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Female Students with Disabilities' Perceptions of Science, Technology, Engineering, Mathematics Education

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This is to certify that the doctoral dissertation by

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has been found to be complete and satisfactory in all respects,
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the review committee have been made.

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Walden University
2025

Abstract

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MPhil, Walden University, 2024

MA, Norwich University, 2019

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Dissertation Submitted in Partial Fulfillment

of the Requirements for the Degree of

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Abstract

The demand to increase enrollment in science, technology, engineering, and mathematics (STEM) education programs has intensified globally since the early 21st century. Researchers have concentrated on the gender divide with limited research on female students with disabilities (FSwDs). The purpose of this qualitative study was to explore FSwDs' perceptions of their successes and challenges with accessibility, inclusion, and support experienced in STEM education programs, as well as their recommendations for improving policies and practices in STEM higher education. The study was grounded in social identity and social learning theories. For this basic qualitative design, semistructured interviews were conducted with nine FSwDs who were engaged in STEM activities or enrolled in STEM education courses at three local colleges and had their disabilities on file with the institution. Axial coding produced the following four themes: 1) appreciation for fostering innovation and motivation, 2) dedication to growing better communication networks, 3) commitment to promoting enrichment and understanding, and 4) supporting structural enhancements. These results could lead to positive social change by enriching the learning environment and academic settings, by streamlining the communication between the disability department and STEM teachers, by strengthening the support services, and by making structural enhancements, such as updating the building infrastructure to accommodate accessible entry at all points of entrance. By providing FSwDs access to STEM education and supporting their academic success, a critical shortage of highly qualified workers in STEM fields can be addressed.

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Dedication

This dissertation is a testament to the combined efforts of many individuals. I extend my heartfelt dedication to everyone involved: colleagues, committee members, family, friends, fellow cohorts, and local colleges, community, and disability centers. Your contributions were integral to the success of this research. Each of you graciously accepted the successes and challenges encountered throughout the research design and development and gathered and collated the data. I am eternally grateful for all your kindness and support throughout this long and, at times, arduous process. Your contributions have made this research possible and enriched it with diverse perspectives and insights to improve the situation academically, personally, and professionally, for which I appreciate and value each of you deeply.

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Though a dissertation bears the name of a single candidate, the overall process that leads to its defense is a group effort accomplished in conjunction with the dedicated work of many more people. I wish to extend my profound appreciation to these people in this acknowledgment. Starting with my committee chair, Professor Dr. Ioan Gelu Ionas, for his unwavering support throughout this remarkable experience. He has the patience of a saint (for handling my unique brain well) and an intellect far beyond my wildest expectations. I also want to emphasize the crucial role of my second committee member, Professor Beate Baltes, and offer my heartfelt thanks. Your continued guidance and encouragement were invaluable during this incredible journey. You stepped in when the chips were down and prepared me for the challenge, so thank you.

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Chapter 1: Introduction to Study

Introduction

Researchers examine social problems to find solutions and achieve specific goals. Topics, such as those within academia, frequently raise concerns about equity in education. One example seen in reports from governmental agencies and nongovernmental organizations (NGOs) was the urgent call to expand science, technology, engineering, and mathematics (STEM) education in the United States because there is a shortage of STEM professionals (Okrent & Burke, 2021; Quirk, 2021). The deficiency of professionals in STEM fields is likely a result of continued high attrition, low enrollment, and low retention rates in STEM higher education courses at colleges around the country (Canaan & Mouganie, 2023; Khan et al., 2023; Rosenzweig et al., 2024). The National Science Foundation (NSF) and several governmental agencies argued that the shortcomings concern national security and future economic stability (National Science Board, 2022; Quirk, 2021). Improvements to STEM education are a top priority for remaining globally competitive in the present and future marketplace.

Paying direct and focused attention to the pressing reports from the U.S. Equal Employment Opportunity Commission (EEOC, n.d.; NSF, 2023; The U.S. Government Accountability Office [GAO], 2022) is essential, as the research suggested that several barriers prevent students from engaging in STEM education and thus pursuing STEM professions. The STEM higher education candidate pool lacks diversity and is inaccessible, exclusionary, and unwelcoming to several social in-groups, particularly females (National Center for Science and Engineering Statistics, 2023; U.S. Equal

Employment Opportunity Commission, 2023; U.S. Government Accountability Office, 2022). A fundamental issue is the severe underrepresentation of more social in-groups, for instance, students with disabilities (SwDs) in STEM education. In addition to, ethnic minorities, such as those identifying as Indigenous, a person of color, and belonging to the lesbian, gay, bisexual, trans, questioning, and queer, plus (LGBTQ+) community (Bock, 2022; Campos, 2020; Dewidar et al., 2022; Freeman, 2020; Lee, 2020; Martin & Fisher-Ari, 2021). A further confounding factor is that the preschool through twelfth grade (P-12) STEM education system often fails to promote student engagement in STEM activities because of a lack of STEM awareness at all levels of the U.S. education system (Klimaitis & Mullen, 2020; National Science Board, 2022; Wiredu et al., 2021). The growing demand is to increase enrollment, lower attrition, and gain retention in STEM education; however, discerning how to implement changes to the system efficiently is a real and ongoing problem.

Scholars often ask complicated questions to understand complex social issues better, find answers, and promote social change. The prime objective of most research was to contribute new knowledge to the literature; however, my goal was also to learn more about the gender and ableism gap in STEM education. To date, researchers know little about the successes and challenges female students with disabilities (FSwDs) face in STEM higher education programs. Educators from all over the world have studied educational disparities in various forms. Most indirectly relate to the conversation about campus climate, while only some correlate directly to the gender and ableism gap in

STEM education, such as the debate on classroom size, how COVID-19 disrupted learning, culturally relevant teaching practices, and the school-to-prison pipeline (Abacioglu et al., 2020; Bondebjerg et al., 2023; Pearson, 2022; Welfare et al., 2021). Campus climate measures the attitudes, behaviors, and perceptions of administrators, staff, students, and teachers in higher education (Peterson & Spencer, 1990). Regardless, academics have studied the persistent gender divide in STEM education and the resulting STEM workforce (National Center for Science and Engineering Statistics, 2023). Even so, researchers have only recently begun to focus on evaluating ableism in the STEM system.

According to the U.S. Census Bureau (n.d.), only 27% of STEM professionals are females. Due in part to the gender gap in STEM higher education programs, where only 35% of STEM degree seekers identify as females (Equal Employment Opportunity Commission, n.d.; National Center for Science and Engineering Statistics, 2023; The United States Census Bureau, 1975). Further complicating the situation in STEM education is that barely 10% of those identifying as FSwDs pursue STEM degrees (Equal Employment Opportunity Commission, n.d.; Fry et al., 2021). The shortage of females and FSwDs in STEM fields became highly concerning when assessing equity in the future STEM workforce. The situation becomes even more worrisome when considering that STEM fields are among the fastest-growing and highest-demand jobs in the global marketplace (Fry et al., 2021; Kennedy et al., 2021; Martinez & Christnacht, 2021; National Center for Science and Engineering Statistics, 2023). As such, researchers have

agreed that a more comprehensive analysis of the gender and ableism gap in STEM education is necessary to determine practical strategies for addressing the issues troubling the system for years (Almukhambetova et al., 2022; Andrews et al., 2021; Bartels et al., 2021; Friedensen et al., 2021). Doing so would enrich the literature by filling the knowledge gaps while offering real-world evidence to support improvements in the overall STEM education system. As a result, I conducted a basic qualitative study to explore FSwDs' perceptions of their successes and challenges with accessibility, inclusion, and support experienced in STEM higher education programs, as well as their recommendations for improving those policies and practices in STEM education.

The following information offers a brief overview to contextualize the ongoing socio-educational problem and familiarize the readers with the study. I will explain this basic qualitative study's research objectives, justifications, and rationale. In doing so, I examined the current situation to assess STEM education's state of affairs. Also, set the scene of the research. Provide the research design and development to address the gender and ableism gap in STEM education.

Background

The topic of STEM education has an ever-growing body of literature. Attrition, lack of diversity, low enrollment, retention, and stagnation within STEM education are recurring themes (Andalib, 2021; Bock, 2022; Canaan & Mouganie, 2023; Gregor et al., 2023; Martin & Fisher-Ari, 2021). The socio-educational problems in the STEM education system have been studied and well-documented. The gender divide was a

common focus, and researchers have discussed the so-called *clogged* and *leaky* STEM education *pipeline* for years (Andalib, 2021; Felder, 2021; Gregor et al., 2023; Rosenzweig et al., 2024; Speer, 2021; Whitcomb & Singh, 2021). The *clogged* STEM education system or *pipeline* refers to low retention and high stagnation notable within STEM education (Lane et al., 2020; Ortiz-Martínez et al., 2023; Roemer et al., 2020). The term *leaky* is an indication of the persistent low enrollment and high attrition rates evident within the STEM education system (Bock, 2022; Gregor et al., 2023; Rosenzweig et al., 2024; Speer, 2021; Whitcomb & Singh, 2021). Researchers have focused on ableism in STEM education, and studies about SwDs in STEM education have recently become a topic of interest. Most research discussed the underrepresentation of SwDs in the overall STEM system (Eagly, 2021; Klimaitis & Mullen, 2020; Lee, 2020; Zambrano, 2023). The specific conversation about FSwDs in STEM education is a burgeoning field of inquiry; however, few articles on FSwDs in STEM education focused on those in STEM higher education.

More females are applying to colleges than ever before. According to the U.S. Census (2022), females account for more than 50% of the student body in colleges across the U.S. In addition, more and more SwDs join higher education institutions annually, as Safer et al. noted in 2020. Still, as the NSF and Zambrano reported in 2023, there was a significant gender and ableism gap in STEM education. The Institute of Education Science, an affiliation of the U.S. Department of Education (ED) and the National Center for Education Statistics, estimated that roughly 21% of higher education students have a

documented disability, with approximately 10% of those being FSwDs who may require additional support (*Students with disabilities*, 2023). Even with the increasing numbers, there is still a considerable disparity between students with and without disabilities in higher education, especially in STEM disciplines.

The situation faced by SwDs in higher education is challenging. Despite the guidelines, incentives, and policies, such as Section 504 in the Rehabilitation Act of 1973, the Individuals with Disabilities Act (IDEA) of 1975, and the Americans with Disabilities Act (ADA) of 1990, high attrition, low enrollment, low retention, and additional problems continue to persist (Americans with Disabilities Act, 1990; *Individuals with Disabilities Education Act*, n.d.; *Section 504 of the Rehabilitation Act of 1973*, n.d.). Research indicated how providing reasonable accommodations and a least restrictive environment (LRE) for SwDs may lead to better grades and higher graduation rates (Carroll & Li, 2022). While laws and regulations in the U.S. aim to protect females and SwDs, FSwDs still face significant obstacles in STEM education (Friedensen et al., 2021; Klimaitis & Mullen, 2020; Lee, 2020). Although previous research has explored genderism in STEM education, more information is still necessary about FSwDs' experiences in STEM higher education (Klimaitis & Mullen, 2020; Lee, 2020; Pfeifer et al., 2021). Researchers know little about the successes and challenges FSwDs experience in STEM higher education programs at local colleges.

Investigations about the gender and ableism gap in STEM education are in demand. More knowledge is essential to illustrate and understand the situation better.

SwDs often face obstacles in their educational journey, including biases, exclusion, lack of role models, negative feedback, poor self-efficacy, and stereotypes. Various studies have highlighted the many obstacles (Andrews et al., 2021; Friedensen et al., 2021; Gin et al., 2020; Griffiths et al., 2020; James et al., 2020; Lee, 2020; Lockhart et al., 2022; Luo et al., 2021; Moriña et al., 2020; Pfeifer et al., 2021). FSwDs face additional challenges due to the intersectionality of being female and having a disability. The influence and intersectionality of age, ethnicity, parenting roles, sociocultural backgrounds, and socioeconomics were notable obstacles experienced by FSwDs in STEM education (National Center for Science and Engineering Statistics, 2023). The topic is complicated and multilayered because of several external and internal factors. In addition, very little research was available on the experiences of FSwDs in STEM higher education programs at local colleges (Aguirre et al., 2020; Safer et al., 2020). Accordingly, this basic qualitative study allowed more distinct details to unfold in the conversation of FSwDs in STEM education, STEM higher education, and the STEM workforce.

Problem Statement

Despite many efforts, researchers know little about the successes and challenges FSwDs experience in STEM higher education programs at local colleges. Many agreed that more knowledge was necessary to understand better the gender and ableism gap in STEM education (Canaan & Mouganie, 2023; González-Pérez et al., 2020; Hussénius, 2020; McKinney et al., 2021; Miller et al., 2021; Safer et al., 2020). The current high

attrition, low enrollment, retention, and stagnation within STEM higher education make understanding FSwDs' perceptions a pressing concern (Andalib, 2021; Bock, 2022; Canaan & Mouganie, 2023; Gregor et al., 2023; Martin & Fisher-Ari, 2021). From the available literature, studies highlighted that FSwDs do experience obstacles in STEM education, such as biases, stereotypes, and stigmas, but little research exists about their experiences in STEM higher education (Andrews et al., 2021; Friedensen et al., 2021; Gin et al., 2020; Griffiths et al., 2020; James et al., 2020; Lee, 2020; Lockhart et al., 2022; Luo et al., 2021; Moriña et al., 2020; Pfeifer et al., 2021). The current study addressed the knowledge gap in the literature regarding the successes and challenges FSwDs experience in STEM higher education at local colleges.

Purpose of the Study

The purpose of this basic qualitative study was to explore FSwDs' perceptions of their successes and challenges with accessibility, inclusion, and support experienced in STEM higher education programs, as well as their recommendations for improving those policies and practices in STEM education. Gathering more data for a broader understanding of FSwDs' experiences in STEM education may allow administrators, organizational leaders, and shareholders, including staff, students, and teachers, to assess the situation in STEM higher education better. To address the study problem, I explored FSwDs' perceptions of their successes and challenges with accessibility, inclusion, and support experienced in STEM higher education programs. I also explored their recommendations for improving those policies and practices in STEM education.

Research Questions

Research questions are the heart of any research design: the aim of what the researcher wishes to learn from the analysis. This basic qualitative study allowed FSwDs to share intimate and meaningful answers based on their experiences of STEM education. Accordingly, the following three research questions guided the study:

1. What are FSwDs' perceptions of their successes with accessibility, inclusion, and support experienced in STEM higher education programs?
2. What are FSwDs' perceptions of the challenges they experience with accessibility, inclusion, and support experienced in STEM higher education programs?
3. What are FSwDs' recommendations for improving the policies and practices of accessibility, inclusion, and support experienced in STEM higher education programs?

Theoretical Framework for the Study

Researchers conduct an academic inquiry into social problems to investigate phenomena of interest and answer complicated questions. While analyzing the literature and determining which theories and concepts applied to an educational investigation of FSwDs' perceptions of STEM education, several theoretical and conceptual frameworks emerged (Berger & Luckmann, 1967; Crenshaw, 1991; Hall, 2007; Reaume, 2014; Steward, 1972; *Universal Design for Learning*, 2021). However, choosing one for a multifaceted topic, such as FSwDs in STEM education, was challenging. Incorporating

additional philosophical support into the manuscript helped offer a more well-rounded exploration of the gender and ableism gap in STEM education (Burkholder et al., 2020d). Still, ensuring all frameworks were acceptable and applicable was vital.

The current research was grounded in Tajfel and Turner's (1979) social identity and Bandura and Walter's (1963) social learning theories. The umbrella of social identity theory included the science identity (SciID) theory, which also served as a useful foundation for interview questions. These two frameworks were ideal for analyzing the perceptions of FSwDs regarding the successes and challenges they faced in accessing, being included, and receiving support in STEM higher education programs at local colleges.

The theories emphasized the importance of investigating the broader situation, as there are several individual learning processes to consider when looking at the views of FSwDs regarding accessibility, inclusion, and support experienced in STEM education. For this basic qualitative study, the social identity and social learning theories, the SciID, and, to a lesser extent, the universal design of learning (UDL) models (or the handbook on inclusive learning) were suitable for the research. Social identity theory examines intergroup behavioral dynamics (Tajfel & Turner, 1979, 1986). Tajfel and Turner (1979) and (1986) posited that individuals are naturally motivated to have a positive self-image and want to fit into a group.

In contrast, the social learning theory suggests that learning is a cognitive rather than a behavioral process, and learning occurs in social settings where learners can

observe said behavior and the consequences of those actions (Bandura & Walters, 1963). Each emphasized and considered the critical role of investigating the bigger picture, as many individual learning processes occurred when discussing FSwDs' perceptions of the successes and challenges with accessibility, inclusion, and support experienced in STEM higher education programs, as well as their recommendations for improving those policies and practices in STEM education. Chapter 2 provides more information about the theoretical frameworks used during this study.

Nature of Study

The logical connections between the chosen methodology and research design helped justify the research. According to Patton (2002), the nature of the study should include relevant facts about the philosophical underpinnings of the research. Researchers should describe a study's who, what, how, and why. The basic qualitative research design is frequently used in socio-educational research to gather in-depth narratives about individual experiences (Denzin et al., 2023; Lazarsfeld, 1958). This approach offers researchers the opportunity to employ various instruments and procedures.

A basic qualitative study typically uses one-on-one interviews to gain insight into individuals' perceptions and help construct their worldviews. Researchers may ask participants how and why questions to understand their social identity and social learning behavior. The approach allows more than words alone to convey the story of those FSwDs (Bandura & Walters, 1963; Tajfel & Turner, 1979). Interviewing and observing FSwDs in this basic qualitative analysis helped me better understand how they experience

STEM education and identified factors that may offer valuable insight into the *clogged* and *leaky* STEM education *pipeline*. As such, the basic qualitative research design was appropriate to link the ongoing investigation with the existing literature on social identity and social learning theories regarding FSwDs' perceptions of STEM education.

Ten to 12 semistructured in-person, over-the-phone, email, or online interviews with FSwDs aged 18-64, currently engaged in STEM activities or enrolled in STEM education courses at local colleges and have their conditions on file helped me understand the perceptions of their successes and challenges with accessibility, inclusion, and support experienced in STEM higher education programs. The interviews lasted approximately 45 minutes, and I asked the participants to share their intimate thoughts and opinions on STEM education. I used a set interview protocol that a panel of subject matter experts (SMEs) validated for trustworthiness and quality.

I designed the interview questions using Tajfel and Turner's (1979, 1986) social identity and Bandura's (1977) and Bandura and Walter's (1963) social learning theory to explore accessibility, inclusion, and support from a perspective of care. The questions helped me better understand individuals' perceptions of the successes and challenges with accessibility, inclusion, and support experienced in STEM higher education programs, as well as their recommendations for improving those policies and practices in STEM education.

The purpose was to collect and analyze data from individual one-on-one interviews. I then reviewed the information gathered from each session. According to

Lester et al. (2020) and Locke et al. (2022), verbatim and summative transcription help create thorough codifications because the researcher systematically analyzes source data for patterns. After each analysis and synthesis, I compared these data to consider similarities and differences in participant responses.

Ensuring the study's credibility and trustworthiness was critical. By cross-referencing all the data collected, I could provide a comprehensive understanding of the phenomenon under investigation (Ahmed, 2024; Stahl & King, 2020). Using the interview transcripts, in conjunction with the descriptive demographic data and researcher notes, allowed me to interpret the data more effectively.

Definitions

In research, each investigation uses a set of working vocabulary, which includes the definitions of the operational terms for this study. Below is a list of key concepts, themes, and necessary variables in the research exploring FSwDs' perceptions of STEM education.

Ableism: The concept of *ableism* is nothing new in humanity's story. Still, the word is only a recent addition to the English lexicon (*Guide to disability rights laws*, 2023). The ED, the U.S. Department of Justice and Civil Rights Division, and the ADA describe *ableism* as the discrimination of and social prejudice against persons with disabilities based on the patronizing belief that typical abilities are in some way superior (*Glossary of ADA terms*, n.d.; *Guide to disability rights laws*, 2020). The concept inadvertently implies that individuals with disabilities are inferior and unable to complete

tasks as their counterparts without disabilities (Durban, 2022). The view is a biased and negative stereotype some people display publicly.

Accessibility: An overarching term used to describe a person's ability to access, engage, interact, navigate, and understand all learning environments, whether in person or online, without barriers (Ingram, 1971). American Sign Language (ASL) interpreters, screen readers, and wheelchair access are but a few essential tools for numerous learners. Being able to eat in classrooms or having gender-neutral bathrooms and requiring students to raise their hands to answer questions assist several more (Klimaitis & Mullen, 2020; Prema & Dhand, 2019; Reinholz & Ridgway, 2021). Accessibility is crucial to ensuring that all learners have the necessary learning tools and feel welcome in their learning environment.

Clogged: Blocked, obstructed, and plugged are synonyms of the word clog. The terms mean something is wrong with a system. The clogged STEM education system or *pipeline* refers to low retention rates and high stagnation notable within STEM education (Lane et al., 2020; Ortiz-Martínez et al., 2023; Roemer et al., 2020). The data suggested that females in the STEM system often feel unwelcomed, are overlooked for promotions, and are left out of research opportunities (Roemer et al., 2020; Van Miegroet et al., 2019). The clogged STEM pipeline reflects the ongoing problems in STEM education.

Disability: According to the ADA, individuals with disabilities are legally defined "as a person who has a physical or mental impairment that substantially limits one or more major life activities, a person who has a history or record of such an impairment, or

a person who is perceived by others as having such an impairment" (*Guide to disability rights laws*, 2020). The U.S. Department of Justice and Civil Rights Division (2020) noted that students with learning disabilities struggle to acquire and retain basic skills in academic content due to difficulties in understanding and using spoken or written language. These setbacks may impact a learner's ability to listen, read, speak, spell, think, write, or understand numbered equations in mathematics (Griffiths et al., 2020; *Guide to disability rights laws*, 2020). Letters and numbers may become transposed, or distractions may exist in a setting, making the learning process challenging (*Students with disabilities*, 2023). The IDEA statute defines SwDs as "…person…who have an intellectual disability, a hearing impairment, a speech or language impairment, a visual impairment, a serious emotional disturbance, an orthopedic impairment, autism, traumatic brain injury, and other health impairment, a specific learning disability, deafblindness, or multiple disabilities, and who, by reason thereof, need special education and related services" (Individuals with Disabilities Education Act, 1990).

Diversity: Diversity is the awareness of having an assortment or variety. In the current research, *diversity* is the inclusion of people from multiple groups to represent better the global community (Dewidar et al., 2022; Servaes et al., 2022). Comprised of those with varying abilities and disabilities or are from various backgrounds, cultures, ethnicities, geographies, and socioeconomic statuses (Bruijnzeel et al., 2022). Employing diversification strategies allows organizations to understand lived experiences better and help nurture an inclusive, positive academic or business climate (National Center for

Science and Engineering Statistics, 2023). The idea is to involve as many people as possible to improve group dynamics and enhance experiences.

Gender: The idea that biological sex is different from gender has become a popular topic in recent years. Cultural and social assumptions complicate the conversation (*Genderism, sexism, and heterosexism*, 2023; Lawrence & Bendixen, 1992). Gender identification is a self-reported personal choice and a social construction (Phillips, 2005; Sparks et al., 2023). For this study, using the term female is then a self-identification. Genderism is a variation of sexism. *Genderism*, then, is a bias resulting from the gender binary view (*Genderism, sexism, and heterosexism*, 2023; Phillips, 2005). The gender binary system perpetuates negative stereotypes of gender nonconformity.

Inclusion: The word inclusion is the act of including all people. In education, *inclusion* means creating accessible environments with equal opportunities for all learners, regardless of learning style (Francisco et al., 2020). Dewdiar et al. (2022) wrote that *inclusion* also makes people from diverse backgrounds feel valued and welcomed in educational settings. Actively encouraging, engaging, and prohibiting the exclusion of cultural and ethnic minorities, females, and persons with disabilities is a primary goal of inclusion in learning environments.

Leaky: When something leaks, it is assumed to be broken, cracked, or punctured. Thus, the term leaky is an indication of the continued low enrollment and high attrition rates visible within the STEM system (Bock, 2022; Gregor et al., 2023; Rosenzweig et

al., 2024; Speer, 2021; Whitcomb & Singh, 2021). Females leave the STEM system for various reasons, such as ableism, ageism, genderism, racism, sexism, and more (Lane et al., 2020; Ortiz-Martínez et al., 2023; Roemer et al., 2020). STEM education requires more information on how to seal the leaks.

Social Identity: Social identity is a multifaceted conversation because a person might belong to several social groups. According to Tajfel and Turner (1979, 1984), *social identity theory* posits that an individual's social identity results from perceived affiliations, involvements, or relationships with a social group. Researchers used the SIT to explore in-group and out-group behaviors (Dou & Cian, 2023; Stewart, 2022; Tajfel & Turner, 1979, 1986). Since one's social identity is a self-described choice and usually multilayered, for this study, FSwDs will be those who self-identify as female to remain unintrusive yet accessible, inclusive, and supportive.

Social Learning: Learning takes place in countless places. Formal or informal. Voluntary or mandatory. The s*ocial learning theory* postulates that group behaviors are acquired mainly by observing and mirroring one another (Bandura & Walters, 1963; Idris et al., 2023). Children tend to model their parents, guardians, and siblings. Students mimic their peers and teachers. In 1963, Bandura and Walters formalized the social learning theory as a comprehensive model that could account for a wide range of learning experiences around the world. Individual behaviors influence and are then influenced by personal factors, motivations, and social environments (Bandura & Walters, 1963; Idris et al., 2023; Wenger-Trayner & Wenger-Trayner, 2020). As a consequence, studying how

people perceive learning experiences may allow researchers to develop a better understanding of a situation.

Exploration drives much STEM research. Accordingly, under the National Science Foundation Act of 1950, the U.S. established the *National Science Foundation* as an independent agency to support innovation in education and research (*A timeline of NSF history*, n.d.; National Science Foundation, 1950). Since then, the NSF has embarked on countless scientific investigations. The agency asked how and why questions to advance learning. In the later 1980s and early 1990s, STEM replaced the acronym science, mathematics, engineering, and technology (SMET) (*A timeline of NSF history*, n.d.). At the time, the NSF and the U.S. government began to emphasize the importance of STEM as a matter of national security (National Science Board, 2022). The organization advocated for new educational policies and updated curricula to enhance enrollment in these disciplines (National Science Board, 2022; The State of U.S. Science & Engineering., 2020). The research suggested there was still room for improvement.

STEM Education: STEM education is the focus of several disciplines - more than the four interconnected schools of thought in the name. STEM education is an interdisciplinary approach based on the studies' concepts, procedures, standards, and strategies that use inquiry (empirical) techniques to model real-world applications (Johnson et al., 2020; Tytler, 2020). In the literature, STEM education is a term used to describe an entire educational network from preschool (P) and kindergarten to high

school (K-12) and higher education (U.S. Government Accountability Office, 2022; Von Zastrow, 2021). The preschool through higher education system encompasses P-20 or graduating with a bachelor's degree (Johnson et al., 2020). So, all learners within the U.S. education system from preschool to undergraduate graduation.

STEM Education Support: In the current research, STEM education support specifically refers to recommended support that FSwDs should receive in school (Bartels et al., 2021; Mishra, 2020; Pfeifer et al., 2021). The necessary support services vary for each person to ensure proper arrangements are specific to that student with disabilities under the ADA and that they learn in an LRE.

Assumptions

Assumptions in research are quite common and necessary. An assumption is an untested or unverified belief–a conclusion drawn without all the facts. Williams (1980) wrote assumptions, often based on an initial view lacking critical thought. In contrast, a critical thinker makes informed decisions based on empirical evidence and facts, thus avoiding unnecessary assumptions. An important note is that just because someone assumes something is true does not necessarily make it so.

Researchers may make an unintended assumption during research. For example, the current study might assume that the participants recruited for the study would be honest when sharing their experiences. In addition, researchers may presume that the self-reported interview responses would accurately reflect individual experiences without bias or exaggeration. Finally, a researcher may suppose the insights collected during the study

would accurately represent the situation regarding FSwDs' perceptions of the successes and challenges they experience in STEM higher education programs at local colleges.

Scope and Delimitations

Delimitations refer to the defined boundaries of a study. Defining its scope and limiting the concepts and variables under the researcher's control (George, 2023). These concepts and variables may include the choice of frameworks, objectives, the phenomena of interest, the population under review, and research questions.

For this study, I recruited nine FSwDs currently engaged in STEM activities or enrolled in STEM education courses at local colleges, and they have the condition(s) on file. In addition, I limited the study to FSwDs aged 18-64 at local colleges instead of including all institutions of learning within the region. I only used local community and disability centers for time and practical feasibility. The focus of this investigation is a global problem within the education system. Thus, the study serves as a convenience sampling rather than a generalizable survey for all higher education.

Limitations

Most research designs have inherent limitations that researchers have no control over much of the time. Researchers regularly discuss these limitations in the literature (Creswell & Creswell, 2022; Denzin et al., 2023). Participant recruitment was a limitation of this basic qualitative study on FSwDs' perceptions of STEM education. I was uncertain whether FSwDs would be willing to participate. Time was a major constraint, as with most social research projects, because there are usually limited timeframes for

completing a project. The restricted geographical location was another limitation of this study.

Also important to note were further limitations to the research. There was a financial incentive to participate, but the funds were limited for participants to volunteer in the study. In addition, accessing a potentially vulnerable population, ensuring confidentiality, confirming online identities and participant safety, and securely storing the collected data presented challenges. There were additional barriers in the research process, such as only interviewing one social group, when insights from various in-groups might have also helped fill the knowledge gaps in the literature.

