1* utilized gender neutral roles, such as the use of the “flag-*person*” [emphasis added]—as opposed to the masculine term, “flagman.” This reflected the research of Bem and Bem (1973), who discussed the importance of using neutral terminology instead of the traditional masculine suffixes. Other gender neutral examples include “[t]he assembly crew member is the only *person* [emphasis added] who can touch the airplane…” and “[d]irect warning systems to alert pilots that *they* [emphasis added] are approaching a runway.” The QDA process did not locate and count how many times the term “they” was used, but assessed *how* this term was used; “they” must have addressed individual student participants (vs. addressing a team, which would grammatically warrant the neutral third person tense without implying gender). As a result of STEM fields being historically male-dominated domains, the lack of gender associated with the gender neutral form may cause individuals to revert back to personal assumptions outlined by SRT and the motivated desire—injunctification—to assume a gender based on preexisting implicit biases (Gaucher, 2011).

Additionally, programs within *Stage 1* also engaged diverse community groups, as multiple programs include an outreach, or STEM engagement, component. These student participants must demonstrate their projects with public audiences, reaching local talent (UCHI, 2019). These demonstrations could take place with informal or formal education groups, such as “Girl Scouts” and “Girls Clubs.” These references were still addressed alongside their binary counterparts—“Boy Scouts” and “Boys Clubs”—throughout the texts. Therefore, it is the author’s interpretation that the mention of female groups was not provided as a means to reach an underrepresented population in STEM, as it was grouped within the terms’ male counterparts.

To promote recruitment at the collegiate level, one national engineering program encouraged teams to “ask other organizations like SWE, IEEE, and NSBE if you can make a short presentation about the project at one of their meetings,” referring to the Society of Women Engineers (SWE), the Institute of Electrical and Electronics Engineers (IEEE), and National Society of Black Engineers (NSBE). The specific callout to the SWE groups (and NSBE) did not provide additional context, so the author was unable to assess whether the goal was to engage minority-serving student organizations.

Lastly, one engineering design program acknowledged female student participation within the role of a driver. This program required teams to construct vehicles that could accommodate drivers across a spectrum of weights; vehicles must support an upper limit for larger male students and a lower limit for smaller female students. The efforts towards encouraging gender DEI participation ended at this statement, as there was no additional text that encouraged female students to volunteer for the driver role. With these design constraints, prospective female participants may consider becoming a driver—a technical role that has historically been male-oriented (Faulkner, 2007).

Interestingly, only 33.3% of these *Stage 1* programs feature female participants in their documents' images. It remains unclear why *Stage 1* has less female representation than *Stage 0*. This could be evidence that *Stage 0* programs were including images for business and public relations goals, but there is insufficient evidence to draw a conclusion. Ultimately, the lack of inclusive imagery does not promote positive growth of female representation in STEM. This inconsistent pattern is an avenue for future research.

Six programs (15.8%) highlighted how their program objectives also support NASA's Artemis program. These programs only focused on Artemis' technology and innovation demands (e.g. more advanced dust mitigation technologies) instead of through a gender inclusion lens. One program did reflect that their program "tackles key aspects of NASA's Artemis missions"...and will "provide students the opportunity to contribute real solutions to problems NASA faces." These "real…problems" were later described solely as technology- and engineering-based obstacles. A major aspect of the Artemis program is the goal of placing the first female astronaut on the moon—a historic initiative that NASA is proud to advertise (NASA, 2020a)—and these TBL programs fail to acknowledge the national demand to train a gender diverse workforce. It is perfect timing to integrate gender equitable training and education into space-related programming, as it would directly align with NASA's goals of selecting a qualified female lunar astronaut.

There were only three programs (7.5%) that met the criteria for *Stage 2*; these programs developed efforts that highlighted gender DEI as a strategic priority with measurable DEI objectives. These programs presented mandatory (with exceptions) and voluntary directives that required student teams to integrate gender-DEI into their year-long programming. These three programs addressed DEI objectives in two ways: 1) offering voluntary team opportunities and 2) enforcing mandatory team directives. In the first category, students could describe how their team integrated DEI into their year-long efforts, submitting a paper or poster presentation (with images) to the competition judges. The judges select a first prize winner to the team who demonstrated the highest level of DEI in their "recruiting, training, and working together" phases. The team members' could decide if they wished to pursue this optional award. In the second category, two vehicle design programs set a gender-inclusion mandate: all teams must complete the course with "at least one female" driver or "at least one driver of each gender." The first quotation suggests the program managers assume teams are predominantly male, as indicated by the mandate to include "at least" one female. The second quotation is less assuming, as "each gender" does not infer that male students make up the majority. It is the author's interpretation that the phrase, "each gender," was designed to increase female participation, as the majority of engineering students in the United States are male students (National Science Board, 2022). As discussed by Prieto-Rodriquez et al. (2022), efforts striving to fill quotas stigmatize gender DEI efforts, as female students' efforts are devalued and work ethics are threatened.

If teams are unable to engage at least one female student as their driver, alternative options are provided so that these gender homogeneous teams may remain in the challenge. These teams may locate a female volunteer and engage her once during the final race (vs. working with the team throughout the academic year). In these instances, teams must submit a written request for a waiver to the program's Head Judge. If accepted, the team's female participant would be unable to volunteer for other teams. One program states "significant penalties are incurred for teams that do not meet this requirement," referring to those who fail to fulfill the mandate. This is significant because the program is conveying their values to the student participants, communicating the critical importance to have a gender diverse team. Adversely, the female volunteer is used as a token female participant (Kanter, 2008), meant to satisfy a mission objective and not as a means to engage her in equitable learning experiences. The waiver system—although necessary for unpredicted circumstances and situations—may be taken advantage of by all-male teams who deprioritize the equitable recruitment process. By filling a quota (e.g. finding a *volunteer* female driver), these programs force diversity without providing female students' with the desired learning outcomes this directive may have intended (Iyer, 2022). In summary, these aforementioned programs have taken positive steps towards an inclusive and gender diverse program, but still may work towards *Stage 3*: institutionalizationaling DEI within their strategic goals. Additionally, further research on the waiver process is needed.

Even though 92.5% of the programs did not show evidence of gender DEI efforts in their strategic goals, a few programs referenced the importance of DEI. One engineering design program shared research-based data in their documentation, informing teams about how more diverse groups, such as "those with a diversity of age, race, ethnicity, gender, and sexual orientation," are more innovative. There was no follow-up to this statement or additional recommendations on how their student teams could recruit and retain a diverse team population. This evidence shows the program facilitators are familiar with evidence-based DEI research, but failing to embrace and commit to specific gender-related DEI inclusions.

No STEM program fully institutionalized gender DEI, and thus, failed to meet criteria for *Stage 3*. A theoretical *Stage 3* program may address gender DEI by integrating specific, measurable, achievable, relevant, and timebound (SMART) goals into their solicitation requirements. Programs that achieve the *Stage 3* status should require teams to highlight their equitable recruitment strategies, equitable engagement and retention goals, and list the penalties for not meeting these goals.

Limitations

The literature has historically reported data through a binary gender construction: male or female. This limited two-option system can be seen in national reports by the US Census data, National Science Foundation data, NASA-reported data, and others. By limiting the process to report only two genders, this assessment is not inclusive of any non-binary or gender non-conforming persons.

This study focused solely on gender-DEI factors. An intersectional framework was not integrated, but its importance should not be overlooked or minimized. There are additional critical social identities that influence learners, such as socioeconomic status, race, ethnicity, and disability status.

Delimitations

Research was delimited to a single year, during the 2021-2022 academic year. At this time, the world was still experiencing the ongoing global health crisis, the COVID-19 pandemic (the highly transmissible Omicron variant was peaking during many of these programs' timelines, directly influencing the potential to hold in-person team-based programming). Despite safety precautions in place, each school across the nation enforced varying levels of regulations and safety precautions. This study did not assess the impacts COVID-19 had on students' motivation to join, especially when some may not have participated due to safety concerns. Studying students' interactions in 2021 could differ from those studied prior to 2020 because of the hands-on tasks and requirements within a group setting.

It is important to clarify why this research did not integrate documentation from two major Space Grant-funded programs, NASA Internships and Research Fellowships (NIFs). NIFs satisfy NASA's goals of enhancing and increasing "the capability, diversity, and size" of America's STEM workforce (NASA, 2020b) but lack the team dynamics in which this study investigates. NIFs also offer students authentic learning experiences, yet these are often completed individually and not in a group setting. Collaborations do occur between students, but the majority of work is completed individually, as defined by NASA (NASA, 2020b).

