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Underrepresentation of Women STEM Leaders: Twelve Women on Different Journeys Using Their Voices to Shape the World through Science

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ABSTRACT

This study examined the conditions contributing to the underrepresentation of women leaders in science, technology, engineering, and mathematics (STEM) education. It was a qualitative phenomenological study of twelve women with twelve unique journeys. The women included secondary educators, postsecondary university professors, and professional STEM field careerists. This study examined the experiences of women in STEM through storytelling and identified four common themes shared by the twelve participants: a) *shaping of mental exploration*; b) *math efficacy*; c) *self-discovery through problem-solving regarding why and how things work;* and d) *connection to an encouraging learning community*.

While numerous studies have uncovered systemic causes of underrepresentation, this qualitative inquiry sought to learn about the experiences of women in STEM through their own voices and therefore advance qualitative studies in this area. The study participants were limited to women in the fields of science, technology, engineering, and mathematics identified through convenience and snowball sampling in the geographical study area. This study aims to reveal how self-efficacy takes shape during adolescence and, in turn, influences the persistence of women leaders in STEM education and careers.

Keywords: STEM, self-efficacy, adolescents, underrepresentation

INTRODUCTION

The underrepresentation of women leaders in science, technology, engineering, and mathematics (STEM) education provides meaning to the journey of those seeking to understand why, after decades of informed research, published literature, and policy implementation, the representation of women leaders in STEM education and careers does not equal that of their male counterparts. Noonan (2017) acknowledged the significance of the underrepresentation of women in STEM compared to the ratio of men and women in the college-educated workforce. To understand better the complexity of this underrepresentation, this research study sought to highlight the voices of twelve accomplished women in STEM with a total of well over 300 years of combined field experience. It was important for this study to examine self-efficacy through the voices of women in STEM, thereby capturing meaningful experiences and perspectives that no other research has previously captured. If self-efficacy is the belief in one's own ability and persistence is the continuation of goal-directed actions despite obstacles, can the reminiscence of adolescence by women in STEM aid in uncovering important details about the relationship between girls' self-efficacy and women's adult lives? To further advance qualitative studies in this area through the lens of women in STEM, this study explored why underrepresentation has occurred by examining two constructs: self-efficacy during adolescence and the persistence of women in the fields of STEM guided by two research questions: a) *How does self-efficacy shape during adolescence among women leaders in STEM?* and b) *What qualities and/or experiences during adolescence are considered to shape self-efficacy and therefore influence persistence among women leaders in STEM?*

The qualitative impact of this study lies in its links to the literature using *a priori* codes to aid in the investigation of STEM-driven interests by examining the connection between self-efficacy during adolescence and the persistence of accomplished women leaders in STEM. Twelve women with unique journeys and voices provided important knowledge about why women are underrepresented in STEM.

EXPLORING STEM THROUGH THE LENS OF SELF-EFFICACY

For the past 50 years, the literature has acknowledged that policies have improved women's persistence in the fields of science, technology, engineering, and mathematics (Carpenter and Acosta, 2005; Robelen, 2010; Rolison, 2003) but have not increased their representation in these fields (Beede et al., 2011). The underrepresentation of women leaders in STEM has been explored and leveraged in literature through the lens of professional development, role-modeling, science literacy, and career choices. For example, in "Looking through the Glass Ceiling," Amon (2017) acknowledges, that efforts have been made toward the advancement of women in science, technology, engineering, and mathematics STEM positions but there is little research directly examining women's perspectives and strategies for advancing in male stereotyped disciplines.

Research has quantified the outcomes contributing to the systemic underrepresentation of women, yet fails to understand from where this phenomenon stems. The relationship of self-efficacy during adolescence and persistence among women in STEM can shoulder an important meaning for those seeking to understand why underrepresentation continues to exist. The relationship supports strong objectivity and the assertion of Bandura's social cognitive theory and acknowledges that a higher sense of self-efficacy reflects an increased effort of persistence (Pajares, 2002). "Research supports the hypothesized relation of self-efficacy to academic motivation [effort, persistence] and achievement" (Bandura, 1977). Self-efficacy—the belief in one's own ability—can shape achievement outcomes, impact ability, and influence competency. A large body of literature is related to self-efficacy, but it does not indicate how self-efficacy is shaped among girls and how it can positively influence the lives of women and, in turn, increase representation among women in STEM. Bandura (1986) acknowledges that sources of self-efficacy are not natural and can be developed through different experiences. In developing girls' interest in STEM education and in sustaining their STEM careers once they graduate, we must recognize the impact of self-efficacy (Rubiano-Matulevich et al., 2019).

WHAT IS THE MEANING OF SELF-EFFICACY FOR GIRLS? AND HOW IS IT ATTRIBUTED TO STEM IDENTITY?