Furthermore, the researcher's role in primary investigations presented obstacles to conducting quality and ethical research. To address these limitations, I created an audit trail using a data collection log and a researcher’s journal to document positionality and reflexivity and establish a network of trustworthiness. I logged all of the details and records of data collection, analysis, and synthesis. I further discussed these points in Chapter 3.

Significance

In this section, I further supported this basic qualitative study on the gender and ableism gap in STEM education. Until recently, the literature mainly focused on the gender divide in STEM education (Anderson, 2020; Eagly, 2021; Zambrano, 2023). In addition, much research concentrated on underrepresented in-groups, such as Indigenous, people of color, LGBTQ+, and SwDs (Andalib, 2021; Fry et al., 2021; National Center

for Science and Engineering Statistics, 2023; U.S. Government Accountability Office, 2022). Regardless, the literature still has knowledge gaps regarding how FSwDs perceive their successes and challenges in STEM higher education programs.

Current research about campus climate has addressed these gaps by answering difficult questions. However, I conducted research that offers an interdisciplinary and cross-organizational change application for improving campus climate and helping lower attrition and increase enrollment in STEM higher education. Through this, I contribute new knowledge toward addressing the gender and ableism gap in STEM education. This study aimed to make STEM education more accessible, inclusive, and supportive of diversifying STEM higher education and ensuring equity in the future STEM workforce. The study provided credible evidence to support practical recommendations in the STEM education system.

Justifying the significance of research in a field of study is a crucial component of quality research. Researchers suggested that the justification should provide readers with the background information, introduce the topic, and indicate why the research was essential to the overall knowledge of the subject (Creswell & Creswell, 2022; Maxwell, 2009; Patton, 2002). The research questions should clearly state what the researchers aim to understand (Maxwell, 2009). Each research question should connect to every study component to ensure proper alignment.

The goal of undertaking this study was to explore FSwDs' perceptions of STEM education. The study was essential to identify and isolate specific successes and

challenges with accessibility, inclusion, and support experienced in STEM higher education programs, as well as their recommendations for improving those policies and practices in STEM education. Underscoring what FSwDs perceived as beneficial to their educational journey and what apparent obstacles they encountered in STEM higher education at local colleges. The findings and outcomes of the investigation may inform administrators, organizational leaders, and shareholders, including staff, students, and teachers, about ways to improve the accessibility, inclusion, and support of STEM education by recommending practical applications to address the *clogged* and *leaky* STEM education *pipeline* directly from those underrepresented in the system. Doing so increases the likelihood that colleges remain relevant in the ever-evolving U.S. education system while effectively contributing to equity for the STEM workforce of the future. The ultimate goal was to disrupt the barriers and support the diversification of STEM higher education while ensuring equity in the future STEM workforce, as a small percentage of STEM degree seekers are female students who identify as having a disability. However, the research answered difficult questions about FSwDs' successes, challenges in STEM education, and their recommendations for STEM higher education programs at local colleges to fill the knowledge gap in the literature.

Summary

The first chapter presented the introduction and background of this basic qualitative study. The section provided the rationale and motivation for undertaking the investigation. One subsection discussed the research problem and offered the problem

statement. Further, despite past studies illustrating how FSwDs experienced several obstacles to their rightful education, researcher knowledge was limited. Thus, exploring FSwDs' perceptions of STEM higher education helped offer a better understanding of the gender and ableism gap in STEM education.

The first chapter also discussed the research questions, limitations, scope and delimitations, and the significance of the study. In this chapter, I further discussed the theoretical framing of the research and defined some keywords and concepts. More concepts and definitions will continue in Chapter 2, along with a discussion of the chosen research methodology in Chapter 3. The upcoming chapter offered a synthesis of the current and available literature. The purpose of this basic qualitative study was to explore FSwDs' perceptions of their successes and challenges with accessibility, inclusion, and support experienced in STEM higher education programs, as well as their recommendations for improving those policies and practices in STEM education.

Chapter 2: Literature Review

Introduction

To conduct a thorough investigation, a researcher must examine the literature on a particular topic. The examination involves identifying knowledge gaps within the research about a phenomenon of interest and using that information to plan a study to address those gaps. The literature review is an essential and ongoing process throughout the entire dissertation journey. By analyzing the existing data, the researcher may increase their knowledge of the topic and identify gaps in the literature. This review also helped isolate critical concepts, theories, and frameworks useful for this study's research design and development (Cooper, 1984, 1989; Creswell & Creswell, 2022). As a result, researchers become well-versed in the subject matter and experts in the field.

Researchers have examined the gender and ableism gap in STEM education. Evidence suggests that the STEM system has a *clogged* and *leaky pipeline* (Almukhambetova et al., 2022; Andalib, 2021; Bock, 2022; Gregor et al., 2023; Van Miegroet et al., 2019). Even with much research available on the current conditions in STEM education, researchers know little about the successes and challenges FSwDs experience in STEM higher education programs at local colleges (Conley & Nadler, 2022; Griffiths et al., 2020; Lee, 2020; Li et al., 2021; Lopez-Gavira et al., 2021; McCall, Paretti, et al., 2020). For that reason, this basic qualitative study aimed to explore FSwDs' perceptions of their successes and challenges with accessibility, inclusion, and support experienced in STEM higher education programs, as well as their recommendations for improving those policies and practices in STEM education.

Becoming adept with the literature on the topic was vital to ensure the ongoing work was appropriate, of good quality, and would broaden knowledge about the field of study. In effect, one analyzes and synthesizes the current research to provide credibility, justification, and validation for the study. One continuously compiles evidence to support the investigation and frame the research problem.

More research on the gender divide in STEM education existed, but the subject of ableism was also becoming a research topic. The literature supported future examinations into the exclusivity of STEM education to understand better the present situation (Eagly, 2021; Hussénius, 2020; Miller et al., 2021; Zambrano, 2023). Further noting, more knowledge is necessary about the experiences of FSwDs in STEM education (Conley & Nadler, 2022; Li et al., 2021; Lopez-Gavira et al., 2021; McCall, Shew, et al., 2020). Studying FSwDs' experiences in STEM education does fill knowledge gaps in the literature but may offer additional insight into the ongoing socio-educational problem in the overall STEM system. To that end, the following chapter will provide evidence to support and validate the current study while contextualizing and synthesizing subject matter-specific content into a cohesive summary of the current literature on FSwDs' experience in STEM education.

Literature Search Strategy

Combining literature and thumbing references, proceed with any dissertation. Analyzing, reviewing, and synthesizing the available literature was a compulsory step in the early stages of choosing a phenomenon of interest to study (Burkholder et al., 2020d;

Cooper, 1989). Researchers gather supporting evidence to warrant any research study. Filling knowledge gaps in literature is the main objective of most dissertation research. Collecting recent (typically within a few years but at most 5 years) is an arduous but necessary task in scholarly investigations. During the process, scholars spend several hours, even days, examining academic databases for credible sources and seminal works, and in the search, using various databases allowed for an effective literature review.

The Walden University Library, similar accredited university libraries, and several educational databases, such as Academic OneFile, Education Source, ERIC, JSTOR, ProQuest, Project MUSE, ScienceDirect, SAGE Journals, Taylor & Francis Online, and Wiley helped to execute an efficient search. Still, using the U.S. ED, Google Chrome browser, and Google Scholar, the NSF, and their affiliates also assisted in completing a more thorough examination of the literature to discern knowledge gaps in the current research about the campus climate and the ongoing gender and ableism gap in STEM education. Also, to distinguish workable frameworks for analyzing the problem. The supporting research suggested that researchers know little about the successes and challenges FSwDs experience in STEM higher education programs at local colleges.

Before landing on an appropriate, timely, and valid research problem, the initial words and phrases, such as *females, women, girls in STEM education, STEM higher education,* and *STEM workforce,* assisted in narrowing the search. Adding descriptive text, *like students with disabilities,* helped narrow it down even more. Doing so allowed for a broader interpretation of research on FSwDs in STEM education.

Employing familiar Boolean operators, particularly *AND, OR, NOT*, etcetera, aided in uncovering an assemblage of resources. Applying the operators with text like accessibility *OR* inclusion *AND* STEM education, *OR* STEM higher education, the STEM workforce becomes the focus. Incorporating the *words gender OR females, NOT males AND STEM education,* added a layer of distinction to the search. Refining the inquiry to explore *barriers, diversity, identities, AND stereotypes* made the topic even more exclusive. Still, including the modifier *disabled OR disabilities* ultimately helped refine the research on FSwDs in STEM education.

The keywords and concepts familiar to the literature become apparent, such as the gender gap, divide, disparity, or *clogged* and *leaky pipeline* in STEM education, STEM higher education, and the STEM workforce or professions. Ideas such as barriers, exclusion, and lack of support in STEM education and STEM higher education emerged, with STEM advocacy, STEM education awareness or lack of STEM education awareness, self-efficacy (STEM-efficacy), STEM identity, and STEM stereotypes coming into view as themes within the research.

The list of concepts above effectively narrowed the search and allowed a better understanding of the literature on FSwDs in STEM education. The literature confirms that FSwDs have many obstacles to overcome in being permanent members of the STEM education community. Still, researchers have suggested (a) barriers and bias, (b) a lack of accessibility, awareness, and inclusion, (c) the gender gap, (d) realization of STEM identities and stereotypes, and (e) the role of academic and student support, are among

the most frequent concepts and themes identified in recent studies (see Gin et al., 2020; Griffiths et al., 2020; James et al., 2020; Klimaitis & Mullen, 2020; Lee, 2020; Lockhart et al., 2022; Miller & Downey, 2020; Moriña et al., 2020; Pfeifer et al., 2021; Wells & Kommers, 2022). Research suggested and supported more investigation into FSwDs' experiences in STEM education. Exploring FSwDs' perceptions of the successes and challenges with accessibility, inclusion, and support experienced in STEM higher education programs, as well as their recommendations for improving those policies and practices in STEM education, will enrich the knowledge on the subject and fill the literature gaps about FSwDs in STEM education.

Theoretical Foundation

Researchers choose a working theory or conceptual model as an example of how to examine the topic. The theoretical and conceptual framework links the current study to existing literature and for good cause. According to Burkholder et al. (2020), theoretical and conceptual frameworks are schools of thought, methodological models, or combinations of interconnecting ideas that align with the research design and allow for a compelling study into the phenomenon of interest. As a result, the selection below offers a review of fundamental theories and concepts used to frame the current research.

Several theoretical and conceptual frameworks emerged while analyzing the literature on FSwDs in STEM education. Picking one for a multifaceted topic, such as FSwDs in STEM education, was challenging. So, an argument for incorporating more than one framework better to comprehend the gender and ableism gap in STEM

education was necessary (Burkholder et al., 2020d). Still, it is paramount to ensure the chosen frameworks are justified; otherwise, the additional approaches will be potentially redundant and might negatively impact the study. They might also complicate and confound the research.

To limit the scope of the research and keep it focused, the theoretical frameworks that ground this dissertation include Tajfel and Turner's (1979) social identity and Bandura and Walter's (1963) social learning theories. These two are appropriate frameworks for analyzing the FSwDs' experiences in STEM education. The science identity (SciID) theory falls under the umbrella of identity theory and thus may also be a useful framework. Each emphasizes the critical role of investigating the broader state of affairs, as several potential individual learning processes are observable when considering FSwDs' perceptions of the successes and challenges with accessibility, inclusion, and support experienced in STEM higher education programs, as well as their recommendations for improving those policies and practices in STEM education.

To conduct quality research, framing a study with an appropriate theory or theories was essential. The chosen frameworks provide the researcher with guided support during the research process and add meaningfulness to the outcomes (Burkholder et al., 2020c). The theoretical underpinnings of a study place the investigation in the context of previous examinations on the subject and offer further support to the planned research design (Louvier, n.d.). Social identity and social learning theories make appropriate choices for the current basic qualitative research exploring FSwDs'

perceptions of STEM education. For this dissertation, a further argument was possible to incorporate the universal design of learning (UDL) educational model (or the handbook on inclusive learning).

Social identity theory and social learning theory come from the changing ideologies of the twentieth century. The theorists studied social behavior and educational psychology during interdisciplinary research (Bandura, 1986a, 1986b; Bandura & Walters, 1963; Tajfel & Turner, 1979, 1986). The social identity theory is a framework for examining intergroup behavioral dynamics(Tajfel & Turner, 1979, 1986). Tajfel and Turner (1979) and (1986) postulate the assumption that individuals are naturally motivated to want a positive self-image and inherently want to fit into a group. In contrast, the social learning theory suggests learning is a cognitive process rather than behavioral and occurs in social settings where students may observe said behavior and the consequences of those actions (Bandura, 1986a, 1986b; Bandura & Walters, 1963). Each highlights the vital role of investigating the broader situation further because many individual identity and learning processes are measured when discussing their successes and challenges with accessibility, inclusion, and support experienced in STEM higher education programs.

Social Identity Theory

Background

Social identity theory focuses on group behaviors in social settings. Tajfel and Turner (1979) and (1986) posit that the theory studies dynamics: in-group, or those

perceived to belong to a group, and out-group, individuals who are perceived outsiders to the group (Tajfel & Turner, 1979, 1986). The theory addresses how social identities affect individual attitudes and behaviors regarding their groups (Tajfel, 1981; Tajfel & Turner, 1986). Tajfel and Turner (1979) noted how an individual's self-identity or self-concept derives from the perception of belonging to a social group. Suggesting group behaviors might also influence how individuals perceive themselves (Tajfel, 1981). The social identity theory deciphers personal and social identities, underpinning the differences between interpersonal and group dynamics (Stewart, 2022). Social identity theory enables investigators to explore intergroup and outergroup behaviors. The methodology allows researchers to explain or predict specific in-group actions (Tajfel, 1981; Tajfel & Turner, 1979, 1986). Examples of social groups might include disability identity, gender identity, ethnic identity, occupational or professional identity, religious identity, and social identity. Individuals commonly have multiple social identities (e.g., being female and identifying with their disability, gender, professional status, and social group).

Supporting Literature

The gender and ableism gap pertains to educational equity, which sits at the forefront of scholarly research worldwide. Exploring FSwDs' experience in STEM education relates to social identity theory because their lack of representation may influence how members of the group feel a sense of exclusion and unwelcomed (Chiu, 2022; Conley & Nadler, 2022; Dou & Cian, 2022; James et al., 2020; Miller et al., 2021;

Sparks et al., 2023). Using the social identity theory to understand better how FSwDs experience STEM education relates to intergroup dynamics (Akbari et al., 2023; McCall, Shew, et al., 2020). Thus, the theory might help explain and predict how identity affects individual perceptions of STEM education.

The social identity theory and processes are relevant when examining the reasons for the gender and ablism gap in STEM education. A review of the literature below offers examples and explanations for understanding how values enforced and reinforced in disability and gender groups may well conflict with the ones associated with STEM (James et al., 2020; Klimaitis & Mullen, 2020). Female students with disabilities might also experience hostility and rejection by cohorts regarding their appearance in STEM activities and STEM achievements (Miller et al., 2021; Sparks et al., 2023). In consequence, FSwDs may be unable to view themselves as belonging to one of the STEM groups.

The link between social identity and group affiliation is a foundation of the social identity theory. When individuals feel a strong connection to their social group, their self-concept or self-identity becomes strongly influenced by their membership in the group (Sparks et al., 2023). Membership in a social group helps build self-confidence, which supports maintaining a social identity (Scheepers & Ellemers, 2019; Tajfel, 1981). Key components and elements of social identities include *within-group assimilation* (conformity to in-group norms) and forms of *intergroup bias* (i.e., in-group favoritism or out-group prejudices) (Hogg, 2021; Sparks et al., 2023; Stewart et al., 2023). In

educational psychology and more, researchers used social identity theory to explain affiliation, conformity, and group socialization (both negative and positive effects) (Hogg, 2021; Sparks et al., 2023; Stewart et al., 2023). Researchers suggested that social identity theory is a frequent choice for theoretical frameworks because it addresses socio-educational problems that focus on the individual's relationships with the group (Hogg, 2021; Tajfel & Turner, 2004). People strive to maintain positive social identities (Tajfel & Turner, 2010). The social identity theory posits that stereotypes defined by society may, in fact, negatively impact already marginalized groups (Dele-Ajayi et al., 2020; Eaton et al., 2020; McKinney et al., 2021; Totonchi et al., 2021). Domingo et al. (2022) noted that marginalized groups, such as FSwDs, LGBTQ+ members, and people of color, are those who experience negative stereotypes in STEM education. The theory conceptualizes social identity to explain groups' motivations and how those affect individual perceptions of STEM education.

Science Identity (SciID) Theory

SciID is a social identity in itself. The SciID theory falls under identity theory and offers a useful foundation and support to understand group dynamics in STEM education (Dou & Cian, 2022). SciID and STEM identity are linked. Data supports SciID and STEM identity, which influence an individual's success in educational settings and beyond (Chiu, 2022; Stewart, 2022). Generally, research on STEM identity among marginalized groups was lacking because of their underrepresentation in STEM (Hussénius, 2020; Miller et al., 2021; National Center for Science and Engineering

Statistics). One exciting challenge in researching the diversification of STEM education was indeed finding further support for exploring FSwDs' experiences in STEM education.

Background and Supporting Literature

Developing a STEM identity and being a member of the STEM in-group is multilayered. Acceptance and belonging are two such elements. SciID research suggested that socio-educational settings and feelings of belonging in STEM may play a significant role in developing STEM identity (Sparks et al., 2023). Being accepted and recognized as a member of the STEM community by existing STEM members might also have a noteworthy influence on nurturing (or hampering) a STEM identity (Dou & Cian, 2022; Lockhart et al., 2022). Data suggested that their STEM identity may strengthen when individuals engage in STEM activities and have positive experiences. However, when participants have less engaging or unsatisfactory experiences, their STEM identity erodes (Dou & Cian, 2022; Lockhart et al., 2022). Perceiving oneself as a science person who belongs to and could succeed in STEM is at the heart of the SciID and, thus, STEM identity.

Social Learning Theory

The social learning theory suggests that learning is cognitive and social behavior. Bandura and Walters (1963) stated that people learn from social interactions. In turn, the theory postulates that individuals learn by observing, modeling, or mirroring one another (Bandura & Walters, 1963). For instance, students watch teachers actively using learning

materials and engaging with the content before following their lead and participating in the process (Wenger-Trayner & Wenger-Trayner, 2020). The learner is actively involved in receiving the information presented. Social learning theory encourages people to understand their self-efficacy, or self-assurance and determination, and personal agency: the ability to control one's actions and course of development (Bandura, 1986a, 1986b). Social learning theory emphasizes that learning is a behavioral and cognitive process in a social context.

Background

Behavior, cognition, and setting influence the learning process. From direct experience, students may engage in problem-solving scenarios to learn what works and what techniques are unsuccessful at solving the problem (Bandura, 1977; Bandura & Walters, 1963). STEM education is largely hands-on and interactive, with a solid inquiry-based approach to solving real-world problems (Idris et al., 2023). Students research the issues to then troubleshoot and formulate findings on the experiments (Wenger-Trayner & Wenger-Trayner, 2020). STEM education experiences encourage students to use available resources and learn content in a way that supports the social learning theory. The lack of FSwDs in STEM education makes researching their social learning experiences more difficult. This knowledge gap further supports the ongoing examination of FSwDs' perceptions of STEM education.

Supporting Literature

During the 1950s, the United States (U.S.) established the National Science Foundation (NSF), an independent agency of the U.S. federal government that supports innovation in research and education (*A timeline of NSF history*, n.d.). At about the same time, the space race fascinated the world. Since then, the U.S. and abroad have increased focus on student-centered learning and encouraged students to engage in problem-solving for the future (Alrashdi, 2023; Idris et al., 2023). Alrashdi (2023) explained student-centered learning as situations where students actively engage in learning. Using active learning strategies allows students to have a unique learning experience, heighten their awareness of critical thought, and find value in science education (Idris et al., 2023; Wenger-Trayner & Wenger-Trayner, 2020). Research suggests learners benefit from student-centered social learning approaches because they help them better understand the subject matter (Akpan & Kennedy, 2020). In fact, they were working together and learning from one another. These factors are pressing issues to discuss. Being accepted and respected is critical in formulating a person's social identity or worldview. However, feeling welcomed is also fundamental for student motivation and success in educational settings and similar learning environments.

STEM Education

By now, STEM education has become well-known as a socio-education problem. As noted above, STEM is the acronym for the four fields of study under the umbrella of science, technology, engineering, and mathematics. The world over, STEM professionals

are increasingly sought-after potential candidates (Almukhambetova et al., 2022; Amirtham S & Kumar, 2023; Kennedy et al., 2021; Martinez & Christnacht, 2021). Throughout the 21st century, educational settings have seen increased demand for STEM education firsthand. For the U.S. to remain economically prosperous, STEM education must become a ubiquitous conversation (Call to action for science education: Building opportunity for the future, 2021; *New report issues an urgent call to improve STEM education assessment*, 2023). STEM education encompasses many moving parts. Preparing and training countless STEM education teachers is paramount. STEM teachers require educators to become multitaskers in the classroom because educators must think past a single subject (Main et al., 2021; Zinth & Weyer, 2021). The learning environments could transform into inquiry-based classrooms, where critical thinking and problem-solving skills become the objective (Alrashdi, 2023; Jeschke et al., 2021; Zinth & Weyer, 2021). (Geesa et al., 2022; Velasco et al., 2022; Von Zastrow, 2021). Burgin (2020) suggested nurturing more student-centered learning with an increased emphasis on scientific rigor as part of the latest STEM education curriculum updates. Suppose the U.S. was to change the current curriculum and improve STEM literacy. In that case, more research was necessary to inspect the effectiveness of STEM education in fixing the *clogged* and *leaking* STEM *pipeline*.

One of the goals of STEM education is to support the development of STEM literacy. Included are the ability to observe phenomena, ask questions, and attempt to solve various problems regarding the human- and naturally-built world so that individuals

become aware of how these disciplines shape our lives, culturally and intellectually (*Functionalist theory on education*, 2020; *The symbolic-interactionist perspective on education*, 2021). A growing concern was that STEM education was too complicated and confused students about what was happening in the real world; thus, they struggled to understand how STEM fields related to their lives and surrounding environments (Burgin, 2020; De Los Santos et al., 2019). The situation leaves far too many students underprepared for critical STEM professions.

According to the NSF (2023), barely 20% of U.S. college-bound high school students are ready for high-level science and math courses required to pursue STEM education majors. Therefore, this adds increased pressure on educators and policymakers to improve STEM education. The ED, NCES, NSF, and more recognize that the U.S. education system requires help in promoting STEM education because the country continues to lag behind China, Germany, India, Korea, and Japan in basic STEM skills, such as critical thinking and problem-solving (National Science Board, 2022; *Students with Disabilities*, 2023; U.S. Department of Education, 2022). Economic prosperity and national security rest on scientific and technological innovation from solid STEM education programs.

Perpetually and inextricably linked to the world's global economy, health, prosperity, and safety are the four main disciplines of STEM education (National Academies of Sciences, Engineering, and Medicine et al., 2020; National Science Board, 2022). According to the Bureau of Labor Statistics (2020), predicted job growth in STEM

professions will be 10% over the next decade, roughly 5% higher than the average for non-STEM occupations. Another aspect of the ongoing problem is that 13% of females in STEM education majors leave STEM for non-STEM fields (The state of U.S. science & engineering, 2020).

Examining the entire STEM system requires more than one researcher and a solitary study to investigate the socio-educational problem, so typically, a segment of the system or situation becomes the focus of analysis. The STEM system might begin in preschool and become never-ending if the STEM network or so-called *pipeline* successfully produces STEM professions for the labor force. After choosing a segment, researchers will likely narrow it down to a set population, such as FSwDs. As shown above in the previous subsections, more often in STEM education, researchers focused on K-12 or higher education (Geesa et al., 2022; Velasco et al., 2022; Von Zastrow, 2021). Still, some may concentrate on STEM for preschool ages, STEM professionals, and the STEM workforce while surveying the STEM *pipeline* (Okrent & Burke, 2021; Wells & Kommers, 2022; Zinth & Weyer, 2021). The U.S. Congress, on several occasions, has requested the NSF and fellow researchers observe students from elementary and middle school through college to track which students had successes in STEM education and what factors might have contributed to or hindered the accomplishment (National Research Council & National Academies of Sciences, 2013; Puckett & Gravel, 2020; Sahin et al., 2023). Sahin et al. (2023) also addressed the loss of females in higher-level STEM courses in grades 9 to 12. The ongoing and previous research contributes to the

growing body of literature on STEM education. Each continues to seek discoveries for ways to decrease attrition and increase retention in the STEM system.

Research about the *clogged* and *leaky pipeline* in STEM education is multilayered, interdisciplinary, and interconnected to many aspects of the education system. Studying these complicated learning environments has begun to fill the pages of peer-reviewed journals, independent research agency reports, and think-tank or organizational research studies (Carroll & Li, 2022; Fry et al., 2021; National Academies of Sciences, Engineering, and Medicine et al., 2020; National Center for Science and Engineering Statistics, 2023). Still, researchers know little about the successes and challenges FSwDs experience in STEM higher education programs at local colleges. Further investigations are necessary to provide the databases with research on the subject to help create a more comprehensive analysis of the gender and ableism gap in STEM education. As more research becomes available on the topic, key concepts or operational vocabulary have become recognizable in STEM education research. The subsequent section reviews the terms in the literature on the gender and ableism gap in STEM education.

Accessibility

Making learning accessible to all learners is paramount. According to the U.S. Department of Health and Human Services (2020), *accessibility* measures how successfully a person with disabilities may locate, understand, and use necessary information. The idea of accessibility is to eliminate barriers to knowledge but encourage

the development of technologies and techniques to increase access for learners with disabilities (Scanlon et al., 2021). Accessibility is a benchmark for SwDs to access an appropriate and reasonable education under IDEA (Raspa et al., 2020). Gin et al. (2020) wondered if active learning, such as STEM education, is accessible to SwDs. They noted how some education settings are inaccessible to SwDs, such as chemistry laboratories (Gin et al., 2020). Then, remarking further on how timing mathematics and science tests may impede some SwDs' access to those classes (Gin et al., 2020). Some researchers argued that adjustments to the existing support network are necessary to enhance accessibility in the learning experience for SwDs, but certainly in STEM education and for FSwDs (García-Holgado & García-Peñalvo, 2022; Klimaitis & Mullen, 2020; Reinholz & Ridgway, 2021; Wells & Kommers, 2022). Citing more interactive tools would assist in making STEM education accessible (Klimaitis & Mullen, 2020; Reinholz & Ridgway, 2021). Little information exists about how FSwDs experience STEM education when examining accessibility.

Advocacy

Activists support many causes, and STEM education has a global reach. Sharma (1996) wrote that the advocacy process is critical in changing policies and programs. Even with many definitions of advocacy, one fits the study of STEM education. *Advocacy* brings attention to a central issue, communicating with and to essential stakeholders, conducting research, speaking out to policymakers who affect decision-makers, and working toward solutions (Johnson et al., 2020; Sharma, 1996). From the

research, advocates of STEM education focused on several themes: (a) accessibility, (b) barriers and biases, (c) the gender gap, (d) higher education, (e) inclusion, (f) the K-12 system, (g) self-advocacy, (h) self-efficacy, (i) STEM-identity, (j) STEM stereotypes, (k) support, and more (Dou & Cian, 2022; James et al., 2020; Klimaitis & Mullen, 2020; McKinney et al., 2021; Pfeifer et al., 2021; Prema & Dhand, 2019; Reinholz & Ridgway, 2021; Velasco et al., 2022). Allies of STEM education promote *self-advocacy* and *self-efficacy* in STEM education among marginalized groups (Hughes & Roberts, 2020; Luo et al., 2021; Pfeifer et al., 2020, 2021; Robinson et al., 2022). Still, more knowledge is necessary to understand better the role of FSwDs in STEM education and how advocacy may contribute.

Awareness

Educational awareness is a social issue. One that receives much attention; however, STEM education awareness is lacking in some settings (Watson et al., 2020, 2022; Wiredu et al., 2021). Watson et al. (2020) sought to understand school administrators' perceptions of STEM awareness and resources in the K-12 system. In addition, Watson et al. (2022) analyzed school administrators' perceptions of parental STEM awareness and STEM knowledge for better student STEM preparation. Findings demonstrate an overall need for increased STEM awareness and strategies to improve STEM knowledge (Watson et al., 2020, 2022).

Further studies focused on inclusion in STEM education and whether the appropriate shareholders, including staff, students, and teachers, are aware of exclusion in

STEM (Dancy et al., 2020; Wiredu et al., 2021). Researchers know little about FSwDs' role in STEM education awareness. Exploring additional shareholders' experiences may help establish strategies for improving this awareness.

Barrier and Bias

Female students with disabilities experience barriers in many instances. STEM education is one of the areas that require more attention (James et al., 2020; Klimaitis & Mullen, 2020). In-group and out-group behaviors play a role in how SwDs experience STEM education. Existing prejudices and stereotypes impede learning for females and SwDs (Adermann, 2020; Batty & Reilly, 2023; Friedensen et al., 2021; García-Ramos et al., 2022). Female students with disabilities encounter intersectionality of in-group and out-group dynamics in STEM education because they may identify with numerous social groups, such as being a person with disabilities, a female, from a low social class, an ethnic minority, or more (Ackerman & Soto-Arzat, 2023; Cech, 2022; Sparks et al., 2023). Some may argue that FSwDs have no place in STEM education because they encounter numerous obstacles to positive and proper STEM education experiences (Eaton et al., 2020; Ikkatai et al., 2020; Knezz et al., 2022; Kong et al., 2020). More knowledge about FSwDs in STEM education is necessary to fill the knowledge gaps.