Conclusion

Policy-making organizations and institutions should assess how effective their current approach is at reducing the gender gaps, and be open to modify current operations. The funding that supports teams to participate also sends a message of acceptance: the current state of STEM—its demographics and actions—are adequate. By sponsoring students to participate in STEM programs that fail to promote gender DEI, these organizations indirectly reinforce institutional barriers that promote male dominant domains. Federal and state sponsoring agencies' funds should propel equitable technical education, rather than sustain the existing STEM demographics and status quo. These sponsoring agencies act as a crucial bridge between academia and the workforce and have an opportunity to help break down these institutional barriers with this funding. The analysis from this study suggests these programs—critical workforce development programs—are not meeting the needs of a diverse and inclusive STEM workforce.

Recommendations

Programs should act as an agent of change, redesigning their strategic frameworks to better reflect DEI goals. The following recommendations describe initial strategies that policymakers, educators, and program facilitators can integrate into their programming to build capacity and introduce equitable and inclusive STEM programming.

Lead from the top. As outlined in the socio-ecological model, policymakers have the power to affect change that influences communities, institutions, and individual learners. Policymakers should make changes that influence the STEM culture, rather than targeting individual students (Moss-Racusin, 2021). Policymakers should also assess whether their programs' current strategic goals integrate gender DEI effectively and work towards enhancing existing plans to meet these objectives. Policymakers should reflect on how their public-facing documentation conveys a sense of belonging, inclusiveness, and diversity, reflective of the community they engage (Harvard, 2020).

Implement and publicize institutional gender-inclusive policies (Moss-Racusin, 2021). As advised by Cech & Blair-Loy (2014), evidence-based policy should be designed to be "opt-out (rather than opt-in)", to normalize the gender-inclusive policy and guard it against stigma. Detailing evidence-based DEI commitment statements—which are not required by law or university policies—publically highlight the program values these goals (Harvard, 2020). While setting gender DEI goals, policymakers should outline specific, measurable, attainable, relevant, and time-bound (SMART) metrics (Lawlor, 2012).

Be wary against gender bias. Administrators should examine their current recruitment methods and implement strategies that foster welcoming and safe environments for diverse students. Document creators should assess products for language that conveys masculine STEM culture and gender-exclusive language, as these systematically deter female applicants (Stout & Dasgupta, 2011). Leaders should reflect on the imagery and language used to market and recruit student participants. Networks will not diversify through intrinsically biased word-of-mouth advertisements, which rely on a narrow network (Zych, 2020). Program leaders should remain cognizant of injunctification—remaining complacent with the status quo—which perpetuates the constant gender statistics in STEM (Gaucher, 2011). Recruitment strategies should be made with intentionality, considering the impact of female representation of faculty mentors, recruiting students from additional STEM fields, and researching their institutions' minority serving organizations and resource centers.

Set goals within the institution. Program administrators should identify their strengths and weaknesses, identify whose voices are omitted from the discussion, and set long-term and short-term goals to create an environment conducive to DEI. Professional development (PD) workshops and resources help train faculty, students, and staff on the benefits of having diverse teams. PD opportunities educate all members about the detrimental effects of microaggressions, implicit biases, and gaslighting. Female mentorship programs can be beneficial if the faculty mentors are financially rewarded for their time and their workloads are respected (Moss-Racusin, 2021).

INVESTIGATING HOW GENDER INFLUENCES STUDENTS' EXPERIENCES IN COLLEGIATE STEM TEAM-BASED LEARNING ENVIRONMENTS

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Abstract—Contribution: **This study investigated science, technology, engineering, and math (STEM) students' experiences in collegiate team-based learning settings, exploring how gender plays a role in technical task distribution, students' levels of motivation, self-efficacy, and their sense of belonging. This research may help STEM institutions deliver more equitable student learning outcomes to strengthen the STEM workforce.**

***Background*: Female college students remain underrepresented in STEM fields, especially fields that promote technical education, such as engineering, physics, and computer science (NSF, 2022). Equitable technical education is critical to strengthen the US STEM workforce.**

***Research Questions: 1)* What are the demographics of students participating on STEM teams? 2) Does the level of motivation, self-efficacy, sense of belonging vary based on students' gender identity? 3) Is the distribution of technical vs. non-technical tasks equitable between gender identities?**

***Methodology:* Data from students on a Space Grant-funded STEM team were gathered through a survey tool.**

***Findings*: The majority of survey participants were White, male, engineering undergraduate students. There was no significant association between gender and students' perceived levels of motivation. Female students were less likely to lead technical tasks on STEM teams, feel like they belonged to the STEM community, and feel respected. Female students were more likely to feel like an outsider and that they could effectively coordinate tasks and activities of a group. The study concluded that these gender disparities impact Space Grant students, and recommended DEI strategies to make systematic changes in their programming.**

***Index Terms*: chi-square test; gender diversity, equity, and inclusion (DEI); motivation; self-efficacy; sense of belonging; science, technology, engineering, and math (STEM); team-based learning (TBL); technical education**

I. INTRODUCTION

In the United States, female college students remain underrepresented in STEM fields, especially fields that promote technical education, such as engineering, physics, and computer science (NSF, 2022). Female students are less likely to graduate with a STEM degree even though they are more likely to graduate college than their male counterparts (NSF, 2022). The low representation is "often rationalized as a lack of interest from individual women" but in reality, it is a result of a systemic process that makes STEM not inclusive to all learners (Foor et al., 2013).

To better prepare all students for the technical workforce, college educators may support students through experiential learning opportunities, where knowledge is scaffolded from textbooks and class lectures into a real-world setting. Some of these experiential learning opportunities include team-based learning (TBL) challenges, where students demonstrate their technical skill sets, critical thinking abilities, and teamwork skills. Within these team settings, the task distribution is critical to determine which student will develop or practice a specific technical or non-technical skill set. Both of these types of skills are necessary for success in the STEM workforce.

To make TBL challenges more inclusive for all genders, tasks and assignments must eliminate associated gender roles; female students must develop technical skill sets and male students must develop non-technical skill sets. Specifically, women must be confident in leading the physical "nuts-and-bolts" work and construction, while the men must be confident in leading marketing, social, and management duties (Faulkner, 2007).

When students participate on STEM teams, they are responsible for one or more tasks, contributing to the overall team goals and objectives. These specialized tasks are perceived to have a gender role, to which team members associate a skill, product, requirement, experience, or procedure with masculine, feminine, or gender-neutral characteristics (Okudan & Mohammed, 2006). Such tasks can influence the team's performance—which is not reflective of the abilities of women and men—but rather the relatability towards each genders' interests and abilities (Rogelberg & Rumery, 1996). All of the tasks and associations are abundantly found within STEM, which reinforces and perpetuates gender stereotypes.

For decades, research has examined the changing gender dynamics within team environments and questioned how all-female teams, all-male teams, and mixed-gender teams perform in relation to tasks, interpersonal cohesion, and decision-making (Rogelberg & Rumery, 1996). Okudan and Mohammed (2006) highlighted past research that showed how all-male teams performed better in short-term task activities and all-female teams performed better in social activities (Eagly and Karau, 1991; Wood, 1987).

Darling-Hammond (2005) articulated how students learn more effectively by participating in authentic, real-life activities (p. 55). Student teams are an effective platform where learners of all ages can be introduced to the engineering design process and gain confidence to enter the STEM workforce (FIRST, 2020; Naumov et al., 2006) TBL settings require students to use collaboration and interpersonal skills, as compared to working independently on projects (Neubert & Taggar, 2004). Students of all majors, genders, and experience levels can work together, perceive a collective identity and a sense of belonging, and therefore, present a great research opportunity (Song et al., 2015). The American workforce depends on these student teams working well together to be motivated, more efficient, and able to respect other group members' perspectives and roles (Schroder et al., 2011).

The purpose of this study was to determine if there were differences between female and male college students' technical learning experiences on STEM teams. This study also explored students' experiences within the constructs of motivations, self-efficacy, and a sense of belonging. Three research questions were developed:

Research Questions

- RQ1: What are the demographics of students participating on STEM teams?
- RQ2: Does the level of motivation, self-efficacy, sense of belonging vary based on the gender identity of students on STEM teams?
- RQ3: Is the distribution of technical vs. non-technical tasks equitable between gender identities?

It is anticipated that the majority of participants on these STEM teams will identify as male students, reflecting the NSF (2022) gender demographics found in the STEM fields in academia. Additionally, it is hypothesized that female students will have a lower sense of motivation, self-efficacy, and a sense of belonging than their male counterparts. Lastly, it is hypothesized that female students are less likely to conduct the technical tasks, reflective of the gendered norms and social roles shaped by society.