Self-efficacy among adolescent girls is an underexplored factor in the underrepresentation of women in STEM education (Zeldin et al., 2007). In terms of a girl's identity, according to Janice, Polnick, and Irby (2014), "gender identity and STEM identity do not come together for many girls and researchers have begun to explore how to address identity as a critical pathway to the STEM pipeline for girls" (pp. 142-143). The literature has recognized that self-efficacy is attributed to choices, persistence, and achievement. As Carlone (2003), notes, "Girls are often fighting against the powerful sociocultural legacy of science, which is often enacted in the classroom without the teacher realizing it." (p. 308)

According to Bandura (2010), "unless people believe they can produce desired effects by their actions, they have little incentive to undertake activities or to persevere in the face of difficulties." (p. 1). Grossman and Porsche (2013) state, "little research explores supports and barriers to STEM success for girls from the perspective of those students who are poised to contribute to STEM fields" (p. 699). The relationship between self-efficacy shaped during adolescence and the persistence of women in STEM has a strong potential to moderate systemic underrepresentation, which guided the present inquiry exploring whether Bandura's social cognitive theory could explain this connection. Bandura's social cognitive theory creates a space to examine how self-efficacy is shaped among girls and influences persistence as adults.

Bandura's Social Cognitive Theory

Bandura's social cognitive theory is based on sound research, but does the explanatory literature apply to girls and women? Given the underrepresentation of women in STEM, Bandura's social cognitive theory guided the inquiry to answer "why" in this research, with the goal of helping to reveal a) what self-efficacy means for girls; b) how is it shaped; and c) how it influences persistence among women in STEM. Bandura's social cognitive theory represents a triad of exchanges and/or reciprocal causations among personal, environmental, and behavioral factors. The term *reciprocal*—defined as something common or shared—explains Bandura's interpretation of how

Figure 1. Girls' Self-efficacy and STEM Persistence Model

each variable influences the others. His framework emphasizes an interaction among behavior, environment, and person/cognition. The inquiry into Bandura's social cognitive theory has created numerous questions. It should be noted, however, that his literature does not explicitly define self-efficacy among girls or its influence on the lives of adult women.

FRAGMENTED STEM CAREER PATTERNS AND EXPERIENCES

Women's self-efficacy and persistence have created a space to acknowledge why the majority struggle to persist, despite their instrumentation and entry into sciences. Rosser (2005) highlighted that the "postmodern feminist argues that there is no common experience for women." Feminists also stated, "women['s] experiences in STEM are fragmented and situation dependent" (p. 50). Situation-dependent experiences among women in STEM raise awareness but do not generate a substantial amount of information to educate society on why women are underrepresented in STEM fields. Maltese and Tai (2011) acknowledged that engagement in math and science is critical for developing the preparation and persistence necessary for college careers in STEM. Pajares and Urdan (2006) acknowledged that personality differences that are often perceived between men and women have varying effects on occupational efficacy, career choices, and preparatory development. Hartman and Hartman (2007) suggest perceptions of negative gender stereotypes related to science, engineering, and math are able to predicted poor retention and advancement for women at university.

Bandura has contributed insightful and meaningful research that added immensely to the framework of the current research encompassing three separate variables: adolescence, self-efficacy, and persistence. The conceptual framework for this study, shown in **Figure 1**, provides a visual representation of self-efficacy among all groups, self-efficacy among girls, and self-efficacy and its influence on persistence among women in STEM. In this manner, three constructs are derived: the exchange of messages, the process of self-discovery, and the process of self-actualization.

CONCEPTUAL FRAMEWORK

Exchange of Messages

The first construct in the conceptual framework represents the fundamental exchange among school, family, and environment. It visually represents the introduction to awareness and the significant importance of how each influence and/or cause changes when it encounters other variables throughout preparatory development. The literature describes self-efficacy as a belief in one's own ability. In the closer examination of self-efficacy among girls, Grossman and Porche (2013) concluded that surrounding social systems (i.e., family, teachers, peers, and school) communicate messages that shape science engagement. Self-efficacy and engagement in science among adolescent girls "[are] shaped by individual agency as well as messages surrounding social systems, such as family, peers, teachers, and school systems" (Grossman and Porche, 2013, p. 3). How a girl identifies with and interprets science creates identifiable engagement and a belief in her own ability (Wang et al., 2016).

Girls are inadvertently exposed to a wide array of beliefs and messages that resonate with gender expectations and identity. "Girls and women face systemic messages that STEM success is incompatible with female gender roles and may perceive science as alienating and inconsistent with girls' gender image expectations" (Hill et al., 2010; Brickhouse et al., 2000). Bandura (1986) acknowledged the existence of "self-beliefs that enable humans to exercise a measure of control over their thoughts, feelings, and actions; that what people think, believe, and feel affects how they behave" (p. 25). The question then remains, *what are those messages, and how do they impact and/or shape self-efficacy among girls?*

Process of Self-Discovery

The second construct visually represents how each element (i.e., self-belief, ability, and mentality) forms a connection of influence through the exploration of self-discovery. The variables illustrate her developmental awareness of how self-belief can influence her overall perception of her abilities, therefore visually explaining how each variable impacts the other throughout preparatory development. Self-discovery throughout adolescence is vital for development. The implications of this shaping and/or connecting of self-efficacy influence the mindset of a girl when she faces challenges. According to Dweck (2002, p. 132), "[A girl's performance in math and science] should also reinforce a growth mindset in girls to increase their understanding that math ability is cultivated through effort and persistence and is not a static or immovable trait. How a girl connects with math or science influences her behavior and potential outcomes. Shaping self-efficacy and nurturing interests in math and science among adolescent girls aid in their overall self-discovery. According to Bandura (1977), "Although self-efficacy is a type of cognition, theory and research support the idea that it can affect other facets of development (e.g., social, emotional, behavioral) and that it is influenced by various personal, social, and contextual variables." The search for meaning and/or self-discovery must shape an internal connection with efficacy to persuade and/or acknowledge intrinsic beliefs that support self-confidence.