STEM Advocacy, Awareness, and Self-Efficacy

Supporters of STEM and STEM education are STEM advocates. STEM advocacy, similar to advocacy in general, brings attention (awareness) to the issues within the STEM system. Topics such as accessibility, exclusion, the gender gap, lack of

support, and more in STEM education fill the pages of research journals (Bock, 2022; Dele-Ajayi et al., 2020; Mishra, 2020; Tytler, 2020; Wells & Kommers, 2022). Each year, more and more SwDs enroll in college classes (National Center for Science and Engineering Statistics, 2023). However, men without disabilities still dominate STEM classes, disciplines, and programs (Cech, 2022; Dancy et al., 2020; Robinson et al., 2022). Statistics continue negatively impacting the STEM workforce (Kennedy et al., 2021; Li et al., 2021; Martinez & Christnacht, 2021; Reinholz & Ridgway, 2021). STEM advocates continue to promote awareness and diversity in STEM education so that the future STEM workforce better represents the overall U.S. demographic makeup (Bergstrom, 2019; Fry et al., 2021; Ham, 2021; Martin & Fisher-Ari, 2021; Miller et al., 2021; Miriti, 2020; National Center for Science and Engineering Statistics, 2023). According to the Centers for Disease Control (CDC), individuals who identify as having a disability represent roughly 20% of the U.S. population and about 20% of undergraduates in the university system, but only two percent in the STEM workforce (*Disability impacts all of us*, 2023; National Center for Science and Engineering Statistics, 2023; *Students with disabilities*, 2023). A University of Michigan (UofM) study conducted by the Office of Culture, Community, and Equity (OCCE) (n.d.) surveyed about 14,000 people in 14 countries to answer questions about STEM education. The study found that more positive STEM awareness and advocacy are necessary because unconscious biases negatively impact STEM education (*The state of science and the need for STEM advocacy*, 2022). The OCCE (n.d.) said that four out of

10 people surveyed claimed their lives would be the same if science did not exist. What an interesting concept. Females and SwDs experience barriers and unconscious biases more often than males without disabilities in STEM education, but negative stereotypes affect all learners (Adermann, 2020; Batty & Reilly, 2023; Dancy et al., 2020; Dele-Ajayi et al., 2020; Eaton et al., 2020; *The state of science and the need for STEM advocacy*, 2022). Statements such as, only geniuses are in science leave many students feeling inadequate and unwelcome and allow for low self-efficacy or STEM-efficacy (Luo et al., 2021; McKinney et al., 2021; *The state of science and the need for STEM advocacy*, 2022). The negativity takes over, and students eventually begin to view themselves as incapable of completing STEM tasks and being an outsider to the group (Andrews et al., 2021; Luo et al., 2021; McKinney et al., 2021; Pfeifer et al., 2020). Ascertaining how FSwDs experience STEM education may offer insight into further negative stereotypes that might hinder their STEM efficacy and overall STEM education enrollment. Filling the knowledge gaps about FSwDs' perceptions of STEM education may help bring about a better understanding of their experiences.

STEM Identity

Identity politics are everywhere. Our social identity is ever-evolving and many-sided (Tajfel & Turner, 1986). One's identity may reflect a sense of belonging to multiple groups. STEM identity is the idea that an individual believes they have the capacity to engage and excel at STEM activities and tasks (Dou & Cian, 2022). They belong to the STEM in-group. Chiu (2022) noted that when students have a strong sense of self-

determination, they develop STEM interests, which helps foster a positive STEM identity. Self-determination is understanding one's ability to decide for oneself (Chiu, 2022; Ryan et al., 2021; Tytler, 2020). According to the literature, self-determination impacts motivation and drives people to try new tasks (Ryan et al., 2021). A positive STEM identity allows learners to cultivate STEM interests and engage in STEM education (Chiu, 2022; Ryan et al., 2021). Female students with disabilities who possess a positive STEM identity would belong to at least three social in-groups: a female, a person with disabilities, and a member of STEM. Investigating how FSwDs experience STEM education may add knowledge about their STEM identity.

STEM Stereotypes

STEM education is unintentionally and unconsciously exclusionary. STEM stereotypes, negative or positive, affect enrollment rates in STEM higher education (Eaton et al., 2020; Luo et al., 2021; Totonchi et al., 2021). Yet, negative stereotypes impact FSwDs' entrance into STEM education programs (Dunn, 2021; Eaton et al., 2020; Miller et al., 2021). Luo et al. (2021) found that stereotypical beliefs about STEM professions negatively influence student self-efficacy. Data supports the notion that STEM education learning environments have continuously been inhospitable to marginalized groups (Domingo et al., 2022; Miller et al., 2021; Miller & Downey, 2020; National Center for Science and Engineering Statistics, 2023). The literature lacks more information on FSwDs' experiences with negative stereotypes in STEM education. More knowledge is thus necessary to fill the research gaps.

Inclusion

Exclusion exists in many forms. The gender and ableism gap in STEM education is an example of exclusion, and the data suggested that exclusionary behaviors are invasive and pervasive (Knezz et al., 2022; Kong et al., 2020; Miller et al., 2021). Inclusion is a means to create educational environments with equal opportunities for *all* students, regardless of learning style (Bartels et al., 2021; Bock, 2022; Francisco et al., 2020; Prema & Dhand, 2019). Dewdiar et al. (2022) wrote that *inclusion* makes the typically marginalized feel accepted, seen, and valued in *all* educational settings. Researchers agreed that the homogenous STEM system lacks people who identify as belonging to social groups of diverse backgrounds (Campos, 2020; Domingo et al., 2022; McCall et al., 2020; Miller et al., 2021; National Center for Science and Engineering Statistics, 2023; Sparks et al., 2023; Tajfel & Turner, 2004). Encouraging, engaging, and prohibiting the exclusion of cultural and ethnic minorities, including females and persons with disabilities, is a primary goal of creating, having, and perpetuating inclusive learning environments. Moriña et al. (2020) suggested that inclusive learning environments enrich learning experiences, motivate fellow students, and provide educators with personal and professional opportunities. Interviewing SwDs allowed researchers to establish ways inclusivity contributes to their learning experiences (Bock, 2022; Dewidar et al., 2022; Moriña et al., 2020). The research further demonstrates that where inclusive pedagogy was present, motivated individuals to reflect on ways to improve awareness of disabilities and transform negative stereotypes (Friedensen et al., 2021; Lee, 2020; Moriña et al.,

2020; Wiredu et al., 2021). The literature acknowledged how exposing learners to more inclusive STEM experiences may improve students with disabilities' self-efficacy and understanding of STEM subjects (Kim et al., 2018; McKinney et al., 2021; Wiredu et al., 2021). Repeated analyses illustrated the benefits of inclusion in pedagogy (Booth, 1996; Diele-Viegas et al., 2022; Hansen et al., 2021; Moriña et al., 2020), but more research is necessary to understand inclusivity in STEM education. Researchers recommended evaluating the perceptions of educational leaders (e.g., administrators, teachers, etc.), females with disabilities (girls, teens, and adults), and disability support services (departments) to help close the leaky *pipeline* in STEM education (Moriña et al., 2020; Robinson et al., 2022; Watson et al., 2022). Exploring FSwDs' perceptions of the successes and challenges with inclusion will fill the knowledge gaps. Still, the research might have noticeable implications for inclusion in STEM higher education.

Universal Design of Learning (UDL)

UDL is a highly recognized educational tool. An essential analytical tool regularly used in social research to gauge inclusion in education settings (Dwyer-Kuntz, 2022; Eagleton, 2024, 2024; Levey, 2023; *Universal Design for Learning*, 2021). The conceptual framework allows researchers to interpret the results more thoroughly and provide generalizable, transferable, and trustworthy findings about accessibility, inclusion, and support experienced in STEM higher education (Atewologun, 2018; Bickenbach et al., 1999; Crenshaw, 1991; Hall, 2003; Orkwis & McLane, 1998). The framework gives educators guidelines to create more accessible and inclusive educational

environments: face-to-face and online (Bickenbach et al., 1999). Adding a conceptual model served as a checklist for confirming whether proper inclusionary measures were present at the institutes of higher learning under review.

Diversity

Diversity is a buzzword that means varied. Diversity, equity, and inclusion are popular phrases in academia and society (Dewidar et al., 2022). New and whole departments continue to form, even with mounting adversarial rhetoric. In this case, *diversity* indicated the presence of multiple social groups in a setting (Servaes et al., 2022). Dewidar et al. (2022) and Servaes et al. (2022) noted that diversity is the inclusion of numerous social groups to represent better the global community. The U.S. is more heterogenic than ever in recorded history (Frey, 2020; Jensen et al., 2021). People are on the move and seeking opportunities.

With the U.S. becoming more multicultural and multiethnic each year, logic would dictate an increase of diversity in the overall STEM system. However, that is far from reality (Equal Employment Opportunity Commission, n.d.; National Center for Science and Engineering Statistics, 2023). The gender and ableism gap continues to grow (Eagly, 2021; Hussénius, 2020; Zambrano, 2023). Over the years, research has focused on advocacy for STEM education (Pfeifer et al., 2020, 2021; *The state of science and the need for STEM advocacy*, 2022; Velasco et al., 2022). In an attempt to raise awareness of STEM, Doing so is crucial for the global economy and national security (Athanasia, 2022; National Science Foundation, 1950; The state of U.S. science & engineering.,

2020). Educators and researchers have devotedly encouraged students to engage in STEM activities throughout the U.S. educational system for generations (Dewidar et al., 2022; Hansen et al., 2021; Martin & Fisher-Ari, 2021; National Center for Science and Engineering Statistics, 2023). They have actively tried to boost the participation of marginalized social groups (Bergstrom, 2019; Bock, 2022; Hansen et al., 2021). They also continually support the notice of diversity, equity, and inclusion in the STEM system.

Research about diversity is ubiquitous in academia. In the 21st century, however, a particular premium is on diversifying STEM higher education (Mishra, 2020). The university system needs more variety in its candidate pool. To one day increase the diversity of the STEM workforce (Van Miegroet et al., 2019). Marginalized students seem invisible and experience countless barriers to their rightful education. Diele-Viegas et al. (2022) found success with a community support program to keep marginalized social groups engaged in STEM activities to encourage STEM education and, thus, STEM degrees. Arif et al. (2021) offered ten simple rules for supporting underrepresented social groups in STEM education, citing accountability, advocacy, connectivity, empathy, empowerment, and promoting student-centered learning as steps to make STEM education more accessible, inclusive, and supportive of marginalized social groups. Statistically, FSwDs are the least represented social group in STEM higher education, with roughly 10% of the overall 35% of females identifying as having a disability (Klimaitis & Mullen, 2020; Lee, 2020; Wells & Kommers, 2022). In STEM

education, Lee (2020) noted that FSwDs are often forgotten, hidden, or invisible. Exploring FSwDs' experiences with STEM higher education will expose barriers specific to their stories that might have future implications on increased enrollment of marginalized social groups.

Intersectionality

Individuals might identify as belonging to more than one social group. The intersection of those is unique to each person. Crenshaw (1991) introduced the concept at a time when black voices were starting to enrich literature and narratives about the overall black experience in the U.S. and, to some extent, abroad. Rather than through the typical Eurocentric, hetero-patriarchal, superiority complex lens of countless historical events (Blaut, 1999; Keita, 2020; Pokhrel, 2011). In this case, intersectionality serves as an analytical tool used to interpret data from participants in the study from a multifocal perspective if necessary. Female students with disabilities might offer insight into their perceptions of accessibility, inclusion, and support experience in STEM education as well as their recommendations for improving those policies and practices in STEM education with intersectionality in focus. Female students with disabilities may identify as belonging to at least three social groups. Being a female, student, and person with disabilities, however, there are more. The data collected might then provide novel observations and perceptions of those belonging to more than one social group and if those experiences differ.

Person(s) with Disabilities

Defining disability is challenging. The ADA defines disabilities as those legally qualifying, such as emotional, mental, or physical impairments that significantly limit learning and social activities (*Guide to disability rights laws*, 2020). The public continues to debate about what constitutes a disability. A person's disabilities could be visible, such as those in wheelchairs or people who are visually impaired, but someone's disability might be undetectable or invisible to the eye. Learning disabilities are an example, as are those with hearing impairments and any neurological disorders.

Some disabilities fall under a group header, such as neurological disorders, which include learning disabilities like ADHD and dyslexia. In academia, learning disabilities impede far too many students learning. The U.S. Department of Justice and Civil Rights Division (2020) noted that SwDs struggle to acquire and retain basic academic skills because of difficulties understanding and using spoken or written language. The impairments may impact the student's ability to listen, read, speak, spell, think, write, or understand numbered equations in mathematics (Griffiths et al., 2020; *Guide to disability rights laws*, 2020). The struggle is real. Sometimes, it is debilitating for those students who start doubting their abilities (Hughes & Roberts, 2020). Wells and Kommers (2020) found that SwDs are far less likely to choose a STEM major and complete a STEM degree. The researchers suggested that SwDs may lack strong self-efficacy (or STEM-efficacy), advocates, and support but also might feel less welcome in STEM fields (Wells & Kommers, 2022). Research about SwDs is available in various academic journals.

Many focused on the student population with a disability (Miller & Downey, 2020; Mishra, 2020; Scanlon et al., 2021). The data confirms that SwDs experience several barriers to their rightful education (Friedensen et al., 2021; James et al., 2020). Pfeifer et al. (2021) noted that SwDs have internal (self) and external (surrounding environment) obstacles in STEM education, such as a lack of advocacy and support, self-doubt, and low self-efficacy. Studies specific to FSwDs are available, but they are limited, and researchers know little about their experiences in STEM education (González-Pérez et al., 2020; Klimaitis & Mullen, 2020; Lee, 2020; McKinney et al., 2021). More research is necessary to fill the knowledge gaps in the literature about the successes and challenges FSwDs experience in STEM higher education programs at local colleges.

Support Networks

Access to support in education is a vital tool for success. Schools offer several networks of support for students, such as advising, counseling, and tutoring (Canaan & Mouganie, 2023; Mishra, 2020). Advocacy, awareness, and support come together in the disability support services for SwDs. The DSS may be a separate department or part of the overall Student Services Department (Lopez-Gavira et al., 2021). Each school will vary. At present, most have disability support services for SwDs. Creating STEM support might be the next big idea.

Laws protect students with disabilities. The U.S. government has ratified laws to protect SwDs since the mid-19th century (*Guide to disability rights laws*, 2020; *Laws and guidance*, n.d.). In 1975, Congress passed IDEA and made a FAPE available for eligible

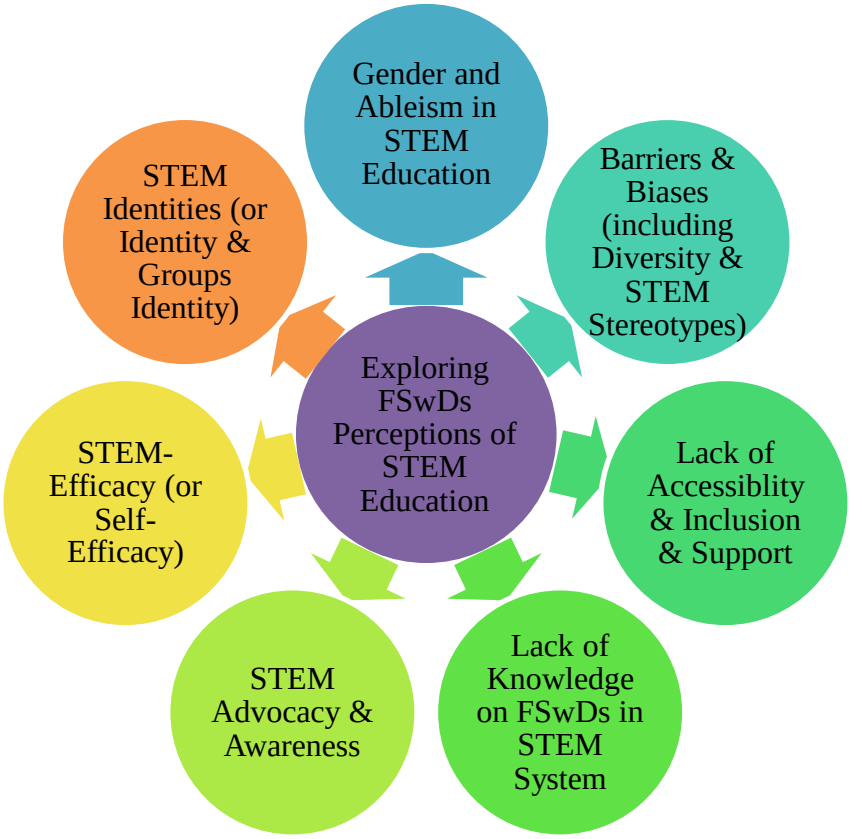
children with disabilities (*Individuals with Disabilities Education Act*, n.d.; Office of Civil Rights, 2020). Arif et al. (2021), Diele-Viegas et al. (2022), and Mishra (2020) found that when SwDs received *proper* support experiences, there was an increased interest in STEM activities. Klimaitis et al. (2021) noted that when SwDs in K-12 settings have STEM-specific instruction using inclusionary applications, such as UDL modifications, SwDs have successes, as do their cohorts without disabilities. In a similar study, Gottfried et al. (2021) observed that SwDs were more likely to graduate high school and attend college after participating in STEM activities. In another instance, and to the contrary, Gottfried et al. (2021) also discovered how those same STEM experiences had no bearing on SwDs' choice of college major.

Despite these laws, FSwDs experience several barriers to their rightful STEM education (Anderson, 2020; Eagly, 2021; National Center for Science and Engineering Statistics, 2023). Lack of awareness, exclusion, and STEM stereotypes are among them (Conley & Nadler, 2022; Eaton et al., 2020; Luo et al., 2021). Accessibility, inclusion, and support experiences are critical concepts in the literature regarding FSwDs in STEM education (Klimaitis & Mullen, 2020; Wiredu et al., 2021). The extreme gender and ableism gap in these disciplines continues to damage the reputation of institutions of higher learning for several reasons: a) illustrates a lack of accessibility, inclusion, and supportive experiences; b) violates several educational laws that protect FSwDs (Lee, 2020; Office of Civil Rights, 2020; Pfeifer et al., 2021; *Title IX and sex discrimination*, 2021). Accordingly, the planned research answered difficult questions about the

successes and challenges FSwDs experience in STEM higher education programs and their recommendations for improving those policies and practices in STEM education. Figure 1 provides a flow chart of key concepts in the literature.

Figure 1

Flowchart of Key Concepts in the Literature



Summary and Conclusions

Even though much knowledge comes from education, several barriers still hinder student learning worldwide. Whether geography, prejudices, religion, or war are the obstacles, having an education is a fundamental human right, and gaining access to a wide range of supportive learning experiences is vital. The United Nations (UN) agreed

and ratified the Universal Declaration of Human Rights in 1948 Paris (United Nations General Assembly, 1948). The proclamation highlighted the importance of equitable and equal instruction for all learners.

Since then, the international community has emphasized gaining comprehensive and compulsory education. Proponents have advocated to make learning more inclusive and supportive. As a result, countries worldwide have ratified laws supporting mandatory education, with some offering further protections for females and students with disabilities (*Department for Education*, 2023; *Japan education history*, n.d.; *14th Amendment to the U.S. Constitution*, 2021). Still, efforts to fully integrate schools and specialized programs, such as science, technology, engineering, and mathematics (STEM) education, have come at a high cost: monetarily and non-monetarily. Countless people have fought and died for their rightful education (Afary & Anderson, 2023; Memon, 2007; *Title IX of the Education Amendments of 1972*, n.d.). The situation has been dire for many people throughout history, but the fight continues for many marginalized groups, including FSwDs.

Educational initiatives and grassroots movements have tried to modify the system over the years. They attempted to make institutes of learning more well-rounded and welcoming to all learners (Americans with Disabilities Act, 1990; *14th Amendment to the U.S. Constitution*, 2021; *Title IX of the Education Amendments of 1972*, n.d.). To further combat global inequities, the United Nations Educational, Scientific and Cultural Organization (UNESCO) placed *quality education* as number four on the Sustainable

Development Goals (SDGs) (*UNESCO and Sustainable Development Goals*, 2015). UNESCO believes the Education for Sustainable Development (ESD) will provide the knowledge, skills, and values necessary to empower learners, thus motivating individuals to make informed decisions about global issues for present and future generations (*UNESCO and Sustainable Development Goals*, 2015). Education is a tool that allows people to learn exciting knowledge and broaden their perceptions or worldviews.

The current research indicated several possible explanations for the continued gender and ableism gaps in STEM education. The data suggested that the lack of accessibility, awareness, effective support networks, group identity, inclusion, self-efficacy, and enduring STEM stereotypes are among the most shared obstacles encountered by SwDs in STEM education (Friedensen et al., 2021; Moriña et al., 2020; Watson et al., 2022; Wiredu et al., 2021). The research further explained more possible root causes for the persistent underrepresentation of females and FSwDs in STEM education, which include a lack of female STEM role models, negative feedback, STEM self-efficacy, and STEM identity (Friedensen et al., 2021; Gin et al., 2020; Griffiths et al., 2020; James et al., 2020; Lee, 2020; Lockhart et al., 2022; Moriña et al., 2020; Pfeifer et al., 2021). The influence of ethnicity, parents, and socioeconomic and sociocultural backgrounds are also notable obstacles experienced by females and FSwDs in STEM education (National Center for Science and Engineering Statistics, 2023). The topic is multilayered because of several external and internal factors. In consequence, this basic qualitative study will explore FSwDs' experiences in STEM education and fill the

knowledge gap in the literature because researchers know little about the successes and challenges FSwDs experience in STEM higher education programs at local colleges.

Chapter 3: Research Method

Introduction

The purpose of this basic qualitative study was to explore FSwDs' perceptions of their successes and challenges with accessibility, inclusion, and support experienced in STEM higher education programs, as well as their recommendations for improving those policies and practices in STEM education. The study was a basic qualitative design, with semistructured interviews as the research instrument. The variation of methodologies presented in qualitative research allowed more flexibility in studying individuals' perceptions. This study has the potential to make a positive impact on STEM education policies and practices. Providing a better understanding of FSwDs' experiences may allow administrators, organizational leaders, and shareholders, including staff, students, and teachers, to assess their equity goals and identify areas for potential growth within the overall system to improve the health of the college culture.

The following chapter explains the research methods used in this study. Opening with a brief discussion of the research design, rationale for the research, and my role as the researcher. Then, a concise description of the development and preparation procedures, including instrumentation, participant recruitment, data collection, and data analysis. In particular, I noted the inclusion criteria, targeted population and group specifics, participation protocols, recruitment procedures, sampling practices, and

sampling size. The methods chapter also described the compulsory steps necessary to comply with the institutional ethics review process. The additional step was vital to ensure the confidentiality and ethical treatment of individuals participating in the study, thus continually reassuring trustworthiness and finishing with strategies to guarantee credibility, dependability, and transferability.

Research Design and Rationale

The socio-educational problem motivating this dissertation was the gender and ablism gap in STEM education. Based on the available literature, researchers know little about the successes and challenges FSwDs experience in STEM higher education programs at local colleges. As a result, the following research questions sought to gather more knowledge about the situation and accomplish the goals of this study.

Research Questions

RQ1**.** What are FSwDs' perceptions of their successes with accessibility, inclusion, and support experienced in STEM higher education programs?

RQ2. What are FSwDs' perceptions of the challenges they experience with accessibility, inclusion, and support in STEM higher education programs?

RQ3**.** What are FSwDs' recommendations for improving the policies and practices of accessibility, inclusion, and support experienced in STEM higher education programs?

The above research questions allowed the research to focus narrowly on one targeted in-group's perceptions of three elements of learning to align with the research

problem and the purpose of the ongoing investigation. The questions also provided the content and context for developing the interview questions outlined later in the manuscript.

The principal concepts under review were accessibility, inclusion, and support experienced in STEM education. Each term was an essential concept in the investigations of SwDs. Ensuring students have appropriate support was vital to the research and a primary reason for this ongoing exploratory study; however, the goal is for *all* students to have rightful access to and feel welcomed by the STEM education community.

Determining a suitable methodology was essential to efficiently investigate the phenomena of interest and answer the research questions effectively. Incorrectly choosing may cause delays in the research process. The most commonly recognized methodologies for social research are qualitative and quantitative methods (Creswell & Creswell, 2022). Quantitative research investigates relationships between and among variables to observe statistical significance (Burkholder et al., 2020a; Creswell & Creswell, 2022). Kang and Evans (2020) noted that quantitative studies are highly structured and use fixed-response questionnaires. Sample sizes are typically larger than those in qualitative studies because empirical research aims to become generalizable and representative of a given population (Kang & Evans, 2020). Though the parameters are excellent, a quantitative study might hinder my ability to gain in-depth personal narratives to understand the research phenomena better. Qualitative studies seek knowledge about the human experience by gathering perception data to explore

individual circumstances and events in a safe and secure location (Burkholder et al., 2020b; Denzin et al., 2023; Ravitch & Carl, 2019). Qualitative research gathers information about discrete experiences to understand phenomena more nuanced and wholly. The qualitative research process draws upon interviews about personal experiences and the researcher's journal entries for data collection sources (Burkholder et al., 2020b; Denzin & Lincoln, 2017). The findings often reveal comprehensive narratives and informational examinations of individual experiences.

To maximize scholarly objectivity, the researcher must frame the problem as a systematic inquiry that permits multiple possible outcomes. A systematic qualitative investigation allows researchers to accomplish those goals. Narrowing the scope further gives qualitative inquiry a chance to ensure that the research is credible and high-quality. Researchers have agreed that qualitative inquiry supports the *constructivist* tradition (Burkholder et al., 2020b; Denzin et al., 2023; Muzari et al., 2022). In understanding, knowledge derives from individual experiences and is socially constructed and largely subjective. The personal narratives of the circumstances and events. A particular point of view. In contrast, *positivism* theorized that knowledge is objective and ascertainable through observation and experimentation (Burkholder et al., 2020a; Creswell & Creswell, 2022). Attributes that lend themselves well to quantitative research: detached and impartial.

Choosing an appropriate design to answer the research question was paramount to expediting the research process. Patton (2015) suggested a dozen research design

approaches in qualitative inquiry. Phenomenological studies explore a phenomenon. The approach involves examining participant emotions, thoughts, and understanding of lived experiences surrounding a phenomenon (Du Plessis, 2020; Husserl & Gibson, 1931). Participants in a phenomenological investigation share experiences with researchers during personal interviews. Even though interviews were the instrument of choice in the current study, I wished to explore more than one phenomenon. Ethnography and grounded theory are also unique. The former examines ethnocultural dynamics closely - explicitly observing in-group behaviors such as language, learning, and religion (Rosa & Orey, 2021). The latter is to develop theories based on a comparative analysis of past and present experiences about a phenomenon of interest (Glaser & Strauss, 1967; Tarozzi, 2020). My goals were neither to examine one ethnocultural group nor to develop a theory, so these two research designs were counterproductive and well-suited for another type of study. Lastly, narrative analysis and case studies focus on participant experiences in chronological order over long periods (Lane et al., 2020; Ni & Wu, 2023). Ni and Wu (2023) wrote that narrative research analyzes specific experiences with specific events, and FSwDs' perceptions of STEM education explore multiple distinct instances of individuals throughout time. Case studies examine real-life cases (Lane et al., 2020). In the absence of an individual case, the research designs thus defeated the purpose of the current study.

When researchers suspect the more common research approaches will leave the research questions unanswered, they may investigate the phenomenon of interest from an

analytical or realistic point of view. Patton (2015) wrote that *pragmatism* and *generic qualitative inquiry* are equivalent to the *basic qualitative study*. Basic qualitative studies are frequently employed in socio-educational research because basic qualitative inquiry aims to gather in-depth narratives about how participants interpret their experiences. This approach may offer insight into the world around them and help construct their perceptions. Even to observe more about their social identity and social learning behavior.

The basic qualitative research design allowed me to observe the practical implications and impacts of FSwDs' perceptions of STEM education. The approach has fewer restrictions and various instruments and procedures. Participant interviews are standard practice, and soliciting FSwDs' perceptions permitted me to observe multiple outcomes.

Role of the Researcher

Producing credible, innovative, and quality research are three main objectives in any qualitative study. To accomplish these goals, the researcher must control for unintended biases in the research and analysis process (Walden University, LLC., 2010; Wa-Mbaleka, 2020). Ravitch and Carl (2019) noted that a scholar's *social identity* could ultimately alter the research process because the researcher is the primary data collection instrument in original research. In that, a researcher's positionality, or how their social identity and position in society might affect and play a role in the research (Muzari et al., 2022; Wa-Mbaleka, 2020). My involvement was omnipresent as the sole researcher and a

vital instrument. Still, ensuring data was factual, reflective, and unbiased was essential. Gathering and comparing resources, keeping critical information confidential, obtaining cooperation from participating organizations, performing fieldwork, remaining ethical, securing consent, sharing findings, and transcribing interviews were a few steps in the process. According to Wa-Mbaleka (2020), maintaining the data's integrity is critical, and researchers must consider any biases or personal views that might influence the research(Wa-Mbaleka, 2020). To manage these biases, one might incorporate reflexivity into the procedures. Beardmore and Bielefeldt (2023) also recommended maintaining reflexivity–the process by which a researcher reflects on their positionality and thus documents them in the field through observation notes, memos, and reflexive journals. Researchers must consider how past experiences might cloud their judgment, noting whether a researcher's social position, age, disability, ethnicity, gender, or educational attainment affects their ability to conduct quality research.