II. BACKGROUND

A. Gender Stereotypes

Gender stereotype threat is pervasive in STEM culture, creating obstacles for engaging and retaining female students in STEM (McKinnon & O'Connell, 2020). As Spencer et al. (1999) stated, any group that experiences prejudice internalizes the stereotypes communicated about them, even if they do not find them believable. These "devaluing group stereotypes are widely known throughout a society" (Spencer et al., 1999, p. 5). STEM-related stereotype threats cause female students to feel unwelcome in math-related courses and programs, which causes them to lose their math self-identity and dissuades them from persevering in the field (Spencer et al., 1999). When women anticipate discrimination or a lack of success due to gender stereotypes, they lose interest in STEM careers or the desire to perform the skill (Moss-Racusin et al., 2018). Women's self-perceived levels of motivation and confidence declined after they were told men were superior in that specific task (a false statement), which adversely affected their interest in pursuing careers with related skill sets (Thebaud & Charles, 2018, p. 6). Ultimately, male students do not have to overcome STEM stereotypes. Such examples display the gender inequities within the STEM pathway.

B. Gendered Perceptions on STEM tasks

Cultural gender stereotypes permeate all STEM fields, frequently classifying tasks, skill sets, and standards as masculine, feminine, or gender-neutral. In fields where women are already underrepresented and face gender disparities along the entire STEM pathway, gender stereotypes present another obstacle to overcome. One leading stereotype states men have more abilities in STEM than women, and that women have an increased struggle in math fields (Davies et al., 2002; Nosek et al., 2002; Spencer et al., 1999). In addition, women are often assumed to be less intellectually competent than men, however educators are aware that gender does not have an effect on intellectual aptitude (Feingold, 1992; Smith & Stewart, 1983; Neubert & Taggar, 2004).

On its own, having a gender diverse team does not directly predict team success. When looking at how gender plays a role in team dynamics, researchers have published conflicting results over the decades. In the 1970s and 1980s, researchers found examples where all-female teams performed worse than all-male teams, equal to all-male teams, or more successful than all-male teams (Sashkin and Maier, 1971; Wood et al., 1985; Bray et al., 1978). Decades later, research on team dynamics continues. Hoogendoorn et al. (2013) suggested an equal mix of female and male students perform better than male-dominated teams.

Current theories posit that if girls persist long enough throughout grade school, study STEM in college, and engage in authentic, real-world STEM experiences, the activity will help dissuade masculine stereotypes by the time they enter the workforce (Wynn & Correll, 2017). Assuming these female students have active female role models, improved support networks, and less hostile and prejudiced work environments, Wynn & Correll (2017) conclude that hands-on STEM programs could help with the issue of underrepresentation, in theory. In actuality, STEM educators facilitate team-based programming, such as collegiate competitions and design challenges, to help address this issue. However, these stereotypes still persist in the workforce, continuing to "influence people's decisions and perceptions once they are in the workplace" regardless of team-based involvement (Wynn & Correll, 2017).

C. Dualities in STEM

Faulkner (2007) asserts that all STEM tasks are influenced by gender norms and can be classified within two major relationships: 1) a technical vs. social duality, and 2) a "hard skills" vs. "soft skills" duality. Instead of having a multi-faceted and multi-dimensional experience based on sociotechnical aspects and interactive expertise, each task is socially assigned a singular masculine or feminine identity (Trevelyan, 2019; Bornasal et al., 2018; Faulkner, 2007). Technical tasks are deemed masculine because of idealized masculine hegemony: instrumentalism and the use of machines, control and dominion over nature, and hands-on applications to interact with the world (Seron et al., 2018; Faulkner, 2007). These masculine qualities are "manly" and reinforce the "hard" skill sets (Seron et al., 2018). On the contrary, non-technical tasks are deemed feminine: skills that require expressiveness and good "people skills" (Faulkner, 2007). Generic "soft" products include presentations, communication skills, critical thinking, problem solving, management, and politics (Falloon et al., 2020; Edwards et al. 2015; Faulkner, 2007).

Statistically, men prefer to produce "things" or items that are effective commercially through "real work"— tinkering, using nuts-and-bolts, and displaying technical competence (Faulkner, 2007). Masculinity is tied to tech and business roles, two gender-authentic identities that instill power and authority. Men also speak for longer time periods than women while in a team setting, impacting the social and power dynamics (Meadows and Sekaquaptewa, 2011). Because of this, men are more commonly found in high-level management and in control of organizational resources (Faulkner, 2007). Even when men ascend up the career ladder as senior leaders and lose their blue collar "nuts-and-bolts" credentials, they still possess their authority, power, and "marketplace manhood" markers (Faulkner, 2007).

Nevertheless, women are still commonly found in these roles, but there is a major gender difference in task allocation: men spend more time than women on tasks that ensure promotability (Babcock et al., 2017). In one study, nearly 90% of women place a higher value on service roles (serving on committees and faculty senate) instead of prioritizing performance evaluations and career advancement than research (writing research papers and presenting at conferences) (Babcock et al., 2017). These soft "fluff skills" help manage people, timelines, and schedules, while creating verbose reports and dealing with politics (Faulkner, 2007). When women conduct these soft skills, it is commonly perceived as "gender authentic" — a gender norm that has come to be expected (Cech, 2013; Faulkner, 2007). Men may downplay the importance of these social roles, distancing themselves away from support roles (Faulkner, 2007). This is not to say women get "left behind" in technical roles; many women choose to stay in the hands-on technical engineering roles, because they formed a technicist identity and thrive in the role (Faulkner, 2007).

These mutually exclusive dualisms hurt all genders. When women perform technical tasks as an engineer, it is easy to "notice something different," yet it is "nothing remarkable when a man is an engineer" (Faulkner, 2007). The effort needed to be valued as a STEM professional is inequitable: women must constantly reestablish themselves throughout their careers, proving that they are a real engineer as well as a real woman with social familial roles. Women may experience a difficult time reentering the workforce after maternity leave; when women return back to the workforce, it may be perceived that they do not have the same interest or effort levels in the job (Di Tullio, 2019). Even though this may not be true, this traditional male-centered vision could produce an auto-identification response or imposter syndrome of being called a fraud (Di Tullio, 2019). If colleagues believe a new mother will be less productive, they can actually behave less efficiently (Di Tullio, 2019). This is not the only cause for female attrition rates, but one of many that impede women's ability to climb the career ladder, reaching a dead end with a glass ceiling (Di Tullio, 2019). When in a mixed-gender pool, women have been shown to volunteer their time 50% more than men; when in an all-female subject pool, all volunteering was eliminated (Babcock, 2017). Babcock (2017) contends the difference to volunteerism is "driven not by preferences but rather by the belief that women more than men will volunteer" (p.743). In summary, when male faculty members were present, female faculty perceived the volunteer roles were their responsibility solely based on their gender.

D. Skill Alignments

When college students participate in TBL programs in the form of STEM competitions, cooperative group settings, and authentic hands-on experiences, they may self-select which STEM-related task to lead. These tasks can range from technical, social, and business-related roles, such as social media manager, design engineer, electronic engineer, coding/computer science lead, and lead presenter. Tasks are also "gender-conforming", offering students satisfaction as they conscribe to the expected gender norms defined by society (Thébaud & Charles, 2018, p. 7). For example, female students often choose female-dominated tasks (such as communal and interactive tasks) because they believe they will enjoy it more than the masculine options (that are more assertive, competitive, and independent) (Ceck, 2013; Charles & Thébaud, 2018). These "cultural alignments" or "skill alignments" (or lack of alignment) occur when individuals match the attributes of a stereotypical successful technical worker's profile (Wynn & Correll, 2016, p.3).

Ultimately, men are more likely than women to believe they fit the cultural image of a technical employee and believe they will be more skilled or find more satisfaction (Wynn & Correll, 2016; Correll, 2004; Charles & Thébaud, 2018). The masculine culture of STEM fields deters women from these technical roles. After believing these cultural gender stereotypes, women often feel that they are misaligned with the quantitative and analytical skills needed, assuming they will not be successful in that role (Wynn & Correll, 2016). Students are directly influenced by these stereotypes, especially throughout their formative years when they are developing their career aspirations. Charles and Bradley (2009) showed how affluent "postmaterialist" societies push the narrative of "follow your passions" and "doing what you love", which are constructed around these stereotypes (Wynn & Correll, 2016; Charles & Thébaud, 2018).