Process of Self-Actualization

The third construct represents self-efficacy and its influence on persistence among women in STEM; namely, this construct reflects a woman's belief in her own ability despite the varied challenges she may endure. It visually demonstrates the transition from recognizing her abilities to acknowledging how self-belief attribute to self-confidence. As Capodilupo and Nadal (2009) said, "Micro-assaults are often conscious explicit derogatory remarks or behaviors; micro-insults may infer ascriptions of intelligence or second-class citizenship, and micro-invalidations infer assumptions of traditional gender roles or denial of sexism." Research paradigms have indicated that self-doubt and a lack of confidence appear to deter women from participating in STEM overall. Pajares and Urdan (2006, p. 13) stated, "The differences usually follow the stereotypic courses, with boys judging themselves more efficacious for careers in science and technology and girls reporting a higher sense of efficacy for social, educational, and health services."

RESEARCH BACKGROUND

This research study involved the analysis of reflective narratives through the lens of women in STEM and was guided by two questions: a) *How does self-efficacy shape during adolescence among women leaders in STEM?* and b) *What qualities and/or experiences during adolescence are considered to shape self-efficacy and therefore influence persistence among women leaders in STEM?* Twelve women were selected based on the following criteria: 1) being recognized as a leader in the field of science, technology, engineering, or mathematics; 2) currently holding or having previously held a leadership position in secondary or postsecondary STEM education or STEM professions; 3) collectively representing diverse fields of science; and 4) currently living and working full-time in a field of science in the U.S. or having retired from work in a field of science in the U.S.

Participants

The study consisted of twelve inspiring women with diverse career paths and unique journeys, namely, two STEM teachers (both former industry professionals), two university professors, and eight STEM professionals. The participants' various fields of science, career paths, and experiences brought value to the research study by capturing relevant and unique experiences that created a genuine understanding of how their self-efficacy had taken shape during adolescence and the qualities and/or experiences that they believed shaped their self-efficacy and thereby influenced their persistence in STEM fields.

Data Collection

Interviews were conducted with each of the twelve women in person and in a private setting between May 14, 2019, and September 18, 2019. During a formal 90-minute interview, the twelve women were asked to recall experiences related to their adolescent self-efficacy and persistence. The interviews were conducted using the Women STEM Leaders Interview Protocol, as shown in **Appendix A**. Throughout the interviews, I had become highly familiar with the interview protocol questions, which shaped the interviews as natural conversations, thus eliminating redundancy to previously discussed mentions throughout the interview. After the completion of manual transcription, member checking was performed for each interview to establish both accuracy and credibility (Lincoln and Guba, 1986). Following each audio-recorded and transcribed interview, member checking consisted of four steps: a) a complete transcript was emailed to each participant; b) time was allocated for each participant to review the transcript for accuracy and credibility; c) a second audio-recorded interview was conducted if inaccuracies were discovered by either the interviewer or interviewee; and d) the final transcript was provided to each participant, including notification that the interview protocol was complete. (**Note:** If inaccuracies, i.e., misspelled words or names or incorrect descriptive experiences, were found or if the participants requested corrections, the interview protocol was repeated for accuracy and credibility.)

Data Analysis

The data analysis was conducted using Dedoose software. *A priori* codes were used for initial coding, and constant comparison analysis was performed to identify emergent codes (Glaser and Strauss, 2017). The eleven *a priori* codes in **Table 2** used for the initial analysis were selected based on their descriptive meanings; these meanings were derived from the literature and can be found in **Appendix B**. Deductive coding, as described by Yi (2018), was also conducted by pre-establishing a set of codes from the literature (Trochim, 2006). To ensure reliability and validity, repeated data coding was conducted in two different periods (Time 1: May 14, 2019 - September 18, 2019; Time 2: September 23, 2019 - October 18, 2019). Further analysis and triangulation included analysis of the code frequency and application charts produced by Dedoose software to help identify themes. This three-year research study revealed four significant findings based on the examination of 155 pages of transcriptions; the analysis of 669 excerpts; countless hours of interviewing, coding, and member-checking over a six-month period; and the creation of visual representations specific to the research study.

Approaches to Ensure Validity

The research study referred to four specific criteria for trustworthiness: credibility, transferability, dependability, and confirmability. Shenton (2004) acknowledged the difficulty of the dependability of qualitative work and further concluded that comparative models should be used for trustworthiness. *Transferability*, as described by Shenton (2004, p. 63), is intended to “provide sufficient detail of the content of the fieldwork for a researcher to be able to decide whether the prevailing environment is similar to another situation.” This research study included an ample sample of participants and