When qualitative research is personal, managing subjectivity during the analysis process might become difficult. Using reflexivity was necessary so the reader could better understand why specific data were relevant to the study while some were extraneous. Before beginning any task, I stopped, reflected, and documented any potential biases. I successfully engaged in reflexivity before and after each data collection and analysis. If, at any point, a conflict of interest occurred, such as one of my current students wishing to participate, I respectfully thanked them for their time. Then, I kindly explained the unintended consequences of the power dynamics in the student-teacher

relationship on the study outcomes. I have taught at local colleges and worked with local community and disability centers around the region for several years, so screening was necessary for ethical concerns, scientific rigor, and trustworthiness.

Methodology

Qualitative research often reveals in-group's or individual's perceptions of an event or experience. Qualitative methods allow researchers to better understand a participant's experiences through an in-depth and personal approach. Qualitative methods allow researchers to analytically and conceptually integrate narrative and textual data for a more well-rounded investigation of a phenomenon. Researchers may discover why participants have specific ideas, motivations, and opinions by gathering data about participants' knowledge of an activity, circumstance, or event (Burkholder et al., 2020b; Muzari et al., 2022). The current research incorporated and analyzed qualitative data to synthesize broad concepts and themes found in the data to form meaningful recommendations and inspire positive social change. I examined these data to gain deeper insight into a real-world socio-educational problem while filling the knowledge gaps in the literature. To offer empirical, novel, practical, and relevant information for handling the ongoing gender and ableism in STEM education.

Participant Selection Logic

Choosing an appropriate population and collecting participant data takes time, planning, and perseverance. The following subsection describes how I established the participant pool by adding more descriptive information about the participant selection

process. As previously determined from the systematic literature review, FSwDs were the targeted population (in-group) for this basic qualitative study.

Further inclusion criteria helped narrow the search for a more nuanced analysis, such as considering the vulnerability of being a minor, a participant older than the age dependency ratio, or a non-STEM education student. According to the Organisation for Economic Co-operation and Development (2023), the age dependency ratio is a demographic indicator for those outside the primary working-age population. As such, FSwDs aged 18-64 who were currently engaged in STEM activities or enrolled in STEM education courses at local colleges and have their conditions on file were the target in-group under review. The next few paragraphs offered assurances of trust and criteria for inclusion. In addition, they contain the instrumentation, sample size, saturation, and selection procedures.

The conversation about inclusion criteria surfaced in the participant selection, as exclusion is common in research. No matter what the study type. Patton (2015) asserted that the concept of exclusion is recurrent in social science research.

Studying the topic of inclusion still brings about exclusion in potential data sources. According to experts on qualitative research, the inclusion criteria support the identification of a target population in a methodical, reliable, and uniform manner; however, the exclusion criteria include factors and variables that might also make a said population ineligible for the study (Burkholder et al., 2020d; Denzin et al., 2023; Muzari

et al., 2022). Remaining inclusive was a limitation of this study, which thus allowed for the exclusion of potential participants in the research process.

The target in-groups for this basic qualitative study were FSwDs aged 18-64 currently engaged in STEM activities or enrolled in STEM education courses at local colleges and have their conditions on file. Thus, female students without disabilities were unable to participate. Likewise, female students with or without disabilities in non-STEM courses then were prohibited from interviewing. So were any male students with or without disabilities, which, in the end, was a major limitation. Lastly, any currently enrolled students of mine also were disqualified from participating in the study because of potential conflicts of interest and ethical considerations.

To help confirm inclusion criteria, potential participants completed a demographic survey (see Appendix F). The short demographic questionnaire offered descriptive or summary statistics about the target population. The demographic survey was also to gather additional social identity indicators. Denzie et al. (2023) explained how descriptive statistics help qualitative researchers describe their participants. For example, the survey asked the volunteers about their age cohort or group and gender identification. Their age of diagnosis, and if their disability was visible or invisible. The questionnaire even inquired whether the individual was engaged in STEM education activities or enrolled in STEM education courses and had their conditions on file.

While determining how to verify the inclusion criteria, researchers also contemplate the number of appropriate participants for their study. A single case is

sufficient in qualitative analysis, as one person's lived experience could answer a researcher's questions. Despite that fact, many researchers assert that 20 to 30 interviews are optimum; however, more recently, a smaller sample size of 10 to 12 participants is adequate in a qualitative study (Cobern & Adams, 2020; Creswell, 1998; Guest et al., 2020). Thus, I originally proposed recruiting 10 to 12 FSwDs; however, many experts, including Denzie et al. (2023), have said that if the research demonstrated theoretical and data saturation, the number of respondents was of no consequence.

To achieve data saturation, researchers must reach the standard and agreed-upon thresholds. The point at which the researchers have collected enough data to draw the necessary conclusions and any further data collection would produce no value-added insight (Guest et al., 2020; Hennink & Kaiser, 2022). For theoretical saturation to occur, no new information emerges during data analysis and synthesis (Patton, 2014). Both data saturation and theoretical saturation were necessary elements to consider while conducting meaningful qualitative research. Documenting more about FSwDs' perceptions of STEM education was possible with more time and was truly desired; however, the nine semistructured one-on-one interviews conducted were an appropriate sample size to reach theoretical and data saturation.

Participation in research is typically voluntary, which can present challenges in participant recruitment. To limit this, I initiated an email dialogue (Appendix A) with potential partner organizations at local colleges, community, and disability centers and

research institutes to establish participant candidate pools more readily. Though helpful, offering a thank-you gift was an added incentive to participate.

Instrumentation

Even though many research instruments would have allowed me to answer my research questions, conducting one-on-one semistructured interviews was an effective method of gathering rich descriptive and contextual data about participants' experiences in STEM education. Researchers have the chance to observe, record, and take notes on the participants' behavior and body language in addition to their narrative text to log as much data about the interview as possible. Researchers may also apply note-taking strategies and audio record sessions, but today, screen capturing with Teams or Zoom meetings, when accessible and applicable, was an appropriate means of data collection. Before and after each interview, I carefully reviewed the notes, made additional memos, and wrote about the experience in my research journal. Those tools allowed me to analyze, interpret, and reflect on the data collected from multiple perspectives.

Interviews vary in their approach and format. Of the various interview styles, the three main types are distinct. Each adheres to a set of protocols for inquiry. The semistructured interview allows for a more fluid interview protocol. The data collection becomes enhanced by the supplemental follow-up questions, probes, and added comments to gain more insight (Denzin & Lincoln, 2017; Muzari et al., 2022). The technique also enables the interviews to remain formal but more approachable because of flexible protocols.

In contrast, structured interviews abide by a strict arrangement and pattern of questions, which expect short answers (Denzin et al., 2023; Muzari et al., 2022). Finally, unstructured interviews use short lists of broad and general questions, where the participant might lead more conversation (Denzin et al., 2023). Choosing an appropriate style was difficult, but the semistructured procedures were most suitable for this basic qualitative study, which explored FSwDs' perceptions of STEM education.

The semi-structured interview guide was a necessary research component so that the study's validity remained upheld in the ethical review, even in future replication. The semistructured approach provided reliable and comparable data sources (Denzin et al., 2023; Muzari et al., 2022). Muzari et al. (2022) noted how the semistructured interview allowed for an open-ended style of questioning–expecting participants to address specific topics while leaving room for them to elaborate and add further details about their experiences when necessary (Muzari et al., 2022). I used follow-up, probing, and secondary questions to draw out more information when applicable. I also reduced researcher bias by using open-ended questions, which improved data credibility and eased data analysis (Yarborough, 2021). The semistructured, open-ended interview technique was appropriate for the interview guide.

As the sole researcher and an instrument in the research, my role extended to the creator and developer of the protocols and standard operating procedures for the interviews. I self-developed the interview guide (see Appendix G) to collect participant data. I wrote the interview protocols based on the principles of social identity and social

learning theories, which included aspects of the SciID to incorporate more science identity-specific inquiries described by Lockhart et al. (2022) and Perry (2022). I used appropriate language under ADA laws and the Walden University Institutional Review Board (IRB) compliance standards. I also incorporate recent scholarly articles with research about SwDs and STEM education as templates to develop appropriate and reasonable semistructured interview questions. (Dou & Cian, 2022; Lockhart et al., 2022; Perry et al., 2022). I was exploratory, ethical, probing, and reflexive in the process.

An appropriate data collection tool is essential in conducting quality research and data analysis. Burkholder et al. (2020) and Denzin et al. (2023) noted how, oftentimes, individual interviews allow for a more intimate setting where participants might feel more comfortable sharing personal thoughts without hesitation. As such, the exploration into STEM education used semistructured one-on-one interviews and gathered further insight for added details from memos and reflexive journals. The chosen data collection tool assisted in assembling information about the successes and challenges FSwDs experience in STEM higher education programs at local colleges.

A detailed explanation of the semistructured interview guide follows, with the full documents in the appendices toward the end of the manuscript (see Appendix G). Still, memos and journals were vital, and using these standards helped me remain reflexive. Busetto et al. (2020) suggested using the subsequent list for taking and keeping quality notes, which I integrated into the data collection and analysis:

1. Bracket thoughts and assumptions.

2. Describe interactions without making inferences.
3. Employ pseudonyms for confidentiality.
4. Explain observations in the order of occurrence.
5. Note contextual details.
6. Record the particulars of each interview, such as date, time, and location.
7. When possible, use exact quotes.

Considering data collection tools, scholars contemplate which line of inquiry will best answer their research questions and ensure participants' safe and ethical treatment. Working with potentially vulnerable populations, such as FSwDs, makes following the ADA and IRB standards to the letter a critical element in the research design (*The Americans with Disabilities Act*, 2020). Developing the interview guides starts by formulating topic-specific interview questions that elicit thorough participant responses.

Interview Guide

The interview guide (see Appendix G) communicates the planned interview protocol. Researchers agreed that having a formal set of procedures helps keep the interview portion of the research design hyper-focused (Denzin et al., 2023). Yob and Brewer (n.d.) emphasized how the interview guide is a list of critical details the researcher plans to cover in the interview. Offering specifics about the inquiry helped answer the IRB's questions on Form C and the work to become replicable.

In the one-on-one semistructured interviews for this basic qualitative study, interview questions ranged from precursory to insightful about personal experiences and

private thoughts. I specifically asked nothing harmful, but the questions may have conjured emotional responses. I ensured limited risk.

The social identity theory and social learning theory offered guidance and structure for the research design in the theoretical frameworks underpinning the investigation. Interviews included (Katz-Buonincontro, 2022). The two theories provided the operational terminology and working definitions to develop ethical interview questions that align with the research design (Bandura & Walters, 1963; Tajfel & Turner, 1979). Still, thoughtful vocabulary assisted in establishing a non-threatening and secure environment for participants to feel comfortable sharing privileged information. Learning about participants' experiences allowed me to illustrate how FSwDs have encountered and perceived accessibility, inclusion, and support experienced in STEM higher education programs.

From the onset, I asked eight preliminary background questions to gauge an individual's common knowledge of key definitions and vocabulary used in academia and specific to STEM education, as well as their particular major and future profession choice. For example, *how* participants define *accessibility* and *inclusion*. Similarly, *what* are *ADA* and *STEM*? Also, *what* support have they experienced in higher education programs at local colleges or in general, specifically in STEM education? The protocol also contained probing questions regarding an individual's social identity and learning behaviors and how in-group and out-group dynamics affected their perceptions of learning. More thematic questions followed about their perceptions of successes and

challenges with accessibility, inclusion, and support experienced in STEM higher education programs. In each set of themed questions, I also asked each FSwDs to offer recommendations for improving those policies and practices in STEM education. The final question of our exchange invited participants to share any further thoughts and feelings they believed were relevant to the discussion. A few follow-up conversations with participants were necessary to gather additional information. In those cases, I reverted to email communication, the most accessible and inclusive method for everyone.

Procedures For Pilot Studies

Pilot studies were part of the preparation for the final study. I asked a few people to assist in mock interviews. Each was a female with disabilities who worked in a STEM field. No consent was necessary, as I only conducted pilot interviews with colleagues, friends, and family to practice. The simulated conversations helped determine the time required for the interviews to ensure that the study's consent form accurately estimated the intended time requested by volunteers. In the end, I conducted three mock interviews. At the end of each interview, I asked if the person would perform a post-interview debriefing over the phone or online at Teams or Zoom (the most accessible for the individual) for respondent validation. The member checking involved asking the participants whether the interview questions were understandable and if they were comfortable answering them. If any necessary changes occurred, I modified the interview questions and resubmitted them to the IRB for approval. Ultimately, the questions were

appropriate and applicable, with little adjustment necessary. Walden University's approval number for this study is 09-10-24-1154573, expiring on 9 September 2025.

Procedures for Recruitment, Participation, and Data Collection

As previously described, conducting semistructured interviews was a suitable data collection instrument to assist me in answering the research questions and allow for a better understanding of the gender and ableism gap in STEM education. The next few paragraphs provide the recruitment, participation, and data collection techniques I used for this study. In the end, I also offered some further limitations of this study and the means to remedy them while complying with IRB approval.

Recruitment

Recruiting interview candidates is difficult for most research. Even when participants come from a random, broad base of candidates (Denzin et al., 2023), soliciting individuals to volunteer is necessary, and the following section offers participant recruitment, participation procedures, and data collection strategies.

The processes listed below were specific to this current study and IRB conditions. Ethical considerations are standard and vital in any human-centered research. As is making the research replicable. Creditability, dependability, and trustworthiness are part of the foundations of quality research (*Research ethics review process by IRB,* n.d.). Confidentiality, privacy, safety, and security are noteworthy, too. Researchers risk becoming denied access to human subjects or in danger of being unreliable. Abiding by the ethical rules documented in the IRB applications and offering a detailed explanation

of the research plans ensured the study remained compliant and of the highest integrity. The rules are rigid, rigorous, and legally mandated because assurances of trust are fundamental to social research.

Early in the research design and development, during pre-prospectus approval at an IRB Office Hours, the specialist advised me to contact potential partner organizations in advance to inquire whether a secondary ethics review specific to their institution was necessary to become a partner organization because an individual's privacy and safety must remain of the utmost importance throughout the entire research process. After securing the necessary email addresses, the initial email correspondence investigated whether potential partner organizations required individual ethics reviews to conduct research at their facilities and if the organizations were interested in becoming research partners (see Appendix A).

At first, four local colleges claimed to have internal review boards for organizational research but made no mention of ethical review for outside researchers to gain access to potential volunteers. In the busyness of graduate studies and the work-life balance, I naively took that to mean no additional permissions were necessary. Once I gained IRB approval, I could work with specific departments to access potential candidate pools.

At the same time, I also emailed (see Appendix A) a few local communities, disability centers, and research institutions to ask if they had any specific research ethics reviews. Some responded, and some messages went unanswered. Out of those who did

reply, none required a separate ethical review. Emails to local research institutes went unreturned. Many affiliated with local colleges and medical schools likely required full IRB approval. After a few weeks, I repeated the process with limited success and, after a month, ceased communication with any who failed to act in response.

During the ethics review stage with the IRB, I emailed potential partner organizations to continue the conversation and officially become partner organizations (see Appendix A). In the six-plus months since my last correspondence, some policies had changed at local colleges; however, I also realized some of the information received previously was inaccurate. Each of the four colleges required an additional review. Some did have an institutional review board, some used the internal research review board to grant permission to outside researchers, and some required senior college administrators' permission.

Even while disheartened with the additional steps in the research process, I began the procedures to become a partner organization with the new information. After procuring the necessary email addresses for those who grant institutional approvals, I sent another message (see Appendix B). Some schools responded promptly, while some took a few weeks and a short follow-up email to see if someone possibly overlooked the message. Each had a research application process, and I corresponded with one person at each college. The requests were to ensure my research posed no potential harm to their students and to present my research plan. The applications varied, but they asked for similar information about the study. Descriptive details include the title, university

affiliation, timeframe, benefits to the community, and conflicts of interest. The schools also required me to detail the participant recruitment and data collection techniques, my chosen instrumentation, the demographic survey, and participation invitations. Some even specifically asked about debriefing strategies.

The participation invitations or *participation flyers* described the purpose of the research, participation inclusion criteria, incentives, and privacy regulations (see Appendix D). The invitation to participate also provided helpful debriefing information about the study, such as entrance and exit strategies, and details about the interviews, such as the length of the conversation, with potential dates, times, and locations. The participation flyer also included the quick response (QR) code, which linked to the consent form and demographic survey, where volunteers implied consent to participate in the study by providing an email address and then answering the demographic survey. The participation flyer also served as a means for departments within the partner organizations to read the planned communication first.

While becoming partner organizations, one college also asked for a letter of recommendation, which the Director of the Graduate Program thoughtfully supplied (see Appendix I). As I continued to complete the applications and submit them for review to the organizations, the opening recruitment technique posed an issue with another college. The college vice president found concerns in the original request to have partner organizations confirm inclusion criteria and have initial contact with volunteers. Since ADA and FERPA laws prohibit me from accessing or obtaining private student records

without prior written authorization, their assistance was necessary to ensure compliance with federal regulations (*Family Educational Rights and Privacy Act (FERPA)*, 2021; *Guide to disability rights laws*, 2020). Directly below is a copy of the initial request.

Initial Participate Recruitment Denied by One College

The organization would confirm the inclusion criteria and email the participation invitation to the target in-group. Once the students responded to the email, the researcher established no conflicts of interest, such as having the student in a current class. The researcher would then reply to the email and set up an interview—first, the place, and then the day and time.

After being denied access to one college, I immediately amended the recruitment procedures to include three additional options. The following ordered list provides each of the four recruitment possibilities. In authorizing the partnership, the organizations kindly accepted one or more of the four choices for participation recruitment: (a) the organization would confirm the inclusion criteria and email the participation invitation to the target in-group. The students would scan the QR code to imply informed consent and complete the demographic survey. The researcher would then establish no conflicts of interest, such as having the student currently in class. The researcher could then email the volunteer to set up a place to interview. Followed by a day and time; (b) the organization would confirm the inclusion criteria and compile a list of target in-group volunteers. They would then send the researcher a password-protected file of the potential volunteers' email addresses. The researcher would establish no conflicts of interest, such as currently

having the student in class. The researchers would then send the participation invitations to the potential candidate pool. The researcher promised to send only one email without any repeat messages. After volunteers had scanned the QR code, provided informed consent, and completed the demographic survey, the researcher emailed the volunteers to set up a place to interview. Followed by a day and time; (c) the organization would allow the researcher to post the participation invitation at their facilities. The students would then scan the QR code to imply informed consent and complete the demographic survey. The researcher would personally verify the inclusion criteria using descriptive data. Additionally, the researcher would verify no conflicts of interest, such as currently having the student in class and any remaining study conditions. Once confirmed, the two would set up a place to interview, followed by a day and time. (d) If the potential partner organization declines to participate in the research, the researcher will respectfully thank them for their time and end communication with that college about my research.

Even with the addition of more recruitment possibilities, one college chose option four and declined to become a partner organization. From there, I approached a fifth local college. I followed the same steps as listed above to become a partner organization. The recently added school opted only to allow number three, while three partner organizations left the choice to the individual departments, staff, and me. After we had decided, the approving members of the college asked me to communicate which options we had chosen. Ultimately, I submitted the acceptance letters with my Walden University IRB Application Form C.

Once the necessary IRB ethical compliance standards were approved, I could begin working with the Walden University Participant Pool. The IRB emailed a notification explaining that they would contact the participation pool on our behalf. Still, students file a form and await confirmation before being added to the Participant Pool webpage. The recruitment tool was helpful, but securing local participants was an initial concern, as was garnering the targeted in-group. Verifying the individual was an FSwDs also worried me because laws prohibit me from assessing such private medical and institutional records. However, in the ethics review application process, the IRB assured me they would work with the Participant Pool administration to secure candidates that meet the inclusion criteria. The help was very much appreciated.

In addition to the Participant Pool, I distributed participation invitations according to the agreed-upon procedure for each of the four colleges outlined above. One school allowed me to post the participation flyer on their campus. The college contact person had me email the Student Development Department for assistance. They graciously posted 25 study flyers around their campus. After two weeks of limited responses, I sent a follow-up email to ask if the college marketing department could help circulate the participation flyer. The marketing department kindly offered to post the study flyer on the college's social media page and weekly newsletter. The participation flyers remained posted until the end of recruitment. I then emailed the college to thank them for their assistance and had the study flyers kindly withdrawn.

The three remaining colleges still had decisions to make. Two schools were fine with options, one through three. One was consolidating student records databases; thus, they were unable to search its databases by the inclusion criteria, so it allowed me to disseminate participation flyers on campus. The Department for Belonging, Diversity, Equity, and Inclusion considerately posted the participation invitation on campus. Similarly to the previous college, I sent a second message after a couple of weeks asking if the college marketing department could circulate the participation flyer. They suggested contacting the Student Empowerment and Success Department, who courteously added my participation invitation to their monthly newsletter. The study flyers remained posted until the end of the recruitment. I then emailed the college to thank them for their assistance and asked if they would please take down the participation flyers.

Of the two remaining colleges, one picked options two and three. The Disability Department and Enrollment Services compiled a password-protected list of email addresses for students who fit the inclusion criteria. After the information arrived, I reviewed it for quality to ensure students did meet the remaining inclusion criteria of having no conflict of interest, such as being a current student. Once I completed those steps, I sent the participation invitation to those students (see Appendix D). I only sent one email to each student without any repeats and waited for a reply. I also worked with their Student Services Department to post participation invitations around campus. I omitted contacting the marketing department because the college had already narrowed

the potential candidate pool. The participation flyers remained posted until the end of the recruitment. I then emailed the college to thank them for their assistance and kindly asked them to remove the participation flyers.

Before the last school could make a final decision, the contact person died suddenly, and I felt that giving the school time to grieve was only polite. After a few weeks, I reached out again and waited to hear back from someone new. When someone responded, they required at least three weeks to decide. The process was still pending after completing the ninth interview.

The local community and disability centers mentioned earlier had no additional ethics review. However, a few of those who responded to my secondary emails did require approval from senior administrators to allow permission to post my participation invitation at their facilities. The main concerns were the potential conflicts of interest and any financial profitability for me. Ultimately, all of those who answered my email approved my requests. From there, I emailed a copy of the participation invitation or dropped off physical copies of the flyer. In total, there were nine local community and disability centers.

Ultimately, I also sought candidates using snowball sampling or asked participants who volunteered if they knew of additional candidates who fit the inclusion criteria and would be willing to participate. I kindly asked them to pass along the participation invitation if they did. New volunteers would follow the abovementioned procedures by scanning the QR code to imply informed consent and complete the

demographic survey. Authentication was paramount, as the study's credibility relied on the trustworthiness of scientific rigor.

Participation

As volunteers implied consent and completed the demographic survey, I established no conflicts of interest. The primary concern was that females did, in fact, meet the inclusion criteria. First, I confirmed that females were aged 18-64. Second, each candidate was a female with a disability who was engaged in STEM education activities or enrolled in STEM education courses at local colleges and had their conditions on file. Lastly, the student was not in my classes to ensure no conflicts of interest.

Once the inclusion criteria were verified and the FSwDs met the conditions, I emailed them to schedule a time and pick a location for the interview. I also explained that individuals were welcome to contact me with questions or concerns before and after our conversation to, hopefully, build an initial rapport with each participant. I also gave them some background information about me, such as my educational journey, disabilities, and what prompted my research. At the time, I reiterated that the interviews should take approximately 45 minutes, as explained in the research invitation (see Appendix D) and consent form, and asked if they had any questions.

As mentioned previously, the locations for the in-person meetings were the same local colleges, community, or disability centers where I had permission to conduct research and post my participation invitations. Still, remaining accessible and inclusive was also the goal. So, FSwDs could choose to have an online interview via Teams and

Zoom, an over-the-phone interview, or even an email interview when applicable, and arrangements for those occurred individually. For participants who identified as deaf or hard of hearing and blind or visually impaired, an email questionnaire mirroring the in-person interview guide was also made available as a data collection instrument for accessibility and inclusion. Each method followed the steps outlined above to remain consistent and compliant with ethical considerations and the rules of scientific inquiry.

Individual Interviews

Ultimately, I conducted nine semistructured interviews with FSwDs about their perceptions of STEM education. Securing one additional volunteer to meet the proposed 10 to 12 participants was difficult. It was more troublesome than anticipated, but later in the manuscript, I offered potential reasons why participant recruitment may have seen delays. Even using snowball sampling and extending the recruitment to include more recent students, securing volunteers took a while. After an initial content data analysis, nine semistructured interviews were adequate to reach data and theoretical saturation. So, recruiting more was no longer necessary, and the study could move into the next stage.

Email interviews

One FSwDs requested an email interview—an accessible choice and availability option—so I coordinated with the volunteer similarly to all FSwDs after they implied informed consent and completed the demographic survey verification process. In the same message, I asked F9 if they would please monitor their time to maintain the approximately 45-minute interview protocol approved by the IRB for consistency. I also

asked if they would please return the answers within 24 hours. I then reiterated that if there were any questions, to please email me.

In-person Interviews

At the onset, I corresponded with partner organizations to arrange private, secure, and soundproof rooms for FSwDs who requested in-person interviews. The plan was to keep interviews on a set schedule, but as the weeks went by, we scheduled interviews as space and time permitted for everyone. There were ultimately three in-person interviews, and I coordinated with partner organizations individually. One volunteer had to reschedule their in-person interview due to illness, which was no issue with the organization. Once we rescheduled a day, the partner organization had no problem reserving a room.

On the day of the in-person interviews, I met participants at the location where we were meeting about fifteen minutes before the set time with a warm greeting and proper introduction. We then used the most accessible and inclusive transport for the FSwDs to the secure interview room. From there, the conversation began.

Online Interviews

For online interviews via Teams or Zoom, I entered the meeting 15 minutes early to ensure that the software had no issues with sound. I also prepared the session to record with closed captions and was ready to begin as the volunteers arrived. Once they did, the conversation started. I originally thought online interviews at Teams or Zoom would be a

popular choice. In the end, two FSwDs chose the online interview option. One selected Teams and one opted for Zoom.

Over-the-Phone Interviews

Online interviews have become so commonplace that I originally had no anticipation of over-the-phone interviews but prepared for them. I have a Google phone number and called the volunteers at or just before the scheduled time. Once they answered, the conversations began. Ultimately, three FSwDs opted for over-the-phone interviews

Data Collection

The steps below were necessary and applied to all data collection techniques: in-person, over-the-phone, and email interviews or online at Teams and Zoom. The email interviews were more structured but limited my involvement; however, the compliance standards were the same. I also reminded the individual that all our emails were recordings of conversations as if we were in a live audio-recorded session. The transcripts were visible throughout our chain of communication.

In the opening statement, I reminded the participants that I would record the sessions for accuracy. I invited them to add further thought during the interview and feel free to stop me or ask me to repeat something if they required clarification or more time to think. Lastly, I asked the participants whether they had any questions before we started. The interviews consisted of a 16-question interview guide: 15 primary queries and one inquiring whether they had anything further to add or ask. The semistructured

approach allowed me to ask secondary questions when necessary, which I built into the protocols from the beginning (see Appendix G).

Each conversation lasted roughly 45 minutes. When FSwDs chose the email option, I politely asked if they would please try to observe the timeframe of approximately 45 minutes to complete the interview questions for consistency with IRB-approved standards. I then stored all data collected in a locked filing cabinet at my home office or on my password-protected computers, and oftentimes both when dealing with electronic and hard copy data.

Using emails ensured accurate verbatim transcripts were available immediately when applicable. Transcripts for online interviews at Teams or Zoom were also available instantly. I transcribed the audio-recorded interviews later for the in-person and over-the-phone interviews.

I provided each participant with a copy of their transcripts to check the accuracy of the data collected. According to Denzie et al. (2023), member checking was a necessary step in the research process to ensure credibility. Detail reviews ensure the transcripts adequately capture what each participant intended to communicate (Denzin et al., 2023; Rubin & Rubin, 2012). The process was demanding but well worth the effort and confidence of knowing that the research was dependable.

Whether the interviews were in-person, over the phone, via email, or online at Teams or Zoom, I reverted to the original email correspondence when I had a follow-up question or required clarification. I used the same email chain so that everything was in

one place for efficiency and easy reference. Again, I thanked them for participating in my study, being an asset to the research, and assisting in filling the knowledge gaps about FSwDs' experiences in STEM higher education at local colleges for a more well-rounded analysis of the gender and ableism gap in STEM education.

I also included a debriefing statement in the initial participation invitation and discussed quality assurance, ethics, and more; however, after the interviews, another debriefing occurred via email to explain the exit strategies. The goal was to offer participants a chance to read the completed dissertation after approval from the Chief Academic Officer at Walden University. The participants' confidentiality and security were of the utmost concern in all aspects of this research process, but also by IRB ethics standards. As a result, I promised to appropriately dispose of all transcripts after five years per the guidelines set forth by Walden University and the IRB. Once possible, I would destroy and shred the documents to comply and thus safeguard against any future harm.

Before data collection, my committee and a small panel of subject matter experts (SMEs) evaluated the interview protocol to establish *face* validity. The panel included an expert in STEM education and a specialist in disability education and support. I kindly asked each member to review the interview guide to ensure all of my questions were aligned with the research questions but were free from basis and in no way leading.