III. METHODS

A. *Participants*

This study used a purposive sample of nationwide college students who were involved on a STEM team during the 2021-2022 academic year. The survey was emailed to 52 Space Grant Consortium managers, who then forwarded the request to their funded student team members. A total of 239 students participated in this study, all of whom were enrolled at a higher education institution within the United States and were 18 years of age or older. Almost all of the participants were undergraduate students (96%). The majority of participants were male (68.5%), White (68.5%), and undergraduate seniors (41.2%). Additional demographics of the participants can be viewed in Table 2.

B. *Instrument*

Participants were asked to rate their level of agreement on a 6-point Likert-type scale with: 6 = strongly agree, 5 = agree, 4 = somewhat agree *(all some form of agreement)*, 3 = somewhat disagree, 2 = disagree, and 1 = strongly disagree *(all some form of disagreement)*. In order to avoid biasing participants towards gender-related responses, survey questions focused on general experiences to ensure the validity of the instrument (Patridge, 2014).

The development of the survey tool's measures were derived by conducting an extensive survey of the literature. Validated scales from three peer-reviewed studies were used to measure constructs of motivation, self-efficacy, and a sense of belonging on the STEM teams. Each construct was detailed in peer-reviewed and validated surveys (Guay, Vallerand, & Blanchard, 2000; Nostrand & Pollenz, 2017; and Eby & Dobbins, 1997) and integrated into the survey tool. The study was approved by an institutional review board.

Situational Motivation Scale (SIMS)

Developed by Guay et al. (2000), the Situational Motivation Scale (SIMS) was designed to assess situational motivation constructs in field settings, when individuals are engaged in the activity. From this validated survey, the author adapted four questions (Q9 to Q12) that assess students' motivation regarding team participation. Specific areas of motivation include intrinsic motivation, extrinsic motivation, identified regulation, and amotivation.

Sense of Belonging Scale

The Sense of Belonging Scale was adapted from Findley-Van Nostrand & Pollenz (2017), who modified the items from the *Sense of Belonging to STEM Scale* by Good et al. (2012). The authors modified the terminology so that the questions would address "STEM" instead of "math" (D. Findley-Van Nostrand, personal communication, December 10, 2021). With this scale, Findley-Van Nostrand & Pollenz (2017) measured students' membership, acceptance, affect, and the desire to fade within the STEM fields. For this study, the *membership*- and *acceptance*-related items were used (Q15 to Q21).

Self-efficacy for Teamwork Validated Scale

The Self-efficacy for Teamwork scale was adapted from Eby & Dobbins (1997). The four questions included in the survey reflect students' perceptions of their ability to work effectively in a team environment. These items are found within Q22 to Q25 in the survey.

C. *Procedure*

The purposive sampling method was used due to its ability to align the research goals with the specific target population, ultimately strengthening the rigor of the study and trustworthiness of the data (Campbell et al., 2020). Nationwide survey participants were instructed to respond as honestly as possible, as all feedback would be anonymous.

To increase the validity of the data, the survey was distributed using the double-blind method. Each individual—including Space Grant managers and survey participants—was informed that the research goal was to investigate students' general experiences on STEM teams and was not informed of the sub-research goal of investigating gender dynamics. By using the double-blind method, the author was able to eliminate bias that may have influenced responses.

The survey's data collection window was selected for April 1, 2022 to April 20, 2022—specifically at the end of the academic year. By waiting until April, the survey gathered rich feedback from students, as they would have more experiences to share. This information would better reflect students' year-long understandings, responsibilities, and perceptions about the team processes. Data was analyzed following the close of the survey with SPSS software.

IV. RESULTS

Using the SPSS software platform, descriptive statistics explored the demographics of survey respondents. A chi-square test of independence was conducted to examine if there was a difference between gender and technical task distribution and leadership (Q7). The chi-square test was also used to reveal if there was a relationship between gender and students' levels of motivation, self-efficacy, and a sense of belonging (Q9-Q12; Q15-25). Statistical significance was set as $p < .05$ for all analysis. Two open response questions (Q13 and Q14) enabled respondents to provide data on the topic of recruitment, as well as a final open response question (Q26) for unsolicited feedback.

Managers at 17 of the 52 consortia (32.7%) confirmed that they forwarded the survey to their Space Grant-funded college students. This helped increase trustworthiness and validate the study. Despite the fact that all student participants were recipients of Space Grant team funding, 27.5% of students responded that they did not receive or were unsure if they received Space Grant funding.

RQ1: Survey Participants

Out of the 239 individuals who consented to complete the survey, 68.53% identified as male, 28.45% as female, and 2.16% as nonbinary. Less than one percent of students did not wish to disclose their gender. The most frequent ethnicities of the students were: White (68.53%), Asian (12.93%), and Hispanic or Latinx or Spanish Origin (9.48%). The majority of participants were undergraduate seniors (40.17%), followed by undergraduate juniors (23.43%). There were only six graduate student participants (2.51%). Table 2 shows the full academic and demographic backgrounds of survey participants.

The majority of students (52.2%) were raised in a household with no parent or guardian working in a STEM field. However, nearly all of the students (98%) were pursuing a STEM degree. The students who were not majoring in STEM identified as female (n=2) and nonbinary (n=2) and they were studying: Women and Gender Studies, English and Foreign Languages, Business, History, and Graphic Communications. A chi-square analysis revealed that the relationship of gender and the decision to study STEM vs. non-STEM was statistically significant, X^2 (1, N = 230) = 4.7, p = .03. Fewer female students were studying STEM fields.

Two hundred and five respondents participated in engineering-focused team-based learning programs. Of the 205, 57.1% participated in general engineering design programs, 34.1% participated in high powered rocketry programs, and 8.8% participated in high altitude ballooning programs.

Table 1

Academic and gender distribution of survey participants.

	Female Participants		Male Participants		Nonbinary Participants		Do not wish to disclose		Total	
	n	%	n	%	n	%	n	%	n	%
First years	10	15.15%	18	11.32%	2	40%	--	--	30	12.55%
Sophomores	15	22.73%	27	16.98%	--	--	--	--	42	17.57%
Juniors	13	19.70%	41	25.79%	1	20%	1	0.11%	56	23.43%
Seniors	26	39.39%	67	42.14%	2	40%	1	0.11%	96	40.17%
Graduate: Masters	2	3.03%	3	1.89%	--	--	--	--	5	2.09%
Graduate: Doctoral	--	--	1	0.63%	--	--	--	--	1	0.42%
Do not wish to Disclose	--	--	2	1.26%			7	0.78%	9	3.77%
Sub-total	66	100%	159	100%	5	100%	9	100%	239	100%
Total					239					

RQ2: Gender and Constructs of Motivation, Self-efficacy, and Inclusion

Table 3 shows questions related to students' levels of motivation, assorted by gender. For all questions, there was no direct relationship between gender and motivation. The lowest ranking score was question 11 ("Because I am supposed to do it"), with 59.6% of females (M = 4.7, SD = 1.5) and 52.9% of males (M = 2.8, 1.5) indicating some form of agreement.

Table 4 shows questions related to self-efficacy, assorted by gender. All STEM team members had a strong sense of self-efficacy and responded with some form of agreement. There was a significant relationship between female and male students for question 24 ("I can effectively coordinate tasks and activities of a group"), X^2 (3, N = 192) = 12.9, *p* = .005. Female students were more likely to feel confident enough to coordinate tasks and activities of a group.

Table 3

Motivation: Percentage of Some Form of Agreement, Mean, and Standard Deviation (strongly disagree = 1, strongly agree = 6)

Question Number	Question	% Some form of Agreement	M	SD	% Some form of Agreement	M	SD
		Female			Male		
Q9	Because I think this activity is fun	100	5.6	0.6	100	5.6	0.6
Q10	Because I am doing it for my own good	100	5.4	0.7	95	5.2	1
Q11	Because I am supposed to do it	40.4	2.9	1.5	47.1	3.2	1.5
Q12(r)	There may be good reasons to do this activity, but personally I don't see any	0	1.3	0.6	8.6	1.6	1

Table 4

Self-Efficacy: Percentage of Some Form of Agreement, Mean, and Standard Deviation (strongly disagree = 1, strongly agree = 6)

Question Number	Question	% Some form of Agreement	M	SD	% Some form of Agreement	M	SD
		Female			Male		
Q22	I can work very effectively in a group setting	98.2	5.5	0.7	99.3	5.4	0.7
Q23	I can contribute valuable insight to a team project	100	5.5	0.6	99.3	5.5	0.7
Q24	I can effectively coordinate tasks and activities of a group*	98.2	5.6	0.6	98.5	5.2	0.7
Q25(r)	I do not feel like I can take on a leadership role in a group and be effective	9.1	1.9	1.1	12.4	2.1	1.3

Table 5 shows questions related to students' sense of belonging, assorted by gender. The lowest ranking score was for question 17, which had 66.7% of female respondents indicating some form of agreement (M = 3.4, SD = 1.5). There was a significant relationship between female and male students for questions 16, 17, and 18. Female students were less likely to feel like they belonged to the STEM community, X^2 (5, N = 196) = 10.7, p = .05; more likely to feel like an outsider, X^2 (5, N = 196) = 11.8, p = .04; and less likely to feel respected, X^2 (5, N = 196) = 17.1, p = .004.