The interview protocols served as a guide during the research design. The procedures helped organize specifics about the data collection process. The primary data

collection for this basic qualitative study consisted of nine semistructured, open-ended, in-person, over-the-phone, email, and online interviews – the most accessible and inclusive for each participant. The ensuing notes, memos, and reflexive journals enhanced data collection. As previously determined, I solicited participants from local colleges and community and disability centers.

Data Analysis Plan

The in-depth nature of qualitative investigations allows researchers to independently assess rich textual (e.g., narrative) data before analyzing and interpreting the results. Lazarsfeld (1937) brought the concept of a qualitative review into scholarly conversation so that researchers could evaluate individual experiences and formulate an understanding of participants' points of view and opinions–their perceptions of a phenomenon. The approach enables investigators to methodically analyze the data collected for a quality investigation of phenomena (Lazarsfeld, 1958, 1961). Burkholder et al. (2020) also noted that the qualitative research design has many steps to execute dependable, meaningful, and trustworthy investigations, such as identifying which research approach aligned appropriately with the purpose of the study and would best answer the research questions early in the process. Remaining ethical during the research process and employing reflexiveness in performing quality data collection and analysis was also vital.

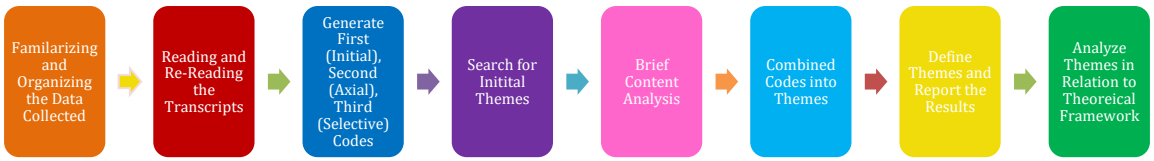
Proper data analysis was foundational in conducting a thorough systemic synthesis of all source data with care and scientific rigor. Lester et al. (2020) and Locke

et al. (2022) systematically analyzed source data for patterns and themes. After each analysis and synthesis, I compared the notes to explore similarities and differences in responses.

Data analysis included a variation on Lester et al. (2020) and (Vears & Gillam, 2022), which used Bruan and Clark (2006). Lester et al. (2020) noted them as phases 1-7. Vears and Gillam (2022) observed them in six phases. Each has some that overlap but adds distinction and consists of:

Figure 1

Flowchart of Data Analysis Steps



Data collection began once the initial research steps, including the IRB Form C application, were organized, completed, and approved. After all the data were collected and organized, the data analysis began. Whether interviews were in-person, over the phone, via email, or online at Teams or Zoom, transcribing the recordings was necessary.

The email interview immediately came with transcripts, as did the online interviews from Teams or Zoom; however, I also transcribed those by hand to ensure correctness before sending each participant their records to check for accuracy. At the outset, I transcribed each in-person and over-the-phone interview by hand. In addition, with the assistance of a transcription service (Denzin et al., 2023; Lazarsfeld, 1972; Lester et al., 2020). Summative and verbatim transcriptions are two primary examples of transcribed interview records (Halcomb & Davidson, 2006; Lester et al., 2020). In the verbatim transcription process, researchers methodically write word for word what precisely a person said.

On the contrary, the summative option allowed for various data collection techniques, such as interview transcripts, reflexive journal notes, interview journals and memos, participants' records, and more. Thus, I created a summative narrative of the keywords, concepts, and themes found in the textual data (Basit, 2003; Halcomb & Davidson, 2006; Lester et al., 2020). Both techniques assisted in comprehensively examining data sources and making further data analysis more manageable.

After the extensive transcription of the text files is complete, most researchers use coding techniques in qualitative research. Codification is a method used to examine interview transcripts and reflexive journals so that researcher carefully examine their notes and organize and categorize the research materials by assigning descriptive classifications and labeling the passages of documents (Lester et al., 2020; Saldaña,

2021). Codes take unstructured information and provide structure to assist researchers in establishing patterns and hidden themes within the data.

Codification is a detailed and intricate process. Researchers agreed that coding may begin after the conclusion of the first interview or observation (Lester et al., 2020; Rubin & Rubin, 2012; Saldaña, 2021). As a result, during the research design and development stages, I became tasked with choosing an appropriate coding style. Researchers may use manual long-hand or automated coding software (Locke et al., 2022; Saldaña, 2021). Computer automation has rapidly become the quick way to codify research materials. Even so, many experts argued that manual, long-hand coding is more accurate, detailed, meticulous, reflexive, and thorough, as described by Locke et al. (2022) and Saldaña (2021). Still, using a combination of hand coding and computer-automated software is now standard practice in qualitative research.

While codifying source data, investigators may rely on a combination of coding techniques. I thus analyzed the data collected using axial, open, and selective coding to identify rich patterns and themes from individual details collected during the research process (Saldaña, 2021; Siegle, 2023). In the hand-coding procedures, various strategies assisted in analyzing and synthesizing these data. As seen in Saldaña (2021), open coding is a typical first step. The approach allows the researcher to take an initial assessment of the materials. Saldaña (2021) wrote that phase one codification is descriptive and identifies concepts, categories, and themes. Some researchers also employed in vivo coding simultaneously (Basit, 2003; Saldaña, 2021; Siegle, 2023). The additional strategy

uses verbatim text from the participant interviews to capture their perceived experiences for authenticity.

Phase two was the axial coding stage. The technique focused more on systematically examining the data to identify relationships between categories and subcategories (Siegle, 2023). According to Saldaña (2021), axial coding establishes connections and linkages between concepts. Thus, it organizes and reorganizes, even re-categorizes, the codes based on their relationships. Researchers may then use those associations to create graphic images, such as diagrams, to visualize the connections.

The next phase was the selective coding stage. Selective coding further refined and organized the data (Siegle, 2023). Researchers use this step to explain the observed phenomena, identifying core categories and central themes that capture the research's essence. Ultimately, this allowed me to integrate each codification phase and create a cumulative, evolving data loop. By completing a thorough data analysis, researchers have the opportunity to contribute new knowledge to their field of study and fill gaps in the research literature. This basic qualitative study allowed me to assess the gender and ableism gap in STEM education more broadly than in the past.

Issues of Trustworthiness

As part of the research process, researchers ensure the utmost quality of their studies. They establish trustworthiness by monitoring research for scientific rigor. Stahl and King (2020) and Ahmed (2024) wrote that reliability is visible in how well the results accurately convey reality. All data collected reflects participants' noted

perceptions and experiences. Four principles should govern the research process, including measures to determine confirmability, creditability, dependability, and transferability.

Making qualitative research findings generalizable to various populations is part of the process. In qualitative investigations, researchers assess transferability by providing comprehensive and detailed explanations of their research design, development, procedures, and methods (Ahmed, 2024; Stahl & King, 2020). Using thick descriptions allows future researchers to replicate their study.

Remaining consistent helps a qualitative study ensure reliability. Having dependable instruments and applications available was comparable to reliability in quantitative research, which made the pre-, during, and post-preparation stages vital for trustworthiness (Ahmed, 2024). The study was replicable, and another researcher could complete the experiment according to the letter.

Being credible might seem daunting and complicated. According to Stahl and King (2020), staying objective in human-centered research is possible when the researchers report positionality and potential biases in the findings instead of personal assumptions, perspectives, and preferences. Researchers also obtain credibility by using cross-referencing techniques to analyze all data collected to examine the phenomenon of interest comprehensively (Ahmed, 2024). Cross-referencing allows for more accuracy in interpretation.

Achieving confirmability was also possible by keeping reflexive journals. Still, allowing peer briefing to occur and agreeing to have one's work receive critical review by committee members during the research process was another (Denzin et al., 2023; Morton et al., 2023). The criteria above might offer examples of how qualitative researchers remain true to scientific rigor and convey accuracy from the beginning to the end. However, more evidence to support the ethics and trustworthiness of this research is available throughout the manuscript and was part of the research design from the start.

Ethical Procedures

Approval and permission to conduct the study during the research process are essential in human-centered research. The ethical treatment of participants must be of the utmost concern. To accomplish this goal, I used several safeguards to ensure participants' confidentiality, safety, and security.

Before beginning participant recruitment, we must obtain Walden University's IRB approval. The institutional review board ensures ethics govern the research. In the process, I confirmed participation from partner organizations to conduct research at their facilities and with students under their care. I secured cooperation with partner organizations through written consent. Once those initial procedures concluded, I also obtained formal written permission from each participant.

The consent form was a letter detailing the study: the purpose, its inclusion criteria, participation requirements, and more. The form explained the terms of the

agreement. The document included wording such as (a) participation was entirely voluntary, (b) confidentiality promises, and (c) participants may withdraw at any time.

By the advice of several colleagues, I respected the guidelines outlined per the Basic Ethical Principles outlined in the Belmont Report (The Belmont Report, 1979). Holding myself to high ethical standards ensured that participants' treatment was of moral conduct and performed with care and kindness. In the Belmont Report, beneficence, justice, and respect are three cornerstones of human-centered research. I ensured the well-being of all participants in the highest regard (Nagai et al., 2022). I created a study design to minimize the risks to participants.

As noted above, no conflicts of interest clouded the research for compliance. Suppose a student was, by chance, a current student. I kindly thanked them for their interest but explained that they were ineligible with the inclusion criteria. I might have professional connections with local colleges because I teach at five colleges and universities in my state. Still, the above inclusion criteria should alleviate any risk of noncompliance.

The only incentive for partner organizations was to become an agent of change through innovative social research. No financial incentive was available to them, but female students with disabilities who volunteered and completed the interviews received a small incentive to participate, as noted in the IRB application. I used pseudonyms without links to their identity for privacy throughout the research process. I redacted any identifying language in the data analysis and synthesis stages.

As the sole researcher, I was the only person with access to data. Raw or otherwise. I am responsible for electronic data, which remains password-protected on my personal computers. I transcribed all of the participants' interviews myself. All printed content or materials, such as handwritten notes and reflexive journals, will also stay secured and locked in a filing cabinet at my home office. I will retain all study-related materials for 5 years, as Walden University requires. After 5 years, I will shred the documents in my home office and take them to the local recycling center for proper disposal.

Summary

The methods section presents a researcher's methodology for a study. In the preceding chapter, I detailed this study's research design and development to explore FSwDs' perceptions of STEM education. The research followed a basic qualitative design with a targeted in-group of nine FSwDs. Each pre-scheduled conversation consisted of a semistructured in-person, over-the-phone, email, or online interview - the most accessible and inclusive for everyone. After each, I analyzed and synthesized the data collected. Surveying interview transcripts, memos, and reflective journals to create and define a set of codes for examining patterns and themes found in the data.

Using a reflexive journal to maintain academic and scientific integrity, I bracketed personal thoughts and opinions. Reflexive memos add to the rich textual data analysis. Per the IRB, I have no personal and current professional relationships with individual participants, ensuring no conflicts of interest. I also used a researcher-developed

interview protocol (see Appendix G) to collect data from semistructured one-on-one interviews.

In the planning stages, I established cooperation with potential partner organizations. Before soliciting potential volunteers from each organization, I forwarded study briefing materials and inclusion criteria. Then, I followed the dissemination strategies outlined above for the participation invitations.

Eligible participants were FSwDs aged 18-64 who were currently engaged in STEM activities or enrolled in STEM education courses at local colleges and had their conditions on file. They also had to provide informed consent and conduct a demographic survey for further descriptive background information. Once FSwDs contacted me, I confirmed no conflict of interest.

To analyze the collected data, I followed the Lester et al. (2022) and Locke et al. (2022) approach to analyze and synthesize the data from the interviews and reflexive journals. Trustworthiness criteria came through assurances of credibility, transferability, dependability, and confirmability. Following IRB compliance standards, I guaranteed the ethical treatment of all participants. I also confirmed the privacy of individual participants and partner organizations. I ensured participation was voluntary, and individuals knew they could withdraw from the study anytime. The results from the investigation follow in the next chapter. I will discuss the findings in detail.

Chapter 4: Results

Introduction

Researchers know little about FSwDs' perceptions of their successes and challenges in STEM higher education programs. The purpose of this basic qualitative study was to explore FSwDs' perceptions of their successes and challenges with accessibility, inclusion, and support experienced in STEM higher education programs, as well as their recommendations for improving those policies and practices in STEM education. To better understand the experiences of FSwDs in STEM education, the following three research questions guided the study:

1. What are FSwDs' perceptions of their successes with accessibility, inclusion, and support experienced in STEM higher education programs?
2. What are FSwDs' perceptions of the challenges they experience with accessibility, inclusion, and support experienced in STEM higher education programs?
3. What are FSwDs' recommendations for improving the policies and practices of accessibility, inclusion, and support experienced in STEM higher education programs?

In this chapter, I provided a detailed report of the study results. The section began with a description of the pilot studies. I then explained the circumstances and settings for the final research and the demographics of the participant sample. Followed by data collection, analysis, and synthesis. The content and thematic analysis are then presented thematically and organized according to the research questions. I close with evidence of

the study's trustworthiness, including specifics about credibility, transferability, dependability, and confirmability throughout the research process. The chapter ends with a summary and transitions to Chapter 5.

Pilot Studies

Conducting pilot studies ensured the reliability and validity of the interview protocol in preparation for the final research. I conducted pilot interviews with four females with disabilities who work in STEM fields and volunteered for the pilot study. The pilot interviews helped me determine the reliability, understandability, and validity of my research questions and confirm the length of the interview so I could give potential participants a reasonable estimate and practice my interviewing skills.

The first pilot study was a mock interview, as the interview was an impromptu discussion with a colleague at work. Unfortunately, I was unorganized, and my hyperactivity made the conversation seem chaotic. The volunteer also had more questions for me than I had anticipated. The individual wanted to know more about the research topic, me, and the PhD program. I realized the study required more organization to make this research possible. I had to focus and improve myself.

The next was success in terms of practice. I was better prepared and had the mindset to conduct research. We were in a private, intimate, and quiet space. The volunteer was cooperative and followed along well in the simulation. The pilot interviewee only asked questions when seeking clarification about a question. The interview took 35 minutes.

The following pilot interview was equally productive but a unique experience because the volunteer talked slower and added more detailed information. The conversation itself was more deliberate and poignant. I even spoke more slowly, and the interview took nearly an hour.

For the dialogue, I decided to include three additional questions to the interview protocols (see Appendix G) about FSwDs' program of study, with secondary inquiries to explore further their chosen career path and even their life's goals to add another layer of complexity to the conversation after asking about their major, presented in Figure 3

Figure 3

New Queries for the Interview Protocols

Added Primary Questions with Additional Secondary and Probing Inquiries
1. Would you please share details as to why you chose the program of study? a. Would you mind sharing some of your life goals? b. What profession or vocation do you hope to join? 2. Would you consider yourself a person who works well with groups or individuals? a. If groups, would you explain why you feel this way? b. For individual work, could you explain why you think this way?

The final pilot interviews took 50 minutes. Adding two more questions allowed more descriptive data to emerge, which was fortuitous in the final study. I started to feel

more comfortable in my role as the researcher and had a sense of calmness and confidence in the process. I was more controlled, and my hyperactivity, impulsive responses, and quickness were in check.

From the experience, I decided to add another question about social identity theory to the interview protocols. Figure 3 above also illustrates the addition of a social learning theory query, each with two more probing questions attached to explore further FSwDs' perceptions of STEM education.

At the end of each pilot interview, I asked the individuals if they would conduct a post-interview debriefing over the phone or online at Teams or Zoom (the most accessible for the individual) for respondent validation. Member checking allowed me to ask whether the interview questions were understandable and if they were comfortable answering them. After modifying anything, such as the interview flyer, QR code, or questions, I resubmitted the amended documents to the IRB for approval. Ultimately, the questions were appropriate and applicable, and I was approved to conduct my final study research.

Setting

In the final study, I collected data from nine ($n = 9$) FSwDs in four different settings: (a) in-person, (b) over the phone, (c) via email, or (d) online at Teams and Zoom. Securing one additional volunteer to meet the proposed 10 to 12 participants was challenging. Even with the use of snowball sampling and extending the recruitment to include recent students, securing volunteers took time.

Recruitment is difficult in most research. Several factors might be the reasons, such as the inclusion criteria, lack of community awareness about ongoing research, logistics, and time commitments to start (Denzie et al., 2023). The exact reason why recruitment took longer and was more difficult than anticipated for my study is speculative; however, narrowing the target population to FSwDs did disrupt the process and pose challenges.

Several male students with disabilities wished to participate but were unable to because of the inclusion criteria. Non-STEM students, male and female, wanted to participate but were again unable to join the study because of the targeted population. Also, our social identity is ever-evolving, changing, and morphing as we grow and progress in life (Tajfel & Turner, 2010). Today, the term non-binary signifies a person who self-identifies uniquely regarding the gender-conforming norms of society (Miller et al., 2021). Thus, this may have been a reason for the lower and slower-than-expected numbers of volunteers.

To further complicate the issue, some females might have a formal medical diagnosis with no accommodation on file or may not socially identify as a person with disabilities. For example, those with neurological disorders such as sensory processing or mental health diagnoses like social anxiety, even those with diabetes, might not socially identify as a person with disabilities (Raspa et al., 2021). To offer an example, anecdotal, but still a sample. I am a person with formal diagnoses of disabilities, but I do not socially identify as an FSwDs; thus, I may have confounded the inclusion criteria myself.

Regardless of which setting an FSwDs chose for accessibility reasons, I scheduled and confirmed the interview through email after receiving implied consent and the demographic survey. Three requested an in-person conversation. Three decided to interview over the phone. Two choose online interviews using Teams and Zoom, and one via email.

The email interview was a result of the volunteer missing three scheduled interview times, and we concluded that the online forum was the most accessible for them at the time. The participant felt remorseful and expressed regret several times but also interest in participating in the study. Consequently, I chose to allow the individual a chance to complete the interview questions via email because of time constraints. I asked them to please try finishing within 45 minutes for consistency with the first eight participants and to please return the answers within 24 hours. After the initial difficulty in scheduling, the email interview ended with the transcripts intact. I conducted transcript verification and member checking afterward for consistency.

Demographics

Eligible participants were (a) FSwDs aged 18-64, (b) currently engaged in STEM activities or enrolled in STEM education courses at local colleges, and (c) have their conditions on file. Figures 4–6 and the narrative text below summarize the descriptive demographic data of the participants in the study. I offered visual and narrative data with details about each FSwDs' current age, level of education, medical diagnosis, social identifiers, age of diagnosis, study pseudonyms, social learning preferences, and the

discernibility of the disability.

Figure 4

Descriptive Graphs–# of Participants by Age Group

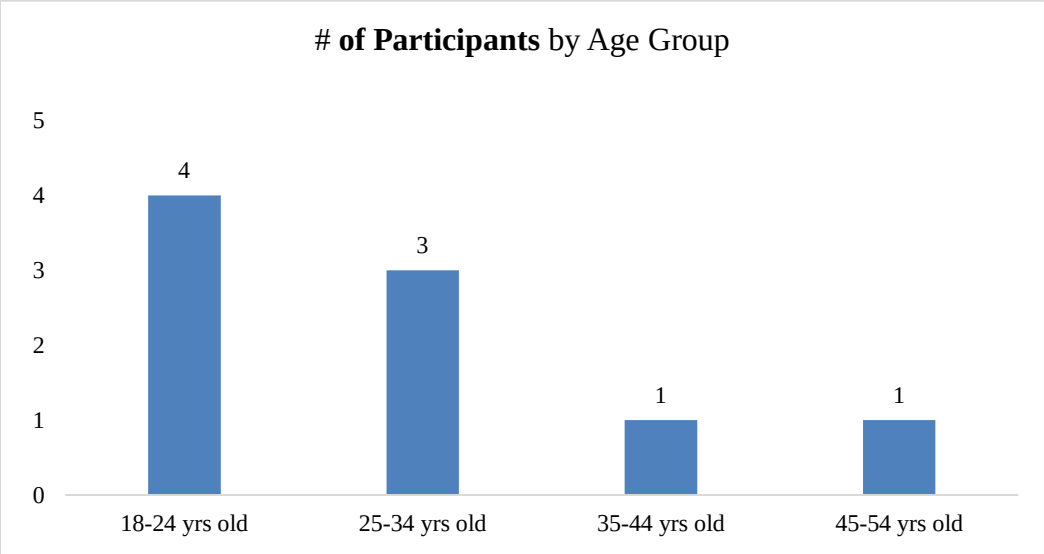


Figure 5

Descriptive Graphs–# by Level of Education Completed

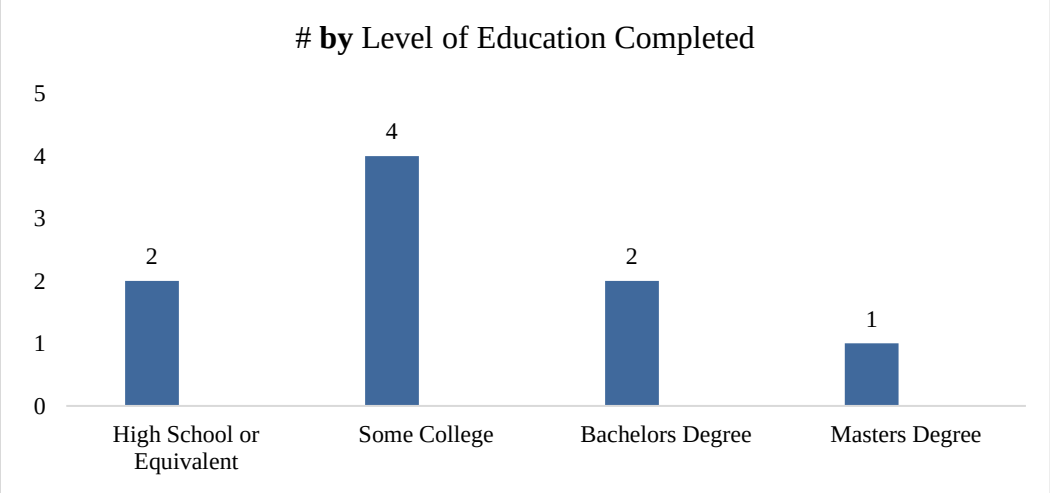
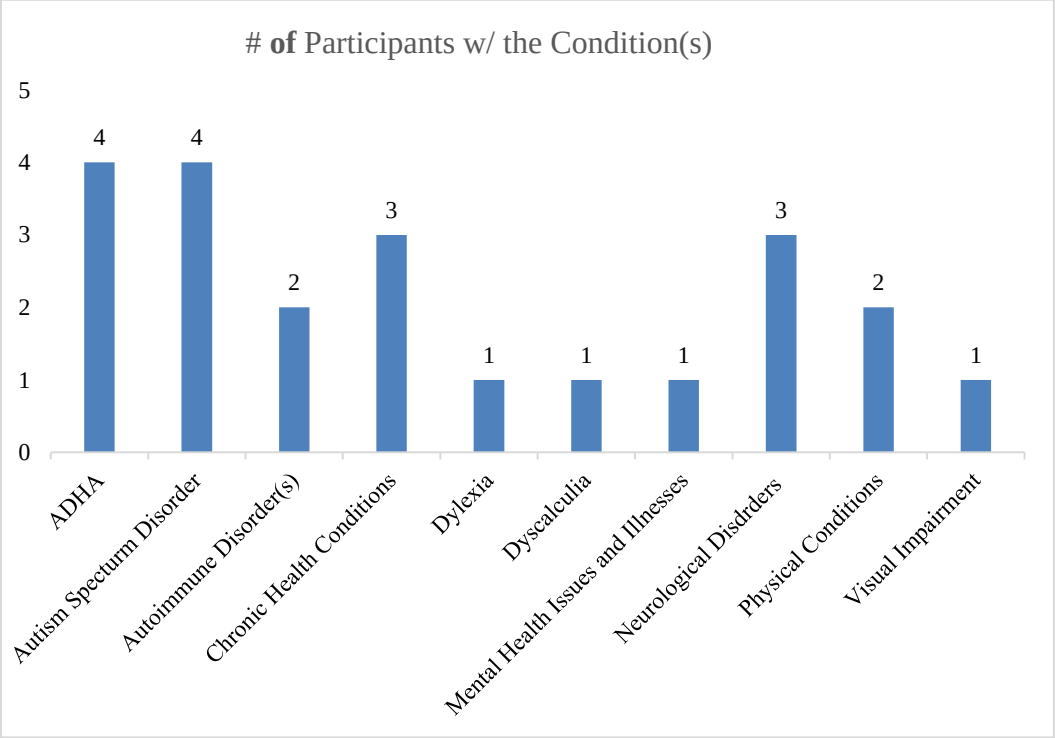


Figure 6

Descriptive Graphs–# of Participants w/ the Condition(s)



Female Student with Disabilities One

F1 was an 18-24-year-old person diagnosed with autism spectrum disorder (ASD) during adolescence. The disorder is largely invisible, and people are only aware of the situation if F1 chooses to share their personal information in public spaces. They also have college experience at two schools in the area: one 4-year university and one community college. F1 is a forensic biotechnology major. F1 socially identifies as being an FSwDs, a member of the LGBTG+ community, as non-binary (they/them), a person with disabilities, and by their ethnicity. The college administration, staff, and teachers know the situation through the accommodations on file with the college. F1 uses college

support services for examinations and prefers working in groups when familiar with the material under review; otherwise, they may fall behind and would rather work individually for optimal success.

Female Student with Disabilities Two

F2 was an 18-24-year-old individual with an adulthood diagnosis of ADHD and is partially blind in one eye. The disorder is invisible; however, the visual impairment becomes visible when the student uses the necessary accommodations to allow for the least restrictive environment in the classroom. F2 sits in the front row and oftentimes uses a recording device to assist. F2 left college for a few years for personal reasons but is back studying zoology. F2 socially identifies as being an FSwDs, a member of the LGBTQ+ community, and a person with disabilities. F2 prefers working alone and has much of their life. F2 expressed feeling shy and awkward in groups. Teachers at an early age would say that F2 could work alone when groups were assigned. F2 rarely uses college support services because of their overall inexperience with them. Disability or any student support, but F2 would like to know more and will investigate further.

Female Student with Disabilities Three

F3 was a 35-44-year-old person diagnosed with rheumatoid arthritis and migraine headaches in adulthood. The participant was formally diagnosed with obesity but went through a gastric bypass, and the medical field no longer classifies them as obese. F3 sometimes still suffers from the symptoms of the condition. The autoimmune disease and neurological disorders are occasionally visible but mainly invisible. F3 has experience at

multiple colleges in the area over several years. F3 is an RN but recently returned to school after a few years away for medical reasons and returned to major in mathematics, but loves the sciences. F3 was currently taking classes within the biology discipline. F3 socially identifies as FSwDs and a person with disabilities. F3 prefers working individually and at their own pace. Working in groups can sometimes pose challenges because effective communication is generally lacking in their experiences, and group members are unreliable. F3 noted having no experience with college support services, disability, or otherwise. Still, F3 would like to know more, will investigate further, and begin next semester with formal accommodation on file with the college.

Female Student with Disabilities Four

F4 was a 25-34-year-old individual with an adulthood diagnosis of narcolepsy without cataplexy, which means F4 goes without episodes of muscle fatigue and paralysis. The illness is a lifelong neurological disorder that went undiagnosed in childhood. The disorder is visible and invisible, which can cause challenges. Narcolepsy remains largely invisible but may become visible when an episode occurs. F4 has a Bachelor of Science, a Master of Arts, and several state and national mental health certifications. Currently, F4 is completing prerequisites for medical school. F4 socially identifies as an FSwDs, a member of the LGBTQ+ community, a person with disabilities, and by their profession or vocation. F4 will work in groups but prefer to work individually because, in their experience, “too many people” allow for “too many opinions” that may “cloud the subject and delay the projects.” F4 uses college support

services occasionally but firmly believes more guidance should be available to all students, especially vulnerable populations, such as SwDs, first-generation college students, and those with limited experiences in academia and college support services.

Female Students with Disabilities Five

F5 was a 45-54-year-old person with adulthood diagnoses of ADHD, ADS, and myasthenia gravis. The disorders are invisible and visible. Myasthenia gravis might cause muscle contractions and spasms, which become noticeable. An instance of hyperactivity in speech or movement is also present sometimes. F5 has completed some college but is currently enrolled in STEM classes and was undecided on a major but leaning toward biology—the biomedical science field. F5 socially identifies as an FSwDs and as a person with disabilities. F5 prefers working individually because of their experience dealing with imprudent and unreliable people. F5 believes the work suffered and wasted valuable time. F5 uses support services for STEM courses, such as tutoring in mathematics and statistics, but rarely uses them otherwise. Disabilities support or any college support services, such as tutoring or the library.

Female Student with Disabilities Six

F6 was a 25-34-year-old individual with several diagnoses throughout their lifetime, but mainly in adolescence with more in progress. In them, ADHD, C-PTSD, depression, general anxiety, and *extreme* social anxiety, with an ADS diagnosis in review. The conditions are visible and invisible. Obvious signs of distress, like a flinch or changes in behavior, such as withdrawal and fluctuations in speech, make them more

visible. F6 was currently enrolled in STEM classes and studying environmental science, focusing on computer automation, such as geographic information systems (GIS). F6 socially identifies as an FSwDs and a person with disabilities. F6 prefers working individually as their extreme social anxiety makes them feel nervous in groups. F6 also expressed challenges noticing social cues and struggles with interpersonal skills. F6 feels more effective and focused when working alone, which works well with their chosen career path in GIS. F6 was also unaware of the many college support services available. Still, together, *we deduced* that social anxiety hindered their ability to seek support services, whether for disability support or any college support services.

Female Students with Disabilities Seven

F7 was an 18-24-year-old person diagnosed with ADS during adolescence. The disorder is largely invisible, but people are aware of the situation without F7's acknowledgment or consent. F7 recently graduated high school and enrolled in college classes for the first time. F7 is an information technology major. F7 has no preference for working in groups or individually. F7 works well in both settings, and I have no issue with either personally. F7 socially identifies as being an FSwDs and a person with disabilities. F7 uses some college support services through their accommodations and generally has positive experiences with college support services but admitted to having little experience with them otherwise and was eager to learn more.

Female Students with Disabilities Eight

F8 was an 18-24-year-old individual who became disabled in adulthood while on special assignment at a STEM education cooperative (co-op) during undergraduate studies. While at a chemical plant, and with minimal to-know safety training, F8 was completing a task under some large metal pipes and accidentally walked into one of them. In doing so, she struck her head and hyperextended her neck. Sometimes called whiplash, the person in charge immediately dismissed the on-the-site incident; thus, the injury went untreated. In the end, F8 said, *"*Too long." F8 was a scared nineteen-year-old at a college-funded co-op, "in pain" and "unsure what to do." The person in charge was unhelpful and unconcerned. Once she received a proper medical evaluation and diagnosis, she suffered a traumatic neck injury, which is a permanent condition and causes chronic pain. The lasting injury is invisible and visible. It is obvious when F8 is in pain and requires assistance opening a door or when placed in the back of the classroom at a military desk.

For example, chronic pain makes opening doors difficult. So, suppose a building lacks the necessary accessibility accommodations, such as automatic doors. In those instances, F8 waits for someone to help, seeks an alternative route, or opens the door herself and "experiences extreme pain." She graduated with a Bachelor of Science. F8 is a doctoral student in biomedical science. F8 prefers working individually in academic settings because F8 are task-oriented and like to work at their own pace. F8 regrettably had several poor experiences in group settings, including becoming permanently disabled

on a group project where F8 was the only female student. F8 socially identifies as an FSwDs, a person with disabilities, and by their profession or vocation. F8 has experience with college support services, disability support, and more, such as libraries and tutoring.

Female Student with Disabilities Nine

F9 was an 18–24-year-old person diagnosed in early childhood with ADHD, dyslexia, and dyscalculia. The conditions are largely invisible. Made visible in various ways, such as reading aloud or becoming impulsive in response. F9 is also undergoing testing for additional neurodevelopmental disorders, such as ASD and auditory and sensory disorders, in addition to mental health concerns, like anxiety and depression. F9 graduated with a Bachelor of Science while waiting for an interview for this study. She is a geoscience major focusing on automated mapmaking, cartography, and GIS. F9 prefers to work individually, which bodes well with their chosen career path in GIS. F9 socially identifies as being an FSwDs, a member of the LGBTQ+ community, by their ethnicity and by their profession or vocation. F9 uses some college support services through their accommodation and has generally had positive experiences with the college support services. However, F9 admitted to having little experience with them outside of using the geoscience lab for tutoring and the library.

All nine FSwDs expressed interest in learning more about college support services, such as disability support services or any college support services like library support and tutoring services. Each noted that they would be very interested in learning

more about STEM education support services—disability or otherwise. In the coming paragraphs, additional details about data collection become available.

Table 1

List of Most Common Participant Diagnoses with Definitions: The National Institute for Mental Health and the National Library of Medicine

Name	Definition	# of participants
Attention Deficit and Hyperactivity Disorder (ADHD)	ADHD is a neurodevelopmental disorder often explained by inattention, impulsivity, and hyperactivity. Three to five percent of the U.S. population have a formal diagnosis.	4
Autism Spectrum Disorder (ASD)	ASD is a neurodevelopmental disorder relating to how someone behaves, communicates, and learns in social settings—common displays of repetitive behaviors and challenges with interpersonal development and communication skills. As of 2020, ASD affects roughly 2.8% of the U.S. population.	4
Autoimmune Disorder(s)	Autoimmune disorders are neurological disorders that occur when the body's immune system attacks and damages healthy cell tissue by mistake. More than 80 autoimmune disorders have formal diagnosis, including narcolepsy, myasthenia gravis, rheumatoid arthritis, etcetera.	3
Chronic Health Conditions	Chronic health conditions are those lasting more than a year and may require ongoing medical treatment. Most are manageable and treatable, but some individuals might develop further health complications. They include conditions such as autoimmune disorders but also conditions like migraines, obesity, traumatic injury, etcetera.	3
Dyscalculia	Dyscalculia is a neurodevelopmental disorder classified as a learning disability that affects an individual's ability to understand numbered information, such as arithmetic and numeracy.	1

Dyslexia	Dyslexia is a neurodevelopmental disorder characterized as a language-based learning disorder.	1
Mental Health Issues and Illnesses	Mental illness is a general term for illnesses that may impact an individual's thoughts, perceptions, feelings, behaviors, etcetera, including anxiety disorder, depression, PTSD, etcetera. Individuals with *anxiety disorders* may experience feelings of panic, extreme physical, mental, or emotional stress, and intense fear. Individuals with *depression* may suffer from a common mental health condition that may cause a persistent feeling of sadness and changes in how one thinks, sleeps, acts, eats, learns, etcetera. Post-*traumatic stress disorder (PTSD)* is a common mental health condition that can develop after a traumatic event. The conditions commonly involve symptoms such as flashbacks, anxiety, negative thoughts and beliefs, hypervigilance, etcetera.	1
Neurological Disorders	Neurological disorders represent an arrangement of complex medical conditions that fundamentally disrupt the functionality of the nervous system. Neurological disorders affect the brain, nerve networks, and spinal cord.	3
Visual Impartment (including blindness and partial sight or blindness)	Visual impairment, including blindness, partial sight, and legal blindness, is impairment in vision that, even with correction, adversely affects an individual's life.	1

Data Collection

For this study, I collected data by conducting nine semistructured one-on-one interviews with FSwDs. Before the interviews, the volunteers provided informed consent, and then they completed a short demographic survey to offer descriptive statistics for the

data analysis stage. I finished all nine interviews between late September and mid-December 2024.

I followed the interview protocol explicitly detailed in Appendix G for the nine semistructured interviews. Eight interviews were audio-recorded, with two being captured online at Teams and Zoom. The eight one-on-one interviews took approximately 45 minutes. More ended earlier than intended, but two went longer. One interview was via email, and transcripts were attached. FSwDs knew about the approximate time maximum, but I also explained how they could openly speak when time allowed, as suggested by some experts (Denzin et al., 2023; Katz-Buonincontro, 2022). Below, I offered a description of how data collection occurred in the nine one-on-one interviews.

Data Collection for Online Interviews

The online interviews at Teams and Zoom were straightforward. I arrived 15 minutes before the scheduled time to prepare the recording and have everything ready when the participant arrived. Each FSwDs arrived early and had no opening questions, so we started immediately. The first online interview ended shortly after 23 minutes. The second was longer at 30 minutes. The reason for the truncated discussions was FSwDs' lack of experience with college support services, but the evidence becomes clearer in the content and thematic analyses. The subsequent seven in-person and over-the-phone sessions varied in length, but the following describes the procedures for the final email interview.

Data Collection for Over-the-Phone Interviews

The over-the-phone interviews occurred at my home office, and the participants' locations were undisclosed. I called each participant at or just before the scheduled time. One sounded as though they were driving in the car, one was at home, and one was indiscernible. The three conversations were 34, 38, and 58 minutes. Each discussion could have easily continued because the dialogue was thoroughly engaging.

Data Collection for the Email Interview

According to F9, completing the interview protocol via email took 48 minutes to complete the questions, but she chose to take a break and finish in two sessions, for a total running time of 76 minutes. The experience went as expected. I sent the interview questions, and F9 responded with their answers. The lack of personal interaction was unfortunate, but adaptation was necessary to complete the interview in a timely manner.

Data Collection for the In-Person Interviews

The in-person interviews required additional steps, which I thus described last. The face-to-face meetings were on local college campuses or at local libraries. I tried to arrive at least 30 minutes early to assimilate into the setting and become better prepared to start on time. I was later than I intended for one interview, and I felt rushed, so I noted that for the next time.

Depending on the planned location, I reserved private rooms once the FSwDs answered the email regarding what times and days worked best for them. Those on college campuses required that I contact college support services to reserve a space. One

college library only allowed current students to use their study rooms. I actively teach at colleges but have no student account on file to reserve the room.

As suggested by the student service department, I contacted the college convention services, which booked the rooms on my behalf for 3 hours to allow the participant flexibility in selection time. The confirmation messages noted the date, time, and location of the room. We reserved three-hour blocks to allow the volunteers a chance to choose the most accessible option.

Afterward, I contacted the volunteer to set an exact time. One participant had to cancel an appointment because of illness. Once the individual was feeling better, we set up another room reservation. I completed the same steps as above to secure a room.

The rooms were standard classrooms with three rows of tables and the front podium with typically dry-erase boards all around the room. I allowed the individual to choose their seat, then sat two seats away but in the same row next to them. We adjusted ourselves and began.

The third in-person interview occurred at a local library. To reserve a space and time, I went to their website and found a place to make the booking right then. Before making the final reservation, I confirmed the exact time via email and booked a private room. The library's website generated email confirmation.

The private room was roughly 8x8 with a dry-erase board and a table with four chairs. This time, I picked the seat facing the door so that when the person arrived, I was ready to greet them. They sat across from me, and we began.

All three interviews were audio recorded on a handheld recording device or smartphone. In retrospect, the smartphone was an unwise choice, as the transcripts have no time or speech separations, the information appears as one long run-on sentence, and it requires more time to organize and transcribe. The three interviews took 37, 29, and 50 minutes. The conversations were highly engaging, with the opportunity to observe the participant's body language as added kinesics in the data collection.

In-Group Data Collection

At the end of each interview, even the one via email, I asked FSwDs if they had anything further to add or if they had any questions. I then thanked them for volunteering and assured them they were incredible assets to the research. Even at the onset of the interviews, I expressed the importance of their involvement in this original research and explained how highly valued they were for their time and experiences.

After the interviews, I listened to the audio recordings to ensure I asked them all the questions and that they answered them. When we accidentally overlooked a question, such as what professional they wished to pursue after college or if they preferred to work in groups or independently, I emailed them for additional input. They kindly reply with their thoughts.

I then transcribed the audio-recorded interviews for the three in-person and three over-the-phone conversations. The email and online interviews from Teams and Zoom arrived with their transcriptions intact. As did any secondary email questions sent after the interviews.

Outside of the email interview, I presented the remaining eight FSwDs with their transcripts to ensure the utmost credibility in data collection. I also sent a copy to check for the accuracy of the information. I noted three errors or typos in them.

Each was partly a fault of automated transcriptions. Two offered corrections to their statements, and two provided additional details to assist further. One recommended adding another question to discuss mental health, which is a college support service but suggested a more focused conversation about those successes and challenges that might benefit the discussion.

My interview notes, and the demographic surveys were another form of naturally occurring information used to cross reference during data analysis. In an initial examination of the overall data collected, I submitted a preliminary findings report based on a brief inductive content analysis to my committee chair. The former analyzed the frequency of words, concepts, and themes noted in the data (Denzin et al., 2023; Vears & Gillam, 2022). In the process, some inductive thematic analysis began, and early patterns arose, but the full thematic analysis took longer.

Data Analysis

I used the procedures described by Lester et al. (2020) to analyze the interview transcripts and my researcher notes in thematic data analytics. Lester et al. (2020) employed Braun and Clark's (2006) recommendations of six phases but allowed additional steps to analyze the data further. Both inductive content and thematic analyses align well with a basic qualitative study. The approach allowed an opportunity to analyze,

synthesize, and present data effectively while also revealing the particulars of the data collection process (Lester et al., 2020; Vears & Gillam, 2022). The content analysis was a brief look at word and pattern frequency with some thematic analysis. The thorough thematic analysis for this study included the following steps (phases): (a) organize the data collected, (b) read and re-read the transcripts, (c) perform brief content analysis, (d) search for patterns and themes, (e) generate first cycle codes, and then axial and selective codes (f) combine codes into themes, (g) define each theme, (h) present and write up the results (i) analyze themes in relation to the theoretical frameworks. The process went as follows:

Steps A and B

Before anything else, I listened to the recordings and cleaned up the transcripts. Then, I immersed myself in the text to become familiar with the enormity of the data. I read through each interview transcript and my corresponding researcher notes. At the second re-read, I began highlighting and making notes with check marks—potential ideas for first-cycle codes I might use in the following steps.

Step C

Even before the final interview, my committee chair requested a preliminary findings report to gauge whether the data collection and analysis were progressing. I conducted a brief content analysis by generating word frequency reports and choosing initial open codes. Using word frequency reports pivots under the assumption that those tools provide insights into the most prevalent concepts, ideas, and words spoken within

the narrative text (Locke et al., 2022). Saldaña (2021) noted that open coding is a standard first step because the initial assessment allows for descriptive and identifiable categories and themes to emerge in the subsequent data analysis.

Steps D and E

From Step C, I continued with phase one of initial coding, identifying and deciphering common words and phrases. Then, I began phase two of codification. The axial coding phase helped me notice relationships between emerging patterns and establish connections between concepts to present broader categories and subcategories. (Basit, 2003; Saldaña, 2021). The codes were reorganized and re-categorized based on their patterned relationships to the research phenomena: s*uccesses, challenges, and recommendations for accessibility, inclusion,* and *support*. The next phase was selective codification. The use of selective coding assisted in further refining and re-organizing the data (Siegle, 2023). All of these will help me later explain my observations and identify core categories and central themes in the data.

Step F

In each step, I methodically moved through each piece of data collected from the interview transcripts, as well as my researcher notes. With every round of reevaluation, more useful codes emerged. According to Vears and Callam (2022), “work systematically through the entire dataset, attending to each data item with equal consideration, and identifying aspects of data items that are interesting and maybe

informative in developing themes" (p. 1399). Visible patterns and relationships became apparent in the narrative data.

I reviewed the list of codes generated from the previous phases and sorted them into potential themes. Paying particular attention to ensuring the data correlated to each theme demonstrated cohesive and meaningful relationships with a clear distinction between all themes included (Denzin et al., 2023; Patton, 1990). During this step, I refined, combined, and reorganized the separate themes and related subthemes as necessary. After establishing the core themes and associated subthemes, I reviewed them again to ensure they were combined and organized appropriately to reflect the dataset.

Tables 2-4 below show all data source analyses from the initial, axial, and selective codes phases. To maintain the study's integrity, I analyzed one data set at a time, individually and in isolation, before combining the entire coded dataset to formulate the results and interpret the findings.

Table 2

Initial Codes with Frequency of Word Use Overall: In Interview Transcripts and Researcher Notes – in Alphabetical Order

Codes	Frequency	Codes	Frequency
Accessible (access, accessibility, etcetera.)	72	Know(s) (knowing, known, knowledge	502
Accommodation(s)	38	Mathematics	51
Analytical (logical, planned, rational, reasoned, sensible, etcetera.)	42	Misconception(s) (misinformation, misinterpretation[s], misperception[s], mistakes)	22

Available (availability)	41	Passion (pride, purpose, etcetera.)	48
Challenges (campus climate)	96	Person or people	203
College	110	Problem(s) (problem-based learning, solving, statements, etcetera.)	36
Communication (lack, miss, poor, etcetera.)	63	Recommendations	45
Critical (minded, thinking, etcetera.)	36	Science(s)	110
Differ (different)	63	Service(s)	131
Disability	158	STEM	139
Education (higher, STEM, overall, etcetera.)	135	Stereotype(s), stigma(s),	130
Engineering	27	Successes (campus climate)	118
Group	34	Support(s) (lack of, limited, supportive, etcetera.)	123
Higher (education)	47	Task-orientated (controlled, organized, planned, prepared, etcetera.)	21
Included (excluded, inclusion, inclusive, etcetera.)	103	Teacher(s) (professor[s])	58
Individual	32	Technology	36

From here, I reviewed my research questions and sorted the combined identifiable codes into categories, such as successes, challenges, and recommendations. In the process, I even considered how organizing (or re-organizing) codes may influence how one might interpret the findings. For instance, combining *analytical* codes with *problem(s)* and *task-oriented* codes forms a *critical thinking* category and subcategory.

Table 3

Axial Codes with Categories (Subcategories) – in Alphabetical Order

A-E	I-T
Accessibility (access, accommodations, availability, etcetera.)	Inclusion (excluded, included, inclusive, etcetera.)

Awareness (aware, acknowledgment)	Mental health (burnout, unsupported, unwanted, unwelcomed, etcetera.)
Biases (prejudices, stereotypes, stigmas, etcetera.)	Motivation (belonging, confidence)
Challenges (school climate)	Objectivity (impartial, impersonal, etcetera.)
Communication (lack of, miss, poor, etcetera.)	Recommendations (structural)
Critical thinking (analytical, planned, problem-solving, reasoning, task-oriented, etcetera.)	Social identity (group and individual identity and learning)
Efficiency (effectiveness)	Subjectivity (partial, personal, etcetera.)
Efficacy (STEM efficacy)	Successes (school climate)
Engagement (active and interactive learning)	Support (lack of, limited, unsupported, etcetera.)
Equity (equality)	Training (bottom up and top down)

I discovered several codes that combined into themes and bracketed subthemes. For example, I combined the concept and phrase codes *awareness, critical thinking, equity, engagement,* and *motivation* into the theme *innovation and motivation* with an associated subtheme of *cultivating critical thinking and knowledge streams*. In this phase, I also identified codes that may combine with another set of codes. No longer does it fit into the established themes or be relevant to the research topic. I chose to omit two codes, with *college and person or people.*

Step G

I identified and named the core themes and subthemes during the next codification step. By the end of this phase, I defined each theme and related subtheme with a clear and descriptive meaning of each. The final themes and associated subthemes to emerge in data analysis are visible in Table 4.

Table 4

Selective Codes into Themes and Subthemes – No Order

Themes	*Subthemes*
Innovation and Motivation	Cultivating Critical Thinking and Knowledge Streams
Professional Development	Student Development and Enrichment
Improving Communication Networks	Cross-Discipline Collaboration
Services, Support, Structural Upgrades	Offering Alternative Assistance
Impact Behavior and Understanding Perceptions	Self-efficacy (STEM-efficacy), Impartiality and Objectivity
Culturally Relevant (STEM) Teaching	STEM Pathways

Step H

As a next-to-last step, I presented and wrote the results. As I completed the interviews, I analyzed and synthesized the data regarding each research question. Table 4 above presents the selective codes with themes and associated subthemes. By the end, I refined and reorganized each selective code into the final core theme and subtheme.

Step I

In the final step, I assessed the final core themes and related subthemes relative to previous research. I evaluated the findings concerning social identity and social learning theories as the underlying theoretical frameworks of this study to contextualize the research further in the existing literature. I noted the similarities and differences seen in the study. In the case of a discrepancy, I mentioned the inconsistencies and offered probable cause and an interpretation of those distinct findings at the time. The findings are novel, with some consistency for consensus. The core themes and subthemes present

in these data represent the sample size of nine FSwDs. Each of their experiences is unique, but there are several underlying commonalities and a few distinctions.

Evidence of Trustworthiness

Throughout the research process, I employed several measures to ensure the trustworthiness of this study. According to Ahmed (2024), trustworthiness is the degree to which findings accurately reflect the experiences and perceptions of the participants. I accomplished those goals by completing steps to safeguard the research's credibility, confirmability, dependability, and transferability. In the process, the only major adjustment from Chapter 3 was the addition of the brief content analysis for quality. I then moved the theoretical framework analysis of the findings with the current literature until the last step in the data analysis process. Otherwise, no major modifications from Chapter 3 required attention. If so, I noted the subtle alteration.

Regardless of adjustments to the proposed data analysis plan, researchers must be mindful of how their behaviors might influence participants. Keeping a reflexive journal and bracketing my personal experiences prevented personal biases from affecting the collected data and increased the study's credibility. To further promote the study's trustworthiness, I incorporated the demographic survey results and my researcher notes as added support to corroborate the findings emerging from the interviews.

The addition of those documents allowed me to analyze participants' perceptions of STEM education further. The researcher notes and demographic surveys allowed me to explore individual kinetics and even word choices related to the study. To further

illustrate credibility in the research, I also employed member-checking techniques to make certain my interpretations of data were, in fact, reflective of the ideas, perceptions, and thoughts participants intended to convey. The process enabled participants to review their transcripts and my preliminary content analysis. To ensure that I accurately captured, described, and interpreted the data from their interviews.

Quality research requires more than credibility. In qualitative inquiry, researchers must also ensure the confirmability, dependability, and transferability of the data (Ahmed, 2024), which is achieved by effectively and efficiently documenting all of the procedures in the research process. By offering thorough descriptions and keeping detailed records of each step of data collection and analysis, I maintained the study's transferability.

A study's dependability refers to the strength of the research findings across time. According to Ahmed (2024), "in order to assure reliability, researchers rigorously document their approaches, techniques for data gathering, and procedures for analysis" (p. 2). Creating, offering, and preserving an audit trail of details documenting all of the decisions made throughout the research process allows future researchers to reproduce the study. Thereby effectively ensuring the dependability of the results.

Finally, confirmability relates to the impartiality and objectivity of the findings. Researchers must remain unaffected by any potential biases. According to Ahmed (2024) and Stahl and King (2020), peer debriefing, member checking, and reflexive journaling are but three approaches used by researchers. Experts explained how peer debriefing

involves requesting input from colleagues or subject matter experts to authenticate interpretations and mitigate researcher bias (Ahmed, 2024; Stahl & King, 2020). Member checking is the process by which participants examine and validate the accuracy of the findings. At the same time, the reflexive journal enables researchers to record their thoughts, such as personal or professional biases, thus promoting transparency and reducing subjectivity.

During the interviews, I also took detailed notes. The comments detailed my reflections, interview notes, and internal thoughts for data analysis. I also monitored the tone, time, and pace of the interviews themselves. I documented my positionality and desire for an in-person interview over the phone and online to observe participants' kinesics or body language. The online video software transcribes the recording, but a more thorough analysis was necessary because auto-transcription had inaccuracies. Each of the nine transcripts underwent participant verification and member checking.

For the over-the-phone interviews, I called the participants at or just before the specified time. Before beginning, we had an initial greeting of hello and how are you. I started the recording before making the call. Once the phone transcribed the conversation, I went through the dialogue again. Then, I verified the text with the volunteer regardless and conducted standard member checking.

Results

This basic qualitative study aimed to explore FSwDs' perceptions of STEM education. Detailing their successes and challenges with (a) accessibility, (b) inclusion,

and (c) support experienced in STEM higher education. FSwDs offered their recommendations for improving those policies and practices in STEM education.

The first question of the interview was to ask participants to define S-T-E-M. The participants offered reasonable responses; for example, F4 said engineering and math while accidentally forgetting to mention science and technology. F9 mentioned the "T" but missed the "S," and F5 noted the "S" and "T" but forgot the "E" and "M." The engineer nearly forgot to include engineering as part of STEM education. Three of those who noted mathematics said the term as math—the shorter, more commonly heard form of the term.

Each of the nine FSwDs heard the term or acronym STEM at various times in their lives. Those in the 18-24-year-old age group learned about STEM and STEM education in middle school. F1 even offered the term "STEAM" education. The addition of the *A* for arts. Arts in terms of *design* and *development* versus artistic expression seen in the performing arts (Aguilera & Ortiz-Revilla, 2021). Female students with disabilities 25 years old or older heard about STEM education later in their education journey, such as in high school, but three were in adulthood.

Even with the various interpretations of STEM, when asked what characteristics or traits a person in STEM education should possess, all nine participants acknowledged that having passion, pride, and purpose were three personality traits that characterized a STEM education student. Each FSwDs believed being analytical, open-minded, and task-orientated was necessary for STEM education students. Effective communication skills,

independence, self-efficacy, and a little humility were also characteristics FSwDs felt were valuable qualities that STEM education students should possess. Being able to collaborate and share ideas, as well as being able to adapt and lead a team, were additional attributes FSwDs mentioned as important.

In the preliminary questions, I also asked participants to define a few more operational terms applied in this research before moving on to their successes and challenges in STEM education. They explained what accessibility and inclusion meant and finally offered their understanding of the Americans with Disabilities *Act* of 1990.

When asked specifically about *accessibility,* the word "access" was first in all nine interviews— "access" as in admission and entry into a setting. F8 has repeatedly been unable to enter buildings because they lack the necessary accessibility elements of automatic doors at entrances with stairs. F8 claimed the "logic" must be, "SwDs don't use stairs…, so why would the doors open automatically?"

Each FSwDs stated that having *equal access* to learning environments, materials, and tools helped define accessibility for them. F2, F3, F5, F6, F8, and F9 mentioned *accessibility* was for SwDs to learn in the same conditions as their fellow students. F1 and F7 noted accessibility is for "everyone to have access," while F4 said, "Nobody really talks about accessibility…."

Upon pivoting to define the term *inclusion,* F1, F3–F7, and F9 said being "included," such as physically in places and even feeling included in general and in learning spaces. Each spoke to how inclusion also meant being open to differences and

inclusive. Differences included variations in knowledge level and perspectives and differences in age, disability, ethnicity, gender, sex, social identity, social learning, etcetera. F2 and F8 spoke of how accessibility and inclusion might mean the same thing to them because they are meant for all students, regardless of learning styles, to have *access* and *be included*.

All nine FSwDs experienced countless instances of *microaggressions* on college campuses, in the classroom, on the job, and in the world, which made them feel excluded, unwanted, and unwelcome. Spoken and unspoken biases in a person's speech that come across as condescending, demeaning, dismissive, presumptive, and offensive are microaggressions. Common examples are belittling and biased language and traditional gender roles (Miller et al., 2021). Overarching themes in the dialogue were making females (FSwDs, too) seem like second-class citizens or less than males, lazy, and incapable were overarching themes in the dialogue. The collective implication was that FSwDs were lucky to do well on assignments. People, staff, students, and teachers were surprised that FSwDs could complete the tasks.

Lastly, all nine FSwDs were familiar with the Americans with Disabilities Act of 1990. Among the many terms and provisions, the ADA is a civil rights law that prohibits discrimination based on disability (Americans with Disabilities Act, 1990). Seven of the nine knew about the ADA because of their school accommodation. F5 was aware because their child is also a female with disabilities, and she has known about the ADA for years. F6 had experience with the ADA in early childhood, adolescence, and adulthood.

Once the preliminaries concluded, the interviews progressed into FSwDs' perceptions of STEM education. Each offered examples of their successes and challenges with accessibility, inclusion, and support experienced in STEM education. They also presented recommendations for improving those policies and practices in STEM education, and I provide a summation of the results below.

I had three distinct research questions, each focused on three fundamental principles within education. I presented the findings below using the research question. Afterward, I organized the results into the core themes and associated subthemes generated during data analysis to evaluate the patterned outcomes further.

The synthesis will begin with a concise explanation of FSwDs' successes and challenges with accessibility, inclusion, and support experienced in STEM higher education programs, as well as their recommendations for STEM education. Contextualizing the data, which offered rich, narrative text and direct quotes for emphasis. Each theme and related subtheme considered below provided further evidence to support how FSwDs perceive STEM education.

Research Question One (RQ1)

Female Students with Disabilities' Successes in STEM Education

Participant interviews and descriptive data from FSwDs' perceptions of STEM education suggest that they experience college success. Connecting with the material and performing well in STEM activities gave them confidence. Each participant enjoyed

having access to and involvement with experimentation and innovation. They all appreciated being in social learning environments and being hands-on.

All nine noted that they experienced success in STEM education by learning new knowledge and engaging with material. Each found great success in the quintessential 'light bulb' moment when they understood the concept or content under review. The experiences made them feel smart and like they belonged. FSwDs felt included and part of something greater in those moments.

Eight out of nine FSwDs experienced success in performing well on examinations, labs, and in STEM education classes overall. Passing hard classes gave them a sense of accomplishment and motivated them. F5 exclaimed, "I love biology," while F6 said, "I learned a lot." F1, F5, and F6 noted that having extra time for examinations through their accommodation made them more comfortable and thus successful.

F6 was enrolled in their first semester of classes, so they had experienced limited success in STEM education. The FSwDs was doing well in classes but had no specification on those being a success. Their social anxiety makes life extremely challenging in all settings, so the *success* was "being there," she said.

The four FSwDs (F3, F4, F8, and F9) with degrees (undergraduate or graduate) noted that graduating was a major success. F4 simply said, "I graduated…, so that was a success…." Five FSwDs (F3, F5, F7, F8, and F9) have won contests and competitions in STEM activities. F7 was a *mathlete* (a competitor in a mathematics competition). Two

FSwDs (F1 and F7) attended a science camp in high school at a local university, F8 worked on a STEM co-op, and F9 co-authored a paper in undergraduate studies.

Six out of nine FSwDs have successful experiences with college support services. A variety of college support services. Including academic and learning support services, such as admissions, advising, disability services, information technology, library services, online services, registration, student center services, tutoring services, writing support, etc. F2, F3, and F6 have limited experience (successful or unsuccessful) with college support services but would enjoy learning more.