Table 5

Sense of Belonging: Percentage of Some Form of Agreement, Mean, and Standard Deviation (strongly disagree = 1, strongly agree = 6)

Question Number	Question	% Some form of Agreement	M	SD	% Some form of Agreement	M	SD
		Female			Male		
Q15	I feel like a member of this team	98.2	5.5	0.9	99.3	5.6	0.6
Q16	I feel like I belong to the STEM community*	94.7	5.3	0.9	98.6	5.6	0.8
Q17(r)	I feel like an outsider*	33.3	2.6	1.5	15.8	2	1.2
Q18	I feel respected*	89.5	4.8	1.3	95.7	5.1	0.8
Q19(r)	I feel disregarded	16.1	2.2	1.3	10.1	1.9	1
Q20	I feel valued	89.5	4.8	1.0	96.4	5.1	0.9
Q21(r)	I feel excluded	14	2.9	1.2	7.2	1.8	1

RQ3: Relationships Between Gender and Technical Education Experiences

A chi-square test of independence was performed to determine if there were differences between gender and the distribution of technical tasks. The relation between these variables was significant, X^2 (1, N = 203) = 7.8, p = .005. Female students were less likely than male students to conduct technical STEM tasks.

V. DISCUSSION

The purpose of this study was to explore students' experiences as they participated on collegiate STEM teams, investigating how factors in the micro-levels of the socio-ecological system impact individual students' learning outcomes. Descriptive statistics were used to examine the demographics of collegiate STEM teams, assessing the gender distribution of the sample. Chi-square tests investigated 1) students' levels of motivation, self-efficacy, and belongingness, assessing if there was a difference between the expected and observed frequencies of gender distributions and 2) the distribution of technical and non-technical tasks, also assessing if there was a difference in the expected and observed frequencies of gender distributions. The sample population for all three research questions consisted entirely of Space Grant-funded college students, and thus, the findings directly impact the Space Grant community.

The implication for the Space Grant community is clear: the Space Grant network is financially supporting students in STEM environments that are not equitable for all learners. Although one of Space Grant's main objectives is to support a diverse student body, the team-based demographics were consistent with national STEM reports: mostly White, male, engineering majors who were more likely to lead technical tasks than their female counterparts. The survey data were representative of gender distributions found in national STEM databases, strengthening the validity of the conclusions (NSF, 2022). The distribution of students' ethnicities in engineering and science fields also closely aligned with the top three ethnicities found in federal STEM reporting databases: 1) White, 2) Asian, and 3) Hispanic (NSF, 2022). These findings were authentic to Space Grant, as the survey tool was distributed to all fifty-two consortia, reaching a widespread geographical distribution of student participants from all around the country. The data collection was also strengthened by a validation from the Space Grant managers, where 33% of consortia provided verbal or written confirmation that the survey tool was forwarded to Space Grant-funded students.

Space Grant has goals to recruit diverse student participants, and this study helps highlight areas where recruiting improvements can be made (NASA Space Grant, 2022). One-third of the survey participants reported that they were recruited to join their team activities by an instructor or professor. Further analysis shows that most survey participants were senior engineering majors, so it can be inferred that the "instructors or professors" who recruited the students instructed the engineering or science courses, such as required senior capstone courses. If STEM fields are to diversify, recruitment for hands-on learning programs must expand outside STEM classrooms, which already lack underrepresented student populations.

Space Grant can also help improve the communication pathway between program administrators, team leaders, and student participants. Twenty-eight percent of student participants reported that they did not receive Space Grant funding or that they were not sure if they were recipients. It is highly likely that every student was supported by Space Grant funds due to the purposive sampling methods of the survey tool and distribution confirmations from the Space Grant managers. The students' unawareness highlights the miscommunication between team leaders and the student body. If the students were unaware where their funding originated, it can be assumed that they were not fully aware that they were stewards of federal funds or that they represented NASA. Therefore, it remains uncertain if students were knowledgeable of Space Grant's DEI objectives, or by extension, NASA's DEI goals. Without guidance from policy, encouragement from mentors, or knowledge of higher-level DEI goals, students may not necessarily pursue more equitable recruitment strategies or diversify task distribution on their own.

Space Grant managers can also benefit from learning about their funded students' levels of motivation, self-efficacy, and a sense of belonging. Contrary to the hypothesis for the second research question, female students were statistically just as likely to feel motivated on their STEM team as the male students. The majority of female participants were undergraduate seniors; these seniors completed the survey in April of 2022, weeks before a traditional graduation date for a four-year program of study. The proximity to graduation suggests that these female undergraduates were motivated enough to stay in the program, successfully navigating through the undergraduate STEM pathway. This finding supports the discussion by Faulkner (2007), who suggests many female students thrive in the "masculine fields" not because they got "left there" but instead, have adopted a technicist identity. These female students enter the STEM fields with a strong sense of motivation, passionate about the "nuts-and-bolts" work, and willing to drop their feminine identities to assimilate into the masculine STEM culture (Faulkner, 2007).

Although levels of students' motivation reached parity between genders, issues regarding motivation remain an area of concern for Space Grant policymakers: the gender disparities are not a result of individual students' lack of motivation, but the larger societal system that supports institutionalized barriers and reinforces systematic inequalities. If female students are equally as motivated as the male students, why are female students less likely to lead the technical tasks? It is important to note that the majority of female students were enrolled as engineering or science majors, similar to their male counterparts. Any disparities between genders is not a result of the female students belonging to non-STEM fields.

The gender disparity of technical tasks is an issue relevant to all Space Grant managers. The Space Grant consortia continue to financially support STEM learning environments where female students are less likely to lead technical tasks. This finding is reinforced by the literature, adding to the body of evidence that shows female students are deprived of technical experiences, ultimately disadvantaging them as they enter the STEM workforce (Trevelyan, 2019; Bornasal et al., 2018; Seron et al., 2018; Faulkner, 2007). These gendered dualities show the inequitable distribution of technical tasks for female and male students.

As hypothesized, there were multiple survey items that suggest individual female students have differing levels of self-efficacy and a lower sense of belonging to the STEM community. First, female students were more likely to feel like they could coordinate tasks and activities of a group than male students. This finding reflects how women are more likely to conduct gender-affirming social roles, such as administrative and coordination tasks (Eagly & Sczesny, 2019; Faulkner, 2011; Eagly, 1987). Second, female students were less likely to feel like a member of the STEM community, less likely to feel valued, and less likely to feel respected. In addition, female students are more likely to feel like an outsider. These findings are important because the female team members are perceiving their STEM environments as chilly and unwelcoming, an arena where they feel like they do not belong (Parson, 2018). Ultimately, Space Grant managers must reassess how their funds continue to reinforce team learning environments that offer a less welcoming learning environment for female students.

Space Grant is one policy-making system that supports student participation in these inequitable TBL settings. Each Space Grant consortium should determine how gender DEI strategies fit into their programming, addressing future solicitations, student team operations, and student learning outcomes. Steps can be taken to help encourage students to address gender inequality as active members in the field. As the National Academies (2022) conclude, "diversifying the full STEM workforce will take a major national effort." Space Grant is one network that can lead this national effort.

The inequitable learning outcomes found in STEM teams directly affects the Space Grant program. Students are a financial investment, and a nationwide program can influence the quality of the future STEM workforce. Additionally, the findings are also important for NASA, and in particular, the Office of STEM Engagement. The college students involved on these teams were stewards of federal funds and many represented NASA's mission and vision towards an equitable and inclusive learning environment. The findings provide a reliable snapshot of the inequalities found in 2022.

VII. LIMITATIONS

Conducted in the midst of an ongoing global health crisis, this study was limited by external factors that may have affected students' comfort levels of working together in physical groups. There may have been fewer students participating in group-based settings and participating on college teams than in past years, which is dependent on future research. Many NASA-facilitated programs were postponed or canceled during the 2020-2022 timeframe and many students may not have felt comfortable joining active programs due to health concerns.

The study was limited to the extent that all survey participants responded honestly and accurately, and assumed these students were familiar with their teams' tasks and operations well enough that they were familiar with the questions found within the survey instrument.

VII. CONCLUSION

The purpose of this study was to investigate differences between female and male students' experiences while they participated on a 2021-2022 STEM team. After surveying Space Grant-funded college student team members, many gender disparities were revealed. First, the demographics of these STEM teams reflect the national STEM reports: the majority of participants were White male engineering majors. As the minority group, female students were less likely to lead team tasks that required technical skill sets, however there was no statistical difference between female and male students' motivation levels. Female students were also statistically more likely to feel like they could effectively coordinate tasks and activities of a group. It was also determined that female students were less likely to feel that they were a member of the STEM community, less likely to feel valued, and more likely to feel like an outsider. Drawing on social role theory, this study offered an explanation for why gender traits influence the distribution of technical tasks.

Despite national charges to increase the number of female students in STEM fields, this study shows the quality of the female students' learning experiences differs from male students. The implication of these gender disparities directly affects the national Space Grant community, including program managers and future Space Grant students. As a workforce development program, Space Grant spends millions of dollars every year to expand authentic STEM engagement opportunities for college students to prepare them for the STEM workforce. Space Grant educators can use the findings of this study to revisit their programming, address the systematic barriers their students may be facing, enhance mentorship training, and ensure female students receive equitable learning experiences while participating on STEM teams. By implementing more equitable policies in these learning spaces, the Space Grant network has the power to increase the diversity, equity, inclusivity, and strength of the future American STEM workforce.

Future research goals and recommendations include conducting an ethnographic study to longitudinally observe students from a single STEM team, observing workshop sessions, student dynamics, and competition performances. Using the Delphi method, interviews of TBL mentors, advisors, and faculty would explore educators' perceptions on STEM TBL and gender DEI.

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CONCLUSION

The purposes of this study were to: (a) investigate how well STEM team-based programs' recruitment documentation integrates gender diversity, equity, and inclusivity (DEI) into their programmatic frameworks and (b) to investigate how gender influences students' technical experiences, motivation, levels of self-efficacy, and sense of belonging. Guided by the SEM, two studies addressed the macro- and micro-levels of the STEM pathway, exploring how STEM policy may impact the individual team members' learning outcomes and experiences. This research concludes with recommendations and actionable steps for STEM leaders to promote gender DEI in their future programming.

By integrating the findings from both the qualitative (macro-level of the SEM) and quantitative (micro-level of the SEM) studies, this research showed that there is a lack of gender DEI support within STEM team programming. Female students continue to receive inequitable technical education that makes them less prepared for the technical STEM workforce. Study 1 investigated STEM programs' recruitment documents, assessing the levels of female representation and investigating how gender DEI is embedded in its framework. Overall, the findings showed the majority of recruitment documentation did include gender neutral or female-inclusive terminology, but failed to integrate gender DEI into students' directives or learning objectives. The female-inclusive terminology acknowledged female participation through the use of binary (he/she) pronouns, gender neutral pronouns ("they"), and gender neutral roles (i.e. "flagperson" as compared to "flagman"). More than 80% of the documents that scored a Stage 0 classification did include female representation in its imagery. Among many benign explanations, female representation may be explained by the concept of counterfeit diversity: where programs project a higher percentage of female participation than in actuality as a strategy to recruit more women.

The findings also showed that there were very few programs that promoted equitable student learning outcomes. Only three STEM programs directed student teams to consider and integrate DEI into specific tasks. All other programs allowed students to select their own roles—technical or non-technical—without DEI-inspired guidance from the policy managers. By not encouraging female participation in technical tasks—which are traditionally male-dominated roles—female students will continue to lack technical training.

The findings from Study 1 directly correlated to students' experiences and technical training, as shown in Study 2. The purpose of Study 2 was to explore the quality of students' experiences as they participated in the same collegiate STEM programs presented in Study 1. It was expected to see team-based demographics consistent with national STEM reports: undergraduate seniors who were White, male, and engineering majors who were more likely to lead technical tasks than their female counterparts. Although female students reported similar motivation levels as the male students, they were less likely to 1) feel respected and 2) feel like they belonged to the STEM community. In addition, female students were more likely to 3) feel like an outsider and 4) like they could effectively coordinate tasks and activities of a group. These findings support social role theory, providing evidence that in 2022, female students continue to conduct gender-affirming non-technical roles across the nation.

Both studies highlighted how inequitable programming affects the individual STEM learner. At the policy level, recruitment documents that guide STEM students along the STEM project life cycle failed to convey the significance of integrating gender DEI. Without encouraging and reinforcing equitable participation, teams will continue to remain male-dominated, sustaining the status quo in STEM. At the individual level, Study 2 suggested that female students will continue to conduct the non-technical roles, which is consistent with the larger issues surrounding social roles and gender disparities in STEM. The findings emphasized the importance of DEI at both the policy and individual levels in order to increase equitable learning outcomes.

In order to improve the STEM culture and female students' experiences, educators must reflect on how gender DEI policy can create a solid foundation to positively affect students' experiences. As seen in the findings, the National Space Grant program should consider additional strategies to help produce female graduates that have equal levels of technical education as the male graduates. With inequitable training, female students are less prepared as they enter the STEM workforce, which fails to reach its full potential until systems of inequalities are addressed throughout the STEM pathway.

Recommendations

National programs and policymakers have the ability to be agents of change and introduce incremental changes that improve students' STEM experiences. The following recommendations describe initial strategies that policymakers, educators, and program facilitators can integrate into their programming to build capacity and introduce equitable and inclusive STEM programming.

Lead from the top

As outlined in the SEM, policymakers have the power to affect change that influences communities, institutions, and individual learners. Policymakers should make changes that influence the STEM culture, rather than targeting individual students (Moss-Racusin, 2021). Policymakers should also assess whether their programs' current strategic goals integrate gender DEI effectively and work towards enhancing existing plans to meet these objectives.

Policymakers should reflect on how their public-facing documentation conveys a sense of belonging, inclusiveness, and diversity, reflective of the community they engage (Harvard, 2020).

Implement and publicize institutional gender-inclusive policies

As advised by Cech & Blair-Loy (2014), evidence-based policy should be designed to be "opt-out (rather than opt-in)" to normalize the gender-inclusive policy and guard it against stigma. Detailing evidence-based DEI commitment statements—which are not required by law or university policies—publically highlight the program values these goals (Harvard, 2020). While setting gender DEI goals, policymakers should outline specific, measurable, attainable, relevant, and time-bound (SMART) metrics (Lawlor, 2012).

Be wary against gender bias

Administrators should examine their current recruitment methods and implement strategies that foster welcoming and safe environments for diverse students. Document creators should assess products for language that conveys masculine STEM culture and gender-exclusive language, as these systematically deter female applicants (Stout & Dasgupta, 2011). Leaders should reflect on the imagery and language used to market and recruit student participants. Networks will not diversify through intrinsically biased word-of-mouth advertisements, which rely on a narrow network (Zych, 2020). Program leaders should remain cognizant of injunctification—remaining complacent with the status quo—which perpetuates the constant gender statistics in STEM (Gaucher, 2011). Recruitment strategies should be made with intentionality, considering the impact of female representation of faculty mentors, recruiting students from additional STEM fields, and researching their institutions' minority serving organizations and resource centers.

Set goals within the institution

Program administrators should identify their strengths and weaknesses, identify whose voices are omitted from the discussion, and set long-term and short-term goals to create an environment conducive to DEI. Professional development (PD) workshops and resources help train faculty, students, and staff on the benefits of having diverse teams. PD opportunities educate all members about the detrimental effects of microaggressions, implicit biases, and gaslighting. Female mentorship programs can be beneficial if the faculty mentors are financially rewarded for their time and their workloads are respected (Moss-Racusin, 2021).

Suggested Actions for Space Grant Programs

Collegiate student team members may approach their local Space Grant Consortium and competitively apply for funding to participate in a STEM competition. It is in the best interest of the Space Grant Consortium to become familiar with the STEM program's own DEI goals.

Professional Development for Students

Encourage student teams to participate in DEI professional development training. Many higher education institutions facilitate their own training. Space Grant managers could invite their student leaders to these workshops.

SMART Goals

Space Grant managers can introduce their own DEI-focused questions in the TBL program application, requiring responses with SMART goals.

Incentivize DEI

Space Grant managers can introduce a multi-tiered funding opportunity for teams who introduce DEI recruitment strategies. Regardless if the national STEM challenges introduce their own DEI objectives, each Space Grant can foster more equitable recruitment strategies and engagements seen at their own home institutions.