Research Question Two (RQ2)

Female Students with Disabilities' Challenges in STEM Education

In the interviews, FSwDs shared countless challenges experienced in STEM education, such as accessibility, inclusion, and support. All nine FSwDs have experienced challenges in STEM education settings with several obstacles, stereotypes, and stigmas. For example, seven FSwDs received negative feedback from their male counterparts in STEM activities. "The struggles are very real," F8 said. F5 said, "They judge us before they know us." "…They don't want us there." Four FSwDs explained that female cohorts without disabilities sometimes engage in negative behavior. Each sharing similar experiences, F6 saying "people act like they don't know…" or F9 noting how people say the disability "isn't bad enough" to "warrant people being nice…."

F5 expressed experiencing ageism, noting that relating to younger people posed a challenge. Even when people acted surprised that an older person (with disabilities or

not) was capable of completing complicated assignments, F5 also said the behavior is *challenging* to accept. Another conveyed feeling unwelcomed and more like a consolation prize and diversity quota than a member of the team. F8 said, "…I became disabled at a STEM education co-op because there was a lack of safety protocols in place…" and "the professor just laughed…"

F3, F5, F8, and F9 have experienced being the only female in the room, at a convention, or out in the field of STEM activities. Each felt awkward and expressed a feeling of insecurity, unwelcomeness, and imposter syndrome. F2, F4, F6, and F7 felt incapable, insecure, and unwanted in STEM settings. F2 says, "We are just as capable…" and "We are here for a reason." F6 said, "I feel out of place," … "I even look different…" and "…people often respond negatively," while F7 replied, "They called me the R-word…." F1, F6, and F9 expressed challenges with mental health. They often felt burned out, exhausted, and unable to perform to their best ability.

Remaining unidentified, three FSwDs openly cried while sharing their challenges with accessibility, inclusion, and support experienced in STEM education. Two more became verbally upset when sharing their stories. Six exhibited audio and visible nervousness, often fidgeting in place. *Fidgeting* is an unconscious movement unnecessary to the task, such as twiddling one's hair, shaking one's foot, clicking a writing utensil, or fiddling with something (Reinecke et al., 2020; Son et al., 2024; Watson, 2024). Four FSwDs have ADHD diagnoses, in which fidgeting is a symptom.

All nine openly spoke about mental health challenges and fears. Each expressed themselves differently, but their frustration and concerns were evident. F1, F6, and F9 spoke directly about mental health challenges experienced in STEM education, including accessibility, inclusion, and support. Six spoke indirectly about mental health challenges.

F1 shared details about autism burnout and their experiences with those struggles, while F9 spoke of ADHD burnout and feeling inadequate, overwhelmed, and stressed. Burnout syndrome is prevalent among many neurodevelopmental disorders, including ADHD and ASD, often caused by chronic stress, which can lead to mental, emotional, and physical exhaustion (Arnold et al., 2023a; Porto et al., 2024). Symptoms might include feeling drained or depleted and overwhelmed, leading to anger and irritability, a lack of motivation, forgetfulness, and procrastination (Arnold et al., 2023b; Tenev, 2024). F9 said, “I didn’t know I had mental health issues until college,” and another said, “Mental health issues have been a really big hurdle in my academic career.”

All nine agreed that miscommunication, poor communication, or lack of communication by the administration, students, support staff, and teachers (professors) made their learning experiences more challenging. Each expressed being misinterpreted on countless occasions, which made succeeding more difficult. Several described how they received misinformation, which confused them. F4 thought, “There is a lot of red tape…” and “We need more help.” F1 explained that *some* teachers try to simplify the complicated material and inaccurately convey the meaning, making learning accurate information more difficult.

Two FSwDs experienced challenges in the classroom with their accommodations. Due to physical limitations, F8 was unable to sit at a standard college desk. The table for her was at the back of the classroom, where the FSwDs felt "isolated," like "outcasts," and unable to perform at their usual levels. F2 also expressed how low lighting and the classroom setup hindered their ability to succeed.

All nine FSwDs experienced challenges with college support services. The same academic and learning support services are above in the successes portion. For instance, the list includes admissions, advising, disability services, information technology, library services, online services, registration, student center services, tutoring services, and writing support. Three expressed having limited experiences with college support services but remarked on challenges within the support system. F3 explained, "Finding help was a problem…." In-person, online, or over the phone. The FSwDs stated that locating information about college support services was a "perpetual challenge." She noted that the website was also confusing and challenging to navigate. F2, F3, and F6 said, "I have limited knowledge about [college support] services."

Research Question Three (RQ3)

Female Students with Disabilities' Recommendations for STEM Education

Based on these findings, FSwDs have some recommendations for STEM education. Each offered advice on improving accessibility, inclusion, and support experienced in STEM higher education. All nine conveyed a sense of urgency in effective

and efficient communication. Providing accurate and timely information was also very important to each FSwDs.

All nine FSwDs agreed that having a support service specialist available to help navigate the college support services was smart. Disability or any academic support services, in-person and online, on campus, and on the college website. Three out of nine FSwDs were unaware of various support services available to students on college campuses, so they highly recommended including a college support service specialist at registration.

Two further suggestions were to offer more embedded services. Embedded services (ES) are those specifically made to enrich online (sometimes in-person) learning experiences (Marwedel, 2021). Several experts have noted how ES computer systems were expressly designed to perform a specific function within a larger electrical, mechanical, or technical system, thus enhancing the learning experience (Austin & Gavin, 2024; Marwedel, 2021; Spangler et al., 2023). Several colleges around the area have implemented ES, such as library services. IT support, tutoring, and writing center services are fairly common in ES today (Austin & Gavin, 2024; Marwedel, 2021). Disability services have begun to utilize the ES platforms, but each FSwDs suggested more efforts to implement ES as a viable support service available to SwDs.

All nine FSwDs agreed that having a STEM education support service department on college campuses would benefit their learning journey. Each found the idea of STEM-specific support services smart and was very interested in learning more about any such

services. They agreed that STEM education support services would be a success in terms of accessibility, inclusion, and support experienced in STEM higher education.

Core Themes and Subthemes

After I combined the interview transcripts, demographic survey, and researcher notes to find overarching successes and challenges with accessibility, inclusion, and support experienced in STEM higher education and their recommendations for improving these policies and practices, observable patterns in the rich narrative and contextual data emerged. The observed outcomes were a product of several cycles of coding. In codification, several themes and subthemes became apparent.

Female students with disabilities shared many intimate details about their educational journey in STEM education. Each had positive and negative experiences. Female students with disabilities have seen huge successes, but all nine encountered far more challenges with accessibility, inclusion, and support in STEM education. Table 5 below illustrates the final four core themes and associated subthemes generated in data analysis.

Table 5

The Final Core Themes and Associated Subthemes

Themes	*Subthemes*
Fostering innovation and motivation	Cultivating critical thinking, knowledge streams, STEM efficacy, and STEM pathways
Growing communication networks	Cross-discipline and cross-situational collaboration while learning impartiality and objectivity

Promoting enrichment and understanding	Professional and student development with understanding perceptions and impact behavior training
Supporting structural enhancements	Embracing culturally relevant (STEM) teaching and offering alternative assistance

Recall from earlier, studying campus climate was an underlying theme throughout the current study about the gender and ableism gap in STEM education. According to Peterson and Spencer (1990), campus climate measures the attitudes, behaviors, and perceptions of administrators, staff, students, and teachers in higher education. From the data collected, FSwDs indirectly rated the campus climate of their institutions in relation to accessibility, inclusion, and support experienced in STEM education.

These data suggest that each college campus has areas to capitalize on and matters to improve. Below is a summary of the four core themes with their corresponding subthemes observed during data analysis. They follow in order, as seen in Table 5 above on page 137.

Theme 1 – Fostering Innovation and Motivation

All nine FSwDs mentioned successful experiences gaining knowledge and participating in innovation in STEM education. Each found confidence and motivation when they performed well in STEM activities. Everyone noted how STEM education fosters critical thinking skills and offers opportunities to better understand the world around them.

Learning new ideas and concepts inspired the FSwDs to engage more with the materials. According to Bandura (1977), a person's self-efficacy hinges on the belief that they can complete a specific behavior or task. The data supports that when FSwDs have positive self-efficacy or even STEM self-efficacy, they are motivated to learn more. F9 spoke of becoming "so engaged and focused with the material that learning became like an obsession…." "…A passion was ignited inside, and I wanted to learn more and more."

On the contrary, all nine FSwDs also expressed challenges with self-efficacy regarding accessibility, inclusion, and support experienced in STEM education. Indirectly, each spoke of stereotypes, stigmas, and poor interpersonal behaviors, which affected their ability to execute the task as well as hoped. In those instances, the FSwDs felt a sense of self-doubt (known as low self-efficacy) and struggled to perform. Often procrastinating, giving up, or becoming stressed. Imposter syndrome sets in, and succeeding becomes more challenging.

F3, F5, and F8 remarked that sometimes teachers were at the root of the problem in those settings. Affectingly noting, poor teacher behaviors allowed poor student behaviors and thus allowed for discrimination in the classroom. F5 indicated that fellow students say, "…[they] don't wanna be with them." All nine FSwDs offered an instance of ridicule and unwanted behavior.

The nine FSwDs recommended incorporating real-world applications, offering project-based learning opportunities, and using technology to make STEM education interactive and hands-on. Seven out of nine agreed that initiating a STEM club or

promoting a STEM week would foster critical thinking and knowledge streams and encourage STEM pathways. All nine FSwDs also directly or indirectly mentioned that having more females with disabilities as role models in STEM education would surely cultivate and reflect a positive image for STEM education. F1 noted how "having or seeing more females with disabilities…" "in STEM education…" "…as role models would be nice."

Theme 2 – Growing Communication Networks

Communication was a key concept observed in the data. Whether FSwDs mentioned a lack of communication, miscommunication, poor communication, or even (in)effective and open communication, they spoke about communication at length – much of the conversations with FSwDs placed communication with RQ2 and the discussion of challenges. All nine FSwDs expressed frustration with ineffective communication. One replied, "Poor communication leads to poor safety…." Another said," …miscommunication causes misinterpretation…, and can even allow for subjectivity in the interpretation."

Each found that the ineffective communication experienced in STEM education makes succeeding more difficult. They also revealed how often miscommunication or misinformation posed challenges. Even though seven of nine FSwDs noted that effective and efficient communication were vital qualities to possess in STEM education, they struggled to offer much success associated with communication and accessibility, inclusion, and support experienced in STEM education. Nevertheless, all nine FSwDs

communicated effectively and efficiently with me and, thus, offered a successful communication example in STEM education for quality control.

Everyone offered recommendations for improving communication networks in STEM education. Each FSwDs spoke of instances when communication should have occurred between multiple departments to ensure everyone communicated effectively. For example, one FSwDs alluded to having the disabilities department collaborate with STEM education teachers and support staff to ensure SwDs have the proper tools to succeed, such as audio recorders and screen readers, even having table seating in the front with adequate lighting options. Three FSwDs mentioned having the support staff experience the classroom setting with various accommodations to see if the accommodations offered were, in fact, efficient for each learner in those learning environments. One suggested improving "the college websites by highlighting college support services."

All nine addressed follow-up, noting that teachers are often unsupportive and untimely in responding, which makes success challenging. One FSwDs expressed having teachers refuse their request to audio record the lectures, even with the appropriate accommodations. Two liked knowing that some teaching offered learning materials for all learning styles. Audio, kinesthetic, and visual learning are three well-known styles that are most easily accessible (Fransisco et al., 2020). All nine FSwDs spoke of being hands-on, which promoted kinesthetic learning.

Female students with disabilities also spoke to cross-cultural or cross-situational exchanges. Such as having individuals with disabilities available to model appropriate behaviors in learning environments–STEM education or otherwise. From all sides, if possible. Tajfel and Turner (1979, 1986) noted that individuals intrinsically strive for a positive self-image and social identity but will often conform to a group. Modeling proper teacher and student behaviors–a project-based learning exercise.

In so much as to model the behavior: how the female with disabilities could teach about the task, complete the task, and report on the experience. A role-play exercise was what one FSwDs said. Two also mentioned having individuals with invisible disabilities perform the same experiment to see the various outcomes.

Three FSwDs suggested seminar-style, group-relations sensitivity training. Another recommended showing videos of SwDs mistreated to see how fellow students respond. She promoted the ideas as a take on sensitivity training. In theory, the exercise would allow people to recognize their behaviors.

Theme 3 – Promoting Enrichment and Understanding

All nine FSwDs conveyed feeling *enriched* by their STEM education. Despite their challenges, each found *pleasure* and *pride* in being part of the STEM education community. One FSwDs expressed how we use science every day. Each FSwDs collectively found success in learning STEM knowledge. They all see themselves in the STEM community for a long time.

Each expressed a sense of wanting to belong but sometimes struggled to fit into the group dynamics. Three FSwDs have experience being the only female involved in a STEM activity. All nine noted several instances of microaggressions. From administrators, students, support staff, and teachers. For example, being called the R-word or teachers laughing at FSwDs' accommodations or ignoring them completely. Individuals acting dismissive or unhelpful. Even biased and rude. Judgmental and prejudice.

From their experiences, FSwDs want STEM education to become more accessible, inclusive, and supportive of SwDs. All nine FSwDs agree that a top-down or a bottom-up approach to improving the situation in STEM education could be effective. In Theme Two, group dynamics and sensitivity training emerged as recommendations for improving communication networks, and the FSwDs also suggested the same training exercises to enrich college campuses collectively.

In these settings, FSwDs indicated behavior training to improve the situation in STEM education. Behavior therapy is the overarching therapeutic term for behavior modifications, but behavior training is particular to teaching specific, more desired behaviors through structured practice and reinforcement (Hornstra et al., 2023; Van der Oord & Tripp, 2020). Sensitivity training is an educational program that helps groups (campuses) become more aware of their biases and the impact of their behaviors (Van der Oord & Tripp, 2020). Self-awareness, self-identity, group identity, and social identity combine to modify social behaviors in a social learning environment. These nine FSwDs

embraced the teachings of Bandura (1977) and Tajfel and Turner (1979) far more than data would suggest. Each believes change is possible.

A further recommendation was for colleges to create a more advanced and modern college orientation. Seven of nine FSwDs said they had no idea if their college offered an orientation. F4 received an email offering some helpful information upon admission but noted that the message was vague regarding college support services, with *no* mention of disability support services. The remaining FSwDs had a difficult time recalling the information.

I also suggested a campus scavenger hunt to familiarize individuals with the campus and college support services. Eight out of nine agreed. F9 was an email interview, and thus, my ability to offer suggestions was limited, if at all. Six thought the interactive, hands-on game sounded fun. One replied, “She wanted to do it now.” One said, “We could do it in groups for socialization and team-building exercises.” Another added the idea of peer mentorships and embedded mentorships. Similar to the embedded support services discussed earlier, such as library services, tutoring, and writing support.

Theme 4 – Supporting Structural Enhancements

Each FSwDs agreed that colleges could use upgrades to their systems. Three out of nine did speak about promoting college support services more readily. All three have limited to no experience with college support services. The remaining six, with more knowledge of college support services, did offer suggestions for ways to improve the accessibility and inclusion of those services. F4 recommended having assistance

available when applying for disabilities on college campuses. Five FSwDs embraced using *embedded services* (ES) to enhance the learning experience in STEM education. All nine suggested including a STEM education *ES* platform. All nine expressed interest in learning more about STEM education support services.

Whether directly or indirectly, all nine FSwDs spoke about mental health. Mental health in general. Mental health concerns. Mental health questions, such as where to go for help. All nine FSwDs have experienced microaggressions, which they explained have caused them trauma. Often making them feel unwanted and unwelcomed.

Four expressed suffering from burnout syndrome. All four have neurodevelopmental disorders where burnout is common. F6 suffers from PTSD and extreme social anxiety but still wants in-person learning to become more readily available again. F4 is currently a mental health practitioner and suggests that everyone at college use the mental health services available to students.

Another indirect topic of conversation observed during data analysis was celebrating differences. All nine FSwDs took pride in being part of a community of adaptable, curious, courageous, and dedicated females in STEM education. Even though each of these individuals revels in being part of the STEM education community, they often feel isolated and like outsiders. From those sentiments, each FSwDs unconsciously recommended that colleges embrace culturally relevant (STEM) teaching. Culturally relevant (responsible) teaching practices account for all students' sociocultural differences in the learning process, regardless of study.

Summary

Four main themes emerged from open, axial, and selective coding, including (a) fostering innovation and motivation, (b) growing communication networks, (c) promoting enrichment and understanding, and (d) supporting structural expansions. Overall, FSwDs encounter successes and challenges in STEM education. Positive and negative behaviors shape their perceptions. From those, each FSwDs provided insight into their experiences and offered recommendations for improving the learning environment in STEM education. In the final chapter, I discuss and interpret the findings, present the implications, suggest recommendations for future research, and offer my conclusions on the study

Chapter 5: Discussion, Conclusions, and Recommendations

Introduction

The purpose of this basic qualitative study was to explore FSwDs' perceptions of their successes and challenges with accessibility, inclusion, and support experienced in STEM higher education programs, as well as their recommendations for improving those policies and practices in STEM education. To address the study problem, I interviewed nine FSwDs. The study assessed FSwDs' perceptions of STEM education to the extent possible with the limited sample size. The results were in no way inclusive of all FSwDs' perceptions of STEM education, nor do the findings indicate overall grievances from all FSwDs in higher education. The outcomes are the product of a convenience sample, representing those nine FSwDs' perceptions of their experiences in the current STEM education system.

Several noteworthy themes and associated subthemes become apparent during the data analysis process. I presented the thematic findings in the chapter below and then contextualized the outcomes in relation to the literature. First, I discussed FSwDs' perceptions of their successes and challenges with accessibility, inclusion, and support experienced in STEM higher education programs, as well as their recommendations for improving those policies and practices in STEM education. Next, I considered the four core themes that emerged during data analysis: (a) fostering innovation and motivation, (b) growing communication networks, (c) promoting enrichment and understanding, and (d) supporting structural expansions.

Overall, FSwDs experienced successes and challenges in STEM higher education. Each aspect of the conversations and all of the elements provided insight into their experiences. In the end, FSwDs offered recommendations for improving the situation in STEM education. Chapter Five discussed and interpreted the findings, presented the implications, suggested recommendations for future research, and offered my conclusions on the study.

Interpretation of the Findings

The following is an interpretation of my findings. I presented the results thematically, as in Chapter 4. First, I explained FSwDs' perceptions of their successes, challenges, and recommendations relative to the literature in Chapter 2, providing broad similarities and discrepancy cases for a more comprehensive interpretation of the data. Second, I concisely discussed the core themes in relation to social identity and social learning theories as the theoretical underpinnings of the research.

Contextualizing Academic Literature

Previously, researchers knew little about FSwDs' perceptions of STEM education. The recent literature discussed SwDs, or lack of SwDs in STEM education overall versus isolating the conversation to FSwDs (Aguirre et al., 2020; Gin et al., 2021; Griffiths et al., 2020; James et al., 2020; Klimaitis & Mullen, 2020, 2021; Lee, 2020; Lopez-Gavira et al., 2021; McCall, Shew, et al., 2020; Moriña et al., 2020; Pfeifer et al., 2021; Wilson et al., 2000; Wiredu et al., 2021). Some research concentrated on ethnicity and gender diversity in relation to SwDs, but limited information was available about

FSwDs as a social in-group (Bhatti, 2021; Campos, 2020; Eaton et al., 2020; Leyva et al., 2022; McGee, 2021; Miller et al., 2021; Miller & Downey, 2020). Studies about the gender gap in STEM education were in abundance, with barely any specifically focused on FSwDs. Fewer still discussed FSwDs in higher education or STEM higher education.

The literature made clear that SwDs experienced several obstacles to their rightful STEM education. The data suggested that the lack of accessibility, awareness, effective support networks, group identity, inclusion, self-efficacy, and enduring STEM stereotypes were among the most shared obstacles encountered by SwDs in STEM education (Friedensen et al., 2021; Moriña et al., 2020; Watson et al., 2022; Wiredu et al., 2021). The literature offered explanations for the possible root causes for the persistent gender and ableism gap in STEM education, which included a *lack* of acceptance, access, female *STEM* role models, negative feedback, STEM identity, and self-efficacy (Friedensen et al., 2021; Gin et al., 2020; Griffiths et al., 2020; James et al., 2020; Lee, 2020; Lockhart et al., 2022; Moriña et al., 2020; Pfeifer et al., 2021). The nine FSwDs under review in this study also expressed their concern about the above barriers and offered plausible explanations for the ongoing situation in STEM education.

Each FSwDs had experience with difficult learning conditions on numerous occasions. Feeling unwanted and unwelcomed were undoubtedly common points of contention. An overall lack of empathy and respect for FSwDs in STEM education resonated throughout all nine interviews–disrespect from administrators, staff, students, and teachers. The FSwDs recommended implementing sensitivity-style training and

promoting individual enrichment to help in STEM education, which made the guidance unique in the literature.

Of course, FSwDs have experienced success in STEM education. They offered several instances of positive encounters, some more so, but that was a matter of years involved with STEM education versus being unsuccessful overall. Each FSwDs found inspiration in performing well in STEM activities, such as coursework, labs, research, etcetera. Passing classes made them feel accomplished and gave them the confidence to continue pursuing STEM education, and gaining new knowledge motivated them to learn more.

Passion, patience, pride, and purpose were resounding patterns in all nine FSwDs. Perseverance came to mind in all nine interviews. Each of these nine FSwDs' were resolved in their abilities and had a sense of self-confidence. All of these were distinct concepts from earlier research.

Collaboration and innovation gave them all a sense of connection to the topics under review. Learning to think critically and objectively and compartmentalizing the facts were core principles among each FSwDs. Accuracy and authenticity mattered to each.

Knowledge and novelty were key. Building STEM pathways and effective conduits for bringing more FSwDs to STEM education was evident in all nine interviews. The current literature does offer sentiments similar to those in the available research, but this present study extended new insight into FSwDs' self-efficacy. Each one believed

they could complete STEM activities, which indicated a strong self-efficacy and a distinguishing quality in the research.

FSwDs did, however, note that some of the challenges with accessibility and inclusion they experienced allowed doubts in their abilities to complete tasks and if they belonged in STEM education to surface. These instances might signal that FSwDs' STEM self-efficacy may be contingent upon feeling wanted and welcomed in STEM learning environments and settings. Distinct in this research, but more evidence is necessary to offer more conclusive data to support the findings.

Miscommunication and poor communication were also overarching patterns seen in the data collected. Previous research does suggest that a lack of communication in STEM education advocacy and awareness were potential reasons for the current gender and ableism gap in STEM education (Diele-Viegas et al., 2022; Light & McNaughton, 2012; Mattison et al., 2022; Ortiz-Martínez et al., 2023; Stewart et al., 2023). All nine FSwDs agreed that miscommunication and poor communication made succeeding more challenging, which placed them at a disadvantage. Each FSwDs conveyed a sense of urgency in improving communication networks to expand advocacy and awareness of STEM education and its internal issues. Growing communication networks was a unique theme observed in the findings. All nine FSwDs suggested using cross-situational exchanges to help improve the state of affairs in STEM education–another distinct contribution from this research.

Even though these nine FSwDs experienced successes with college support services, each offered recommendations to improve accessibility, inclusion, and support experience in STEM higher education. The findings were novel and brought more insight into the gender and ableism gap in STEM education. Regardless, all nine often labored to think of various college support services outside of disability support.

Advising, library, and student services were typically mentioned after I offered them as examples. Six out of nine were more familiar with college support services than the remaining three. Each of those three indicated wishes to learn more about college support services. All nine would happily accept more information on college support services–disability support or any service, and most certainly STEM support services.

Each FSwDs highly recommended using alternative forms of college support services. Individual support specialists and embedded assistants came up in several interviews—personal support from registration onward: embedded disability support services, peer mentorships, and STEM education support services. Two FSwDs even suggested having someone available to help navigate student exit and graduation procedures. The nine FSwDs favored more support—compassionate, friendly, knowledgeable, and timely assistance. Even more help with ADA-compliant standards student and teacher support. Each recommendation was distinguishable from the current literature.

Theoretical Contextualization

According to Tajfel and Turner (1979), social identity theory considers intergroup behavioral dynamics. They claimed that individuals are naturally motivated to have a positive self-image and want to fit into a group (Tajfel & Turner, 1979, 1986). Bandura and Walter's (1963) social learning theory suggested that learning is cognitive rather than behavioral and often occurs in social settings where learners observe behaviors and the consequences of those actions (Bandura & Walters, 1963). Each emphasizes the critical role in investigating the full situation in STEM education to improve moving forward.

The final four core themes and associated subtheme generated from the nine semistructured one-on-one interview transcripts represent basic tenets of social identity and social learning theories in many ways. By examining in-group behaviors, one may observe how social groups interact, learn, and become motivated (Bandura, 1977; Bandura & Walters, 1963; Tajfel & Turner, 1979, 1986). By investigating in-group and out-group dynamics, I could discern underlying themes to address from the data analysis. Table 6 illustrates those four themes and associated subthemes observed in the data. Later, I discussed those four themes in relation to the theoretical underpinning of this study.

Table 6

The Final Core Themes and Subthemes – in Alphabetical Order by Themes

Themes	*Subthemes*
Fostering Innovation and Motivation	Cultivating Critical Thinking, Knowledge Streams, STEM-Efficacy, and STEM Pathways

Growing Communication Networks	Cross-Departmental, Cross-Discipline, and Cross-Situational Collaboration while Learning Impartiality and Objectivity
Promoting Enrichment and Understanding	Professional and Student Development with Understanding Perceptions and Impact Behavior Training
Supporting Structural Enhancements	Embracing Culturally Relevant (STEM) Teaching and Offering Alternative Assistance

The interview data revealed significant patterns of in-group favoritism, where individuals regularly defended and supported their social group more than out-group members. The finding supports social identity theory, suggesting that participants actively constructed a positive social identity by favoring one's in-group, which aligns with the social identity theory (Tajfel & Turner, 1979, 1986). Moreover, participants who received negative feedback demonstrated less self-confidence, which lowers motivation, aligning with Bandura and Walter's (1963) emphasis on positive reinforcement. The study findings also revealed that some FSwDs used their gender identity to challenge negative stereotypes, often actively claiming a more assertive and powerful social identity when faced with gender-based and disability-based discrimination, aligning with Tajfel and Turner's (1979) argument that individuals seek to maintain a positive social identity within their group. In addition, those FSwDs occupying multiple social identities at once actively experienced intersectionality within themselves, which influences their perceptions, aligning with Tajfel and Turner (1979), who positioned that those factors affect how participants respond to external and internal stimuli. Furthermore, Bandura

and Walter (1963) argued that learning occurs through observation and imitation, where participants actively model appropriate social behaviors, aligning with factors involving self-efficacy or STEM self-efficacy and dynamics of inclusion. Lastly, cognitive learning processes, such as concentration, problem-solving, and retention, actively motivate participants to reproduce observed behaviors, aligning with social learning theory's assertion that learning involves many cognitive processes.

Limitations of the Study

As with most, this study was subject to limitations. One primary limitation was the time restrictions the college, IRB, and Walden University set forth. Doctoral research takes time, but the data collection and analysis occur rather quickly compared to the early stages of the dissertation process. Data collection occurred over several weeks in a few locations, which is typical. Still, a mixed methods study may have helped detect additional underlying or even outlying relationships in the demographic data. Measurable statistics might have also provided evidence of correlations; however, the time constraints of the current study were prohibitive of mixed-method design.

My study was limited to those organizations that permitted me to conduct research at their facilities. Even with the assurance of confidentiality, ethical considerations, and a few choices of recruitment strategies, some potential partner organizations rescinded their offer to participate because of privacy concerns. There is also the possibility that the research might *expose* areas where partner organizations *could* improve and *reflect poorly* on organizations. My guarantee of responsible

confidentiality should have reassured potential organizations. Besides, as mentioned earlier, this study is neither generalizable to all FSwDs in STEM education nor representative of the partner organizations or institutions under review.

Another study limitation was the number of FSwDs volunteers available to participate. I proposed 10 to 12 FSwDs, but recruitment was challenging as usual and took longer than anticipated for unforeseen reasons. One might have been that some individuals are still unaware of what exactly a STEM activity is or what STEM education entails.

After I went into data analysis, two more FSwDs wished to participate in the study but were unfortunately unable to contribute. On several occasions, I had male students with disabilities interested in the study, but we were unable to participate because of the inclusion criteria.

In terms of trustworthiness, I believe there may have been an unavoidable limitation related to participants' wishes to stay candid. As in most qualitative research, my presence may have inevitably affected participants' responses. Individuals may become nervous and forget to include a thought or sentiment. They may also completely overlook a subject. A further limitation may have been that I was unable to know if I had influenced the participants. Another limitation of semistructured one-on-one interviews is that people have no time to prepare. One potential volunteer decided against participating because they misunderstood the terms of the study and thought they would receive the interview questions in advance.

Recommendations

Findings from this study revealed opportunities for future investigation. An important direction for future research involves exploring male students with disabilities' perceptions of STEM education. While it was evident that FSwDs wanted to volunteer for this research, so did male students with disabilities. The findings might indicate further areas for improving STEM education.

Another area for review involves examining, specifically, the online learning environment in relation to accessibility, inclusion, and support experienced in STEM education or higher education overall. Additionally, focusing specifically on science, technology, engineering, OR mathematics might offer salient findings for the future.

An unavoidable limitation in qualitative research is the effect of the researcher's presence, especially when conducting in-person interviews. As I had previously noted, individuals may become nervous and forget to include a thought. They may also completely overlook a subject. Finding a solution is still up for consideration, as what are the best practices when in-person interviews provide observable data in kinesics and body movements?

Partnering with only a few local colleges limited the scope of the current research. A future study could include more colleges, community centers, research institutes, and educational organization types. Another important recommendation is that initially, I thought more about learning disabilities rather than incorporating accommodations that cover more than learning support. Structural support became an important topic of

conversation because some buildings are inaccessible to SwDs. An additional way future research may build upon the current investigation is to replicate this study using another conceptual or theoretical framework.

One of the challenges of the current study was the small sample size–a convenience study. Nine interviews were appropriate to reach data and theoretical saturation; however, more data about FSwDs' perceptions of STEM education would allow for more textual data to contextualize. The depth and detail of a qualitative study may also become leveraged with the inclusion of focus groups. The possibility is that focus group settings may result in novel data, as it would draw upon the socialization of participants engaged in a conversation about their experiences in STEM education. Besides, they could aid one another when stuck on a question or thought. The assistance might expose further similarities but possibly reveal further discrepancies in results and connections to existing data.

Implications

Social Change Impact

The current study addressed a knowledge gap in STEM education. The research assessed the gender and ableism gap in STEM higher education. The ongoing situation in STEM education is of major importance because STEM jobs are in demand (National Center for Science and Engineering Statistics, 2023; The U.S. Department of Education, 2020). This study aimed to explore FSwDs' perceptions of STEM education. The study categorized and isolated specific successes and challenges FSwDs experienced with

accessibility, inclusion, and support experienced in STEM higher education programs. In the end, FSwDs offered recommendations for improving the situation in STEM education.

Ultimately, I underscored what FSwDs perceived as beneficial to their educational journey and what obstacles they encountered. They also recommended techniques to increase enrollment in STEM education. The investigation findings may inform administrators, staff, students, and teachers of ways to improve accessibility, inclusion, and support experienced in STEM education by providing recommendations for strengthening those policies and practices in STEM education. Doing so increases the likelihood that colleges remain relevant in the ever-evolving U.S. education system while effectively contributing to the future of equity in STEM education. The goal was to disrupt the barriers and offer recommendations to diversify STEM higher education and ensure parity in the future STEM workforce, as a small percentage of STEM degree seekers are female students who identify as having a disability.

Practical Implications

The main practical takeaways from the current study are FSwDs' recommendations for STEM education. Some were for colleges overall, while some were specific to STEM education. All nine suggested in one form or another that impact behavior and sensitivity training were options for creating a more compassionate and understanding learning environment. Each indicated that teachers should automatically have learning materials available for multiple learning styles, such as audio, visual, and

kinesthetic—closed captions on lectures, screen readers for textual data, descriptive text for ADA compliance, hands-on experimentation, etcetera.

All nine FSwDs know that higher education provides various college support services. Most colleges offer support services that range from academics to admissions to disabilities, financial aid, mental health, public safety, tutoring, and much more. There are many steps to success when applying to and becoming registered at college. In all of the commotion, a step or two might become overlooked, which causes challenges to success. FSwDs may also have social anxiety, causing them to struggle with social environments, thus adding another challenge to the process.

For those reasons, all nine FSwDs suggest more orientation-style materials so that all students become aware of the various college support services available on campus and online. All nine FSwDs were also interested in learning more about college support services for STEM education. Seven of them were unaware of the support services available for STEM education. Disability support or any services. For example, chemistry and mathematics tutoring or using computer and science labs for help, but becoming aware of those services is fundamental and crucial for success. In addition, FSwDs suggested that using scavenger hunts with checklists for on-campus and online education was an excellent idea for improving the accessibility, inclusion, and support experienced in STEM education. Working in groups for socialization or individually to become familiar with the college support services.

Theoretical Implications

As discussed earlier in this chapter, data from the current study revealed that while participants perceive themselves as an out-group, they often actively claim a more assertive and powerful social in-group identity when faced with gender-based and disability-based discrimination, aligning with Tajfel and Turner (1979) argument that individuals seek to maintain a positive social identity within their group. All nine FSwDs want their in-group perceived as capable, intelligent, smart, and welcomed community members. Actively exposing the importance of self-efficacy aligns with Bandura and Walter's (1963) claim that students' self-efficacy accentuates positive attitudes in academic environments. Finally, FSwDs noted that the efforts to tailor instruction to individual students expose their cognitive development and learning progress, aligning with Bandura and Walter's (1963) assertion that repeated positive behaviors influence student learning and motivation.

Conclusion

My aim with this research was to expand the body of literature on gender and ableism in STEM education by filling the knowledge gaps. In the process, I offered a glimpse into the experiences of these FSwDs in STEM education. The data revealed FSwDs' perceptions of their successes and challenges in STEM education as well as their recommendations for improving STEM higher education. Overall, the study was adequate, but FSwDs had more to say. Once, in data analysis, two more FSwDs came forth to participate, but I was unable to oblige their requests.

Ultimately, I will say that each of these nine FSwDs were “extraordinary.” It was truly a delight to meet, talk with, and share stories with each of them. They were knowledgeable, patient, polite, skilled, and understanding. Their wit and ability to adapt were incredible. They each conveyed passion, pride, and purpose. They were each unique and genuinely loved being in STEM education. They humbled me and inspired me by their stories.

When I started this dissertation journey, I really had no expectations but assumed there would be negative and positive takeaways. My findings were significant and illustrated a similarity in experiences, but there were distinctions to each narrative. Data suggested that FSwDs have many successes with accessibility, inclusion, and support in STEM education. They also have several challenges to overcome. Physical barriers and social biases plagued their experiences in STEM education. Ableism, ageism, and genderism were obvious in all nine FSwDs STEM education experiences. Cultural and ethnic prejudices and racism were apparent but paled in comparison to the gender and ableism experienced by these nine FSwDs in the present STEM education system.

The negatives did outweigh the positives, but these FSwDs showed such resolve and determination that they were willing to contemplate and find solutions to increase the positive outcomes. All nine FSwDs had possible and practical applications to improve the accessibility, inclusion, and support experience in STEM education. They each truly wish to see more females and FSwDs in STEM education and the STEM workforce, and so do

I. The changes may well improve the campus climate and might bring about even more success stories.

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Appendix A: Initial Email

Preparing an initial Depending on the recruitment strategy employed, each person will receive the invitations below. This message will help me determine if potential partner organizations require a secondary ethics review before permitting me to conduct research at their institutions.

Initial Email.

Good day (morning, afternoon, evening, etcetera.), (person's name or department):

How are you today? Hopefully, you are doing well. My name is Toni Walkowiak, and I am a doctoral candidate at Walden University in a Ph.D. program. I am pleased to make your acquaintance. As part of the regulatory oversight in research involving human subjects, the institutional review board (IRB) at Walden University advises us to inquire whether a possible research site has an independent ethics committee or specific ethical procedures necessary to conduct research on their campuses.

For that reason, I am writing to graciously ask if your organization would be willing to assist me in pursuing a Ph.D. in Education by helping me gain access to potential volunteers. If you generously accept these terms, thank you for your time.

Considering IRB suggestions, could you please tell me if such an ethics review exists at your organization, or would you kindly pass this information along to someone who might know more about such procedures? By deciding to help, we will become partner organizations in the research process, and your institution will receive copies of all formal ethics review compliance documents for your records. If you have any questions, please contact me by email at xxx.xxxx@xxxxxx.xxx

Sincerely,
Toni A. Walkowiak ~ MPhil, MS, MA, & PhD Candidate

Appendix B: Second Contact Email

If there are no secondary IRB protocols, I will send a message to the academic support staff, deans, etc., that would possibly look different. The selection below exemplifies what I would add in those instances.

Second Email.

Good day (morning, afternoon, evening, etcetera.), (person's name or department head):

How are you today? Hopefully, all is well. My name is Toni Walkowiak, and I am a doctoral candidate at Walden University in a Ph.D. program. I am pleased to make your acquaintance. As part of the regulatory oversight in research involving human subjects, the institutional review board (IRB) at Walden University requires us to gain implied consent to conduct research at an institutional level.

For that reason, I am writing to graciously ask if your organization would be willing to assist me in pursuing a Ph.D. in Education by helping me gain access to potential volunteers. If you generously accept these terms, thank you for your time.

To remain compliant with IRB ethics. Do you know who I might speak with about these standards, or would you kindly pass this information along to someone who might know more about conducting research at your organization? If *you (your organization)* decide to help, we will become partner organizations in the research process, and your institution will then receive copies of all formal ethics review compliance forms for your records. If you have any questions, please contact me by email at xxx.xxxx@xxxxxx.xxx

Appendix C: Solicitation E-mail to Partner Organizations

Once I check that the ethical review standards are in line, becoming a partner organization with local colleges occurs through more email correspondence. The following message provides the solicitation to potential research sites.

Solicitation E-mail to Partner Organizations.

Dear (person's name or department head):

My name is Toni Walkowiak, and I am a doctoral candidate at Walden University. I am pleased to make your acquaintance. The Institutional Review Board (IRB) ethics standards require us to request permission to become partner organizations as part of the requirements to conduct research at an institution.

For that reason, I am writing to inquire if your organization would be willing to participate in my dissertation research. The purpose of my study is to explore FSwDs' perceptions of their successes and challenges with accessibility, inclusion, and support experienced in STEM higher education programs, as well as their recommendations for improving those policies and practices in STEM education. The main objective is to gain more insight into the gender and ableism gap in STEM education to understand the situation better. *Specifically, insight into FSwDs' perceptions of the successes and challenges with accessibility, inclusion, and support experienced in STEM higher education programs, as well as their recommendations for improving those policies and practices in STEM education* [can be redacted if you feel it is unnecessary].

As an organizational leader, you understand how vital information about student learning is to academia. The more knowledge we gain, the better equipped the system becomes to work with students regardless of their learning styles. Knowing more about individual learning experiences is necessary to provide quality educational settings for all learners.

Much of the current research on the gender and ableism gap in STEM education focused on the overall socio-educational problem. Despite this, researchers know little about the successes and challenges FSwDs experience in STEM higher education programs at local colleges. Thus, my investigation aims to explore FSwDs' perceptions of the successes and challenges with accessibility, inclusion, and support experienced in STEM higher education programs and their recommendations for improving those policies and practices in STEM education.

The study will collect data through individual interviews: in person, by email, over the phone, and online at Teams or Zoom with FSwDs. I will request an individual participant interview (~45 minutes) to volunteer.

For eligibility, participants must be female students with disabilities, 18–64 years old, currently engaged in STEM activities or enrolled in STEM classes at local colleges, and have their conditions on file. The ADA and FERPA laws prohibit my access to those sensitive data. Thus, the *administration, disabilities department, enrollment services, or student services* must also kindly offer implied consent to help disseminate the participation invitations.

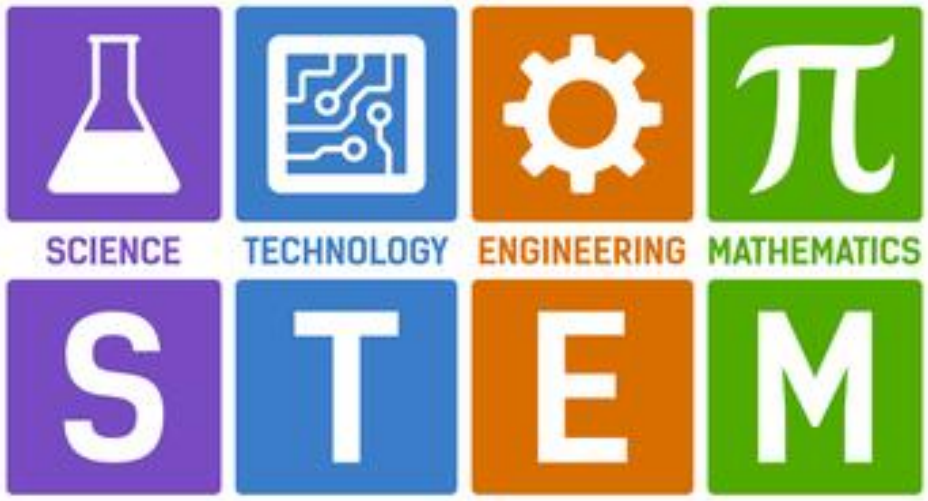
The current doctoral project is under regulatory oversight by Walden University's Institutional Review Board (IRB), approval number *XYZ*. The IRB reviews several aspects of my study involving human beings to ensure adequate and ethical protection of all participants. I vow to remain compliant throughout the entire process.

The intended data collection timeframe is during the summer of 2024. In keeping with the IRB ethics regulations, all data collected will remain confidential. The names of organizations, participants, personal information, shared disability, and study sites will receive a pseudonym or go unpublished in any report of the findings. After the research and writing, I will happily provide your institution with a copy of the study. I will also invite you or anyone at your organization to contact me by email at xxx.xxxx@xxxxxx.xxx if you have any questions.

Considering IRB's ethical standards, would your organization be interested in becoming a partner for the upcoming research? If you generously accept the terms above, thank you for your time. I truly appreciate your consideration and look forward to hearing from you.

Sincerely,
Toni A. Walkowiak ~ MPhil, MS, MA, & PhD Candidate

Appendix D: The Flyer Participation Invitation



The acronym STEM, with corresponding icons for each word from the National Science Foundation

Heading:

Interviewing female students with disabilities in STEM education courses during the summer and autumn of 2024

Body:

This research is part of a new study about female students with disabilities (FSwDs) perceptions of science, technology, engineering, and mathematics (STEM) education. Each participant will be asked to describe their experiences in STEM education at local colleges. The study aims to benefit society by contributing new knowledge to address the gender and ableism gap in STEM education.

About the study:

- Volunteers provide informed consent to participate in the study via QR codes.
    - Complete a confidential demographic survey after providing implied consent (~5 minutes).
- Then, participate in **ONE** pre-scheduled, confidential, private, and securely audio-recorded interview during the summer and autumn of 2024.
    - Either in person, by email, over the phone, or online at Teams and Zoom (~45 minutes).
    - You would pick from:

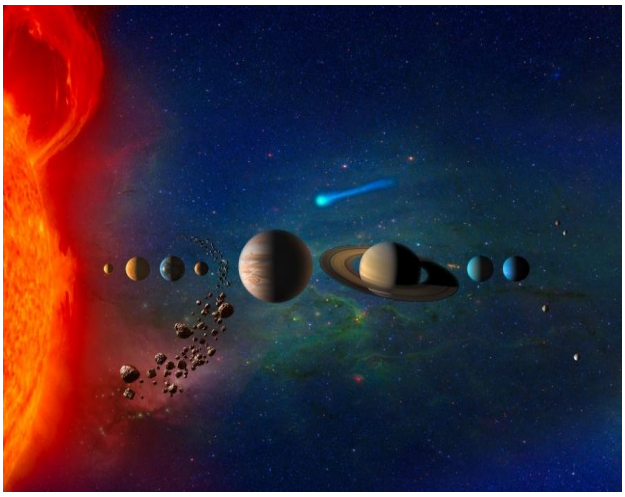
    - **Choice A:** $25 gift card to Amazon, a local supermarket, or Target at the interview
    - **Choice B:** $25 directly sent through Cash App, Venmo, or Zelle at the interview
- Review the transcriptions from the interview to make or recommend corrections as necessary in an email (~10 minutes).
- After the interview, you can speak with the researcher one last time to hear the researcher's interpretations and share your feedback (a step called member checking, and it usually takes ~20 to 30 minutes as an email or phone call.

Volunteers must meet these requirements:

- Are a female student with disabilities
- Aged 18 to 64 years old
- Engaged in STEM activities or enrolled in STEM education courses at local colleges
- Have their conditions on file

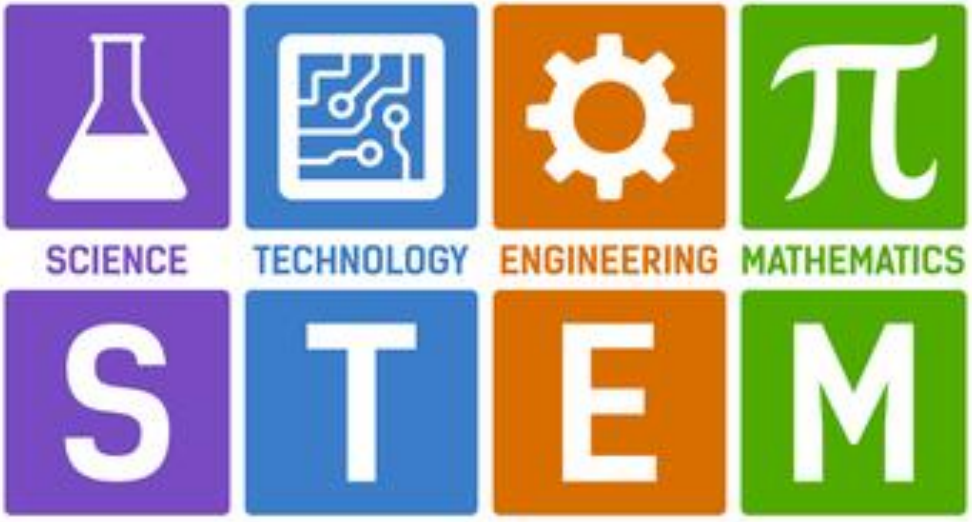
The interview is part of the doctoral study for Toni Walkowiak, a Ph.D. candidate at Walden University. Interviews will take place during the summer and autumn of 2024. If interested, please scan the QR code below to participate in this study. You are welcome to forward this invitation to anyone who might meet the volunteer criteria and is interested in helping.

The entire study is confidential, and the researcher will never share any names or details that could identify you to protect your privacy.



Our Evolving Understanding of the Solar System from NASA

Appendix E: The Participant Social Media Invitation



The image is the acronym STEM, with corresponding icons for each word from the National Science Foundation

Heading:

Interviewing female students with disabilities in STEM education courses during the summer and autumn of 2024

Body:

This research is part of a new study about female students with disabilities (FSwDs) perceptions of science, technology, engineering, and mathematics (STEM) education. Each participant will be asked to describe their experiences in STEM education at local colleges. The study aims to benefit society by contributing new knowledge to address the gender and ableism gap in STEM education.

About the study:

- Volunteers provide informed consent to participate in the study via QR codes
    - Complete a confidential demographic survey after providing implied consent (~5 minutes).
- Then, participate in **ONE** pre-scheduled, confidential, private, and securely audio-recorded interview during the summer and autumn of 2024.
    - Either in person, by email, over the phone, or online at Teams and Zoom (~45 minutes).
    - You would pick from:

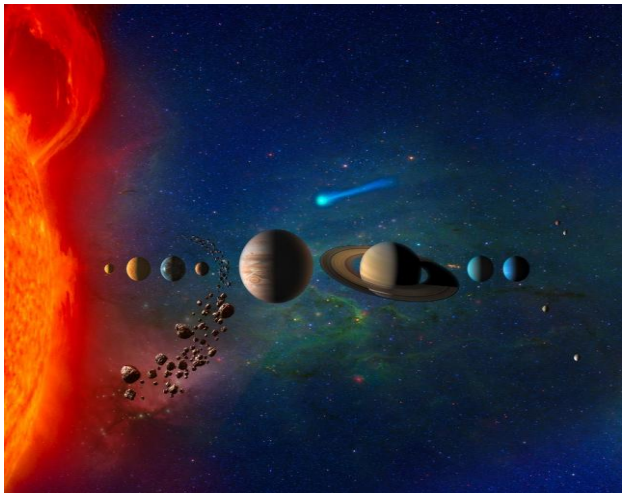
    - **Choice A:** $25 gift card to Amazon, a local supermarket, or Target at the interview
    - **Choice B:** $25 directly sent through Cash App, Venmo, or Zelle at the interview
- Review the transcriptions from the interview to make or recommend corrections as necessary in an email (~10 minutes).
- After the interview, you can speak with the researcher one last time to hear the researcher's interpretations and share your feedback (a step called member checking, and it usually takes ~20 to 30 minutes as an email or phone call.

Volunteers must meet these requirements:

- Are a female student with disabilities
- Aged 18 to 64 years old
- Engaged in STEM activities or enrolled in STEM education courses at local colleges
- Have existing documentation on file.

The interview is part of the doctoral study for Toni Walkowiak, a Ph.D. candidate at Walden University. Interviews will take place during the summer and autumn of 2024. If interested, please scan the QR code below to participate in this study. You are welcome to forward this invitation to anyone who might meet the volunteer criteria and is interested in helping.

The entire study is confidential, and the researcher will never share any names or details that could identify you to protect your privacy.



Our Evolving Understanding of the Solar System from NASA

Appendix F: Demographic Survey

Please indicate all that apply to you. You may include additional information in the space provided below.

1. What is the highest level of education you have completed?
    a. High school or equivalent
    b. Vocational/technical school (2-year degree)
    c. Some college
    d. Bachelor's Degree
    e. Master's Degree
    f. Doctoral Degree
    g. Professional Degree (MD, JD, etc.)
    h. Other_____

2. Are you engaged in science, technology, engineering, and mathematics (STEM) activities, such as STEM challenges, demonstrations, exercises, experiments, or projects?
    a. Yes
    b. No
    c. Unsure

3. Are you enrolled in science, technology, engineering, and mathematics (STEM) courses?
    a. Yes
    b. No

   c. Unsure

4. Are you a science, technology, engineering, and mathematics (STEM) major?
   a. Yes
   b. No

5. Are you a science, technology, engineering, and mathematics (STEM) minor?
   a. Yes
   b. No

6. What is your self-identified gender?
   a. Female
   b. Non-binary
   c. Male
   d. I prefer no comment
7. What is your age group?
   a. 18-24 years old
   b. 25-34 years old
   c. 35-44 years old
   d. 45-54 years old
   e. 54-64 years old

8. Do you recall your age when you received a medical diagnosis of the disability?
   a. As an infant
   b. A toddler
   c. In early childhood
   d. Adolescence
   e. Adulthood

9. Would you mind sharing if your disability is
   a. Invisible
   b. Visible

10. Would you mind sharing your diagnosed disability?
    a. Yes
    b. No
    c. Unsure

11. Would you mind sharing if you have an ADA educational plan or program on file?
    a. Yes
    b. No
    c. Unsure

d. I prefer no comment

12. Do you self-identify as part of a social group, such as
    a. A member of the LGBTQ+ community
    b. An immigrant
    c. By your ethnicity
        i. Would you be willing to share which one(s):
        _____
        _____
    d. By your profession or vocation
        i. Would you mind sharing which you belong:
        _____
        _____
    e. Another social group
        i. Would you be able to share which one(s):
        _____
        _____
    f. Female or non-binary
    g. Person with disabilities
    h. Student/Candidate
    i. More than one
        i. Would you kindly share which one(s):
        _____
        _____
    j. None
        i. If so, would you please share those self-identifiers
        _____
        _____

13. What is your marital status?
    a. A member of an unmarried couple
    b. Divorced
    c. Never married
    d. Married
    e. Separated
    f. Single or Independent
    g. Widowed

14. Is there anything else you would like to share with me?

    _____
    _____
    _____
    _____

Appendix G: Interview Protocol

Upon greeting an individual at the entrance and welcoming them to the study while walking to the interview room, I will thank them again for participating. After this, I will ask if they mind if I audio record the session to remain compliant.

From the onset, I will ask the participants how they are doing today. Then, wait for an answer (a natural probing technique to sense if someone is interested in having a conversation). Once we complete the formalities, the interview questions may begin. A set of introductory questions will open the discussion. Then, more specific inquiries about a participant's social identity and learning behaviors will occur, followed by detailed queries regarding individual experiences with accessibility, inclusion, and support experienced in STEM higher education programs, as well as their recommendations for improving those policies and practices in STEM education. Lastly, I will extend a formal offer to provide further insight or opinion about the current conversation.

Interview Protocol

Hello, and welcome to our approximately 45-minute conversation about your experiences in STEM education.

1. Do you have any questions before we begin
2. Would you mind sharing some preliminary educational information with me before I begin? For example,
    a. What is your declared degree, college, or program of study at the college?
        i. An example is an Associate or a Bachelor of Science in GIS from the College of Social and Human Behavioral Sciences.
3. Would you please share details as to why you chose the program of study?
    a. Would you mind sharing some of your life's goals?
    b. What profession or vocation do you hope to join?
4. Would you consider yourself a person who works well with groups or individually?
    a. If groups, would you explain why you feel this way?

    b. For individual work, could you explain why you think this way?

As we continue, we will turn the conversation to STEM education.

1. Are you familiar with the term STEM education?
    a. If you are unfamiliar with it, that is fine. Would you offer an educated guess as to what you think STEM education might mean?
        i. ?
    b. If you are aware of STEM education, please share your understanding of what STEM education is and where you learned the phrase.
2. Now that we have a working definition of STEM education, could you describe your experiences with STEM higher education activities?
    a. I will happily provide examples if necessary.
    b. What are any successes you have experienced in STEM higher education activities?
        i. I will happily provide examples.
    c. What are some challenges you have experienced in STEM higher education activities?
        i. I will happily offer examples.
    d. What are your recommendations for improving the experiences of FSwDs in STEM higher education activities?
        i. I will happily offer examples.
3. Please tell me a few personality traits you believe a person in STEM education should possess.
    a. I could provide examples if necessary.
    b. Why do you think those qualities are important for a person in STEM education to possess?
        i. Do any of those qualities describe your personality?
            1. If so, which ones and why?
            2. If not, please share why you feel this way.

Next, we will shift the conversation to accessibility, inclusion, and support available in STEM higher education.

1. Are you familiar with the concepts of accessibility and inclusion?
    a. If you are unfamiliar with it, that is fine. Would you mind taking an educated guess as to what you think accessibility and inclusion might mean?
        i. ?
    b. If you understand them, please explain your understanding of them and why or how you know these terms.

2. Given those operation definitions of accessibility and inclusion, would you mind describing your experiences with them in STEM higher education?
    a. What successes have you experienced with accessibility and inclusion in STEM higher education?
        i. I will happily provide examples.
    b. What challenges have you experienced with accessibility and inclusion in STEM higher education?
        i. I will happily offer examples.
    c. What are your recommendations for improving FSwDs' experiences with accessibility and inclusion in STEM higher education?
        ii. I will happily offer examples.
3. Are you aware of any support services available for students at the college?
    a. If so, what support services are available to students at the college?
        i. What successes have you experienced with the support services available at the college?
            1. I will happily provide examples.
        ii. What challenges have you experienced with the support services available at the college?
            1. I will happily offer examples.
        iii. What are your recommendations for improving the support services available to students at the college?
            1. I will happily offer examples.
    b. If not, would you like to learn more about the support services available for students at the college?
4. Are you familiar with any support services available for students in STEM education programs at the college?
    a. If so, what support services are available for students in STEM education programs at the college?
        i. What successes have you experienced with the support services available for students in STEM education programs at the college?
            1. I will happily provide examples.
        ii. What challenges have you experienced with the support services available for students in STEM education programs at the college?
            1. I will happily offer examples.
        iii. What are your recommendations for improving the support services available for students in STEM education programs for students?
    b. If not, would you like to learn more about the support services available for students in STEM education programs at the college?

We will finish by discussing the Americans with Disabilities Act (ADA) and disability support services available for college students.

1. Are you familiar with the ADA?
    a. If so, please explain how the ADA affects your life.
    b. If not, would you like to know more about the ADA?
2. Are you aware of any disability support services available for students at the college?
    a. If so, what disability support services are available for students at the college?
        i. What successes have you experienced with the disability support services available for students at the college?
            1. I will happily provide examples.
        ii. What challenges have you experienced with the disability support services available for students at the college?
            1. I will happily offer examples.
        iii. What are your recommendations for improving the disability support services available for students in STEM education programs at the college?
            1. I will happily offer examples.
    b. If not, would you like to learn more about the disability support services available to college students?
3. Are you familiar with any disability support services available for students in STEM education programs at college?
    a. If so, what disability support services are available for students in STEM higher education programs at the college?
        i. What successes have you experienced with the disability support services available for students in STEM higher education programs at the college?
            1. I will happily provide examples.
        ii. What challenges have you experienced with the disability support services available for students in STEM higher education programs at the college?
            1. I will happily offer examples.
        iii. What are your recommendations for improving the disability support services available for students in STEM education programs at the college?
            1. I will happily offer examples.
    b. If not, would you like to learn more about the disability support services available at the college for students in STEM higher education programs?

4. To close, are there any final thoughts or feelings you want to share before we end our session today?

Thank you again for taking part in my doctoral study. I am forever grateful for your kindness and voluntary participation.

Appendix H: Letter of Recommendation from Walden to Partner Organizations

July 25, 2024

To Whom it May Concern,
Walden University student, Toni Walkowiak, has successfully defended her PhD doctoral study proposal titled, *Exploring Female Students with Disabilities' Perceptions of Science, Technology, Engineering, Mathematics Education* and she now qualifies to begin her research data collection. Ms. Walkowiak's research is supervised by a doctoral committee with Dr. Ionas Gelu (xxx.xxxx@xxxxxx.xxx) serving in the role of chair. I highly recommend that this student partner with your organization to support her research. All research sites are deidentified, and all students must adhere to the standards of Walden University and partner site's institutional review board(s). Thank you for your cooperation in facilitating the progress of our students.

Respectfully,
Dr. Stacy E. Wahl

Stacy E Wahl, Ph.D., RN, NPD-BC, CCRN
Associate Dean II
Diversity & Inclusion Ambassador
Riley College of Education & Human Sciences
Doctoral Programs: Education & Human Sciences
Master's Programs: Health Sciences
Ed.S. & Certificate Programs: Education
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