Increase communication

Almost one-third of Space Grant-funded students (in Study 2) reported that they "did not" or "were unsure" that they received Space Grant support. This revealed a lack of communication, due to the purposive sampling method. Space Grant managers can set up an orientation meeting with all funded teams, conveying the goals and objectives of Space Grant, grant deliverables, and DEI expectations to strengthen communication.

Assessing STEM Programs

Using the findings from this research, a checklist with programmatic assessments was formed to help program managers broadly assess their own STEM programs and consider strategies to advance to a higher Stage (see Figure 5). These benchmarks are fluid and offer guidance on how to continuously improve student learning outcomes and integrate gender DEI.

Figure 5

Programmatic Self-Assessment Checklist

Stage 0: Start Up

- ☐ The program provides participants with student-centric documentation, handbooks, or programmatic guidelines that identify student learning outcomes and directives.
- ☐ The program uses at least one referral to male-specific terminology such as "flagman" or "he/him" when referencing student participants.

Stage 1: Emerging

- ☐ The program provides verbiage that welcomes all learners to join the program, such as "we strongly encourage underrepresented students" and/or "female students to participate."
- ☐ The program acknowledges the participation of non-male genders in its documentation, such as *she, her, hers, they, them,* or *theirs.*

Stage 2: Developing

- ☐ The program integrates gender DEI in the final assessment/judging criteria.
- ☐ The program rewards teams that engage multiple genders in a technical task.
- ☐ The program offers waivers to teams that do not satisfy the gender DEI goals.

Stage 3: Transforming

- ☐ The program has fully embedded gender DEI into its solicitations, requiring teams to elaborate on their gender inclusive recruitment strategies, retention goals, and other practices.
- ☐ The program penalizes teams that fail to acknowledge gender DEI

Programs that wish to progress through the Stages should consider how the above recommendations best fit their own programming. Programs should be willing to assess where they can improve, close the feedback loop, and reevaluate how to enhance students' learning.

Conflict of Interest Statement

The author is employed with the North Dakota Space Grant Consortium (NDSGC), the program that is sponsoring nine ND collegiate teams during the 2021-2022 academic year. All of the North Dakota students involved on a collegiate team would be eligible to complete this study's survey. As one of three team members who review the team applications each November, the author acknowledges that she helps evaluate applications, providing input on which teams should be awarded funding. Once the review panel makes a funding decision, the author's role in the team programming concludes. The NDSGC Coordinator is the NDSGC competition team project manager, and this individual conducts all communications and day-to-day operations with the ND teams. The author does not interact with any of the student team members throughout the academic year. If a situation arose during the timeframe of this research, she recused herself from any direct interactions with the student team members, and worked with the NDSGC team to handle the situation to avoid bias and conflict.

In order to invite North Dakota students to participate, the author removed herself from the recruitment process as much as possible. The author forwarded the email with the study's survey to the ND Space Grant director and coordinator, addressing them like any other consortium's management team. After receiving the request, the director and coordinator decided which ND teams would be eligible to participate in the survey (without any input from the author) and forwarded the email to the student leads. Throughout the year, if any team lead or faculty mentor emailed the author, she forwarded their message to the Program Coordinator, removing herself from the conversation.

As mentioned in the consent form, all students were made aware that their involvement would be completely voluntary and their decision would never reflect back on their sponsorship if they choose to decline participation. All participation—including student participation from North Dakota—remained 100% anonymous. None of the students' data was connected to their identities.

Additionally, one member of the author's dissertation committee is a director of a Space Grant consortium. In order to keep the second study a double-blind experiment, the author emailed the survey to the committee member's colleagues, because this committee member would know of the gender-focused sub-research goals.

Career Research post-Dissertation

Future research for the author may include continued explorations of how gender DEI impacts the Space Grant students, alumni, and program managers. To investigate individuals' experiences on STEM teams, interviews of nationwide students would help the Space Grant community learn how to better serve its students. To learn how to better serve North Dakota Space Grant students, an ethnographic study conducted over an entire academic year, consisting of observations of meetings, workshop sessions, and launches could be completed. This research could focus on enhancing student retention, group dynamics, and task distribution. Using the Delphi method, future interviews of faculty team mentors could help illuminate the important relationship between mentors, mentees, and role models. Faculty member's DEI expectations, beliefs, and actions could be investigated, exploring perceptions on recruitment, experiences, and retention. Alternatively, interviewing or surveying Space Grant alumni who have entered the STEM workforce could help highlight important transition periods of students' lives.

Appendix A

IRB Approval

Tuesday, March 22, 2022 at 22:19:54 Central Daylight Time

Subject: UND IRB Approval Letter for Exempt Protocol
Date: Monday, March 21, 2022 at 4:42:56 PM Central Daylight Time
From: no-reply@erac.und.edu
To: Pearson, Donna
CC: Saad, Marissa

UND UNIVERSITY OF NORTH DAKOTA UND.edu

Division of Research & Economic Development
Office of Research Compliance & Ethics

Principal Investigator: Donna Kay Pearson
Protocol Title: Investigating students' experiences within team-based learning (TBL) environments
Protocol Number: IRB0004395
Protocol Review Level: Exempt 2
Approval Date: 03/21/2022
Expiration Date: 03/20/2025

The application form and all included documentation for the above-referenced project have been reviewed and approved via the procedures of the University of North Dakota Institutional Review Board.

If you need to make changes to your research, you must submit an amendment to the IRB for review and approval. No changes to approved research may take place without prior IRB approval.

This project has been approved for 3 years, as permitted by UND IRB policies for exempt research. You have approval for this project through the above-listed expiration date. When this research is completed, please submit a termination request to the IRB.

Sincerely,

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Appendix B

Assessment Tool for Study 1

Stage 0 = Start Up: the STEM program does not define any gender DEI strategies nor make them a priority; There is no gender diverse or gender neutral terminology used within the resources. Programs are at the beginning of their DEI journey.

Stage 1 = Emerging: the STEM program is beginning to integrate gender DEI terminology into its documentation, acknowledging diverse learners. The program lacks gender DEI strategic goals.

Stage 2 = Developing: the STEM program is developing efforts to integrate gender DEI into its strategic goals by providing measurable DEI objectives. Some gender diverse terminology is used.

Stage 3 = Transforming: the STEM program has institutionalized DEI into its strategic goals with specific, measurable, achievable, realistic, and time-bound (SMART) objectives. Many gender diverse terminologies are used in program documentation.

(Adapted from Nerche (2017) and Harvard (2020))

Appendix C

Survey Tool for Study 2

Study on Team Experiences - 2022

Start of Block: Default Question Block

Q2 **Survey Consent Form**

Please read the following information and then indicate whether you consent to this survey. Thank you!
Title of Project: Investigating students' experiences within team-based learning (TBL) environments
Principal Investigator: Marissa Saad, marissa.saad@und.edu
Advisor: Dr. Donna Pearson, 701-77-2861, donna.pearson@und.edu

Purpose of the Study: The purpose of this study is to investigate college students' experiences during their time as a team member within a science, technology, engineering, and math (STEM) team-based learning (TBL) environment. A quantitative approach will be taken to measure if different dynamics or other demographics influence students' role assignments, specifically the distribution of technical or non-technical tasks. In addition to exploring students' levels of technical education on these teams, this study will explore students' motivations for joining their STEM team, levels of self-efficacy, and sense of belonging.

Procedures to be followed: You will be given one online survey using the Qualtrics web service. You will be asked to honestly answer 37 questions. These questions are all anonymous and will not be linked to any personal identifying information.

Risks: There are no risks in participating in this research beyond those experienced in everyday life.

Benefits:

- This research might provide STEM program administrators a clearer view and new perspective into students' experiences on a STEM team, providing them with recommendations and context, impacting positive change for future students.
- This research might influence the way technical education is facilitated within team environments, allowing students (regardless of experience levels and identities) to engage in hands-on learning.

Duration: This survey should take between 5-10 minutes.

Statement of Confidentiality: This study is 100% confidential. We will never link any personal or identifying information back to your survey responses. All your responses will be recorded anonymously. If this research is published, no information that would identify you will be included since your name is in no way linked to your responses.

All survey responses that we receive will be treated confidentially and stored on a secure server. However, given that the surveys can be completed from any computer (e.g., personal, work, school), we are unable to guarantee the security of the computer on which you choose to enter your responses. As a participant in our study, we want you to be aware that certain "key logging" software programs exist that can be used to track or capture data that you enter and/or websites that you visit.

Right to Ask Questions: The researchers conducting this study are Marissa Saad and her advisor, Dr. Donna Pearson. You may ask any questions you have now through email (marissa.saad@und.edu). If you later have questions, concerns, or complaints about the research please contact Ms. Saad (701-777-4161) during the day, or Dr. Pearson (701-77-2861).

If you have questions regarding your rights as a research subject, you may contact The University of North Dakota Institutional Review Board at (701) 777-4279 or UND.irb@UND.edu. You may contact the UND IRB with problems, complaints, or concerns about the research. Please contact the UND IRB if you cannot reach research staff, or you wish to talk with someone who is an informed individual who is independent of the research team.

General information about being a research subject can be found on the Institutional Review Board website "Information for Research Participants"
http://und.edu/research/resources/human-subjects/research-participants.html

Compensation: You will not receive compensation for your participation.

Voluntary Participation: You do not have to participate in this research. You can stop your participation at any time. You may refuse to participate or choose to discontinue participation at any time without losing any benefits to which you are otherwise entitled.

You do not have to answer any questions you do not want to answer. You must be 18 years of age older to participate in this research study.

Completion and return of the online survey implies that you have read the information in this form and consent to participate in the research. Thank you!

Please indicate whether you consent to this study:

O Yes, I consent to take this survey (1)

O No, I do not consent to take this survey (2)

Skip To: End of Survey If Please indicate whether you consent to this study: = No, I do not consent to take this survey

Page Break

Q1 **Your gender identity**

- O Female (1)
- O Male (2)
- O Non-binary (3)
- O Other (4)
- O Do not wish to disclose (5)

Q2 **Your ethnicity identity**

- O Alaskan Native (1)
- O American Indian or Native American (2)
- O Asian (3)
- O Black or African American (4)
- O Hispanic or Latinx or Spanish Origin (5)
- O Middle Eastern or North African (6)
- O Multiracial American (7)
- O Native Hawaiian or Other Pacific Islander (8)
- O White (9)
- O Other (10)

O Prefer not to say (11)

Q3 Your **year** in school:

O First Year (1)

O Sophomore (2)

O Junior (3)

O Senior (4)

O Masters student (5)

O Doctoral student (6)

O Alumni (8)

O Other (7)

Display This Question:

If Your year in school: = Other

Q3a If other, please describe your year in school:

____

Q4 Please select your **major(s):**

▢ Aerospace: Aviation Fields (31)

- ☐ Aerospace: Space Studies (35)
- ☐ Aerospace: Unmanned Aerial Systems (34)
- ☐ Agriculture and Natural Resource Conservation (1)
- ☐ Architecture (6)
- ☐ Area, Ethnic, and Multidisciplinary Studies (7)
- ☐ Arts: Visual and Performing (8)
- ☐ Business (9)
- ☐ Communications (10)
- ☐ Community, Family, and Personal Services (11)
- ☐ Computer Science (12)
- ☐ Criminal Justice (40)
- ☐ Economics (44)
- ☐ Education (4)
- ☐ Engineering: Mechanical (2)
- ☐ Engineering: Bioengineering & Biosystems (21)
- ☐ Engineering: Civil (30)
- ☐ Engineering: Chemical (22)

- [ ] Engineering: Electrical (27)
- [ ] Engineering: Industrial (23)
- [ ] Engineering: Material Science (24)
- [ ] Engineering: Mining (25)
- [ ] Engineering: Petroleum (26)
- [ ] Engineering: Other (28)
- [ ] English and Foreign Languages (3)
- [ ] Forensic Science (47)
- [ ] Graphic Design (52)
- [ ] Health Administration & Assisting (14)
- [ ] Health Science and Technologies (15)
- [ ] History (53)
- [ ] Kinesiology (54)
- [ ] Mathematics (13)
- [ ] Music (56)
- [ ] Philosophy, Religion, & Theology (16)
- [ ] Psychology (51)

- [ ] Public Affairs (57)
- [ ] Repair, Production, & Construction (17)
- [ ] Sciences: Astronomy (36)
- [ ] Sciences: Atmospheric (38)
- [ ] Sciences: Biology (5)
- [ ] Sciences: Chemistry (39)
- [ ] Sciences: Data (43)
- [ ] Sciences: Environmental (45)
- [ ] Sciences: Geography (49)
- [ ] Sciences: Geology (50)
- [ ] Sciences: Medical Laboratory (55)
- [ ] Sciences: Physics/Astrophysics (37)
- [ ] Social Sciences & Law (18)
- [ ] Undecided (48)
- [ ] Visual Arts (59)
- [ ] Women and Gender Studies (60)

▢ Other (please provide your major in the textbox) (19) ____

Q4b If other, please list your major:

____

Q5 Growing up, did you live with a **parent or guardian** who worked in a STEM field (science, technology, engineering, or math)?

O Yes, I lived with someone in a STEM field (1)

O No, I did not live with someone in a STEM field (2)

Page Break

Q37 If you are involved in more than one team, please select ONLY ONE for the remainder of this survey. After finishing the survey, you are welcome to click the link again and provide responses for each additional team.

Q6 Your team affiliation:

O Big Idea Challenge (1)

O First Nations Launch (7)

O High Altitude Balloon Launch Teams (8)

O Micro-G Neutral Buoyancy Experiment Design Teams (6)

O NASA Human Exploration Rover Challenge (3)

O NASA Student Launch (rocketry) (2)

O Robotic Mining Competition: Lunabotics (5)

O SUITS: Spacesuit User Interface Technologies for Students (4)

O Other (please type in your program's name): (9)
____

Q6a How many students are on your team?

O 1-5 (1)

O 6-10 (4)

O 11-15 (2)

O 16-20 (3)

O 21-30 (5)

O 31-40 (6)

O 41+ (7)

Q6b Was your team funded by a **Space Grant Consortium?**

O Yes, we received Space Grant funds (1)

O No, we did not receive Space Grant funds (2)

O I am not sure if we received Space Grant funds (3)

Q7 How would you describe your **primary responsibility** on the team?

O Architectural/Design (blueprints, layouts, planning, etc.) (2)

O Management (writing reports, organizing schedules, people, and timelines, etc.) (8)

O Marketing (making presentations, gathering sponsors, etc.) (4)

O Mechanical (using hands-on tools, tinkering with nuts and bolts, constructing something physical, etc.) (7)

O Outreach/STEM Engagements (K-12 involvement, informal education, etc.) (5)

O Social (social media, photography, advertisement, etc.) (1)

O Software (coding, programming, etc.) (3)

O Other (6) ________________________

Q8 How did you hear about the opportunity to join your team?

O An instructor or professor (1)

O A student (2)

O A friend (3)

O Social media advertising (4)

O Formal class setting (5)

O Academic club or group (6)

O Other (7) ________________

Page Break

Q9 Please answer the following questions based on your level of agreement:

Q9
What motivated you to join this team?

	Strongly agree (6)	Agree (5)	Somewhat agree (4)	Somewhat Disagree (3)	Disagree (2)	Strongly Disagree (1)
Because I think this activity is fun (2)	O	O	O	O	O	O
Because I am doing it for my own good (6)	O	O	O	O	O	O
Because I am supposed to do it (8)	O	O	O	O	O	O
There may be good reasons to do this activity, but personally I don't see any (10)	O	O	O	O	O	O

Q13 How did your team **recruit** its student team members?

____

____

____

Q14 Do you have any **recommendations for other teams** as they decide how to recruit their own team members?

____

____

Page Break

Q15
Please rate your level of agreement with the following statements:

	Strongly agree (6)	Agree (5)	Somewhat agree (4)	Somewhat disagree (3)	Disagree (2)	Strongly disagree (1)
I feel like a member of this team (1)	o	o	o	o	o	o
I feel that I belong to the STEM community (5)	o	o	o	o	o	o
I feel like an outsider (6)	o	o	o	o	o	o
I feel respected (8)	o	o	o	o	o	o
I feel disregarded (9)	o	o	o	o	o	o
I feel valued (10)	o	o	o	o	o	o
I feel excluded (11)	o	o	o	o	o	o

Page Break

Q22
Please rate your level of agreement with the following statements:

	Strongly agree (6)	Agree (5)	Somewhat agree (4)	Somewhat disagree (3)	Disagree (2)	Strongly disagree (1)
I can work very effectively in a group setting (1)	O	O	O	O	O	O
I can contribute valuable insight to a team project (10)	O	O	O	O	O	O
I can effectively coordinate tasks and activities of a group (3)	O	O	O	O	O	O
I do not feel I can take on a leadership role in a group and be effective (4)	O	O	O	O	O	O

Q26 If you have any other comments that were not addressed in the survey, please add them here:

____

____

End of Block: Default Question Block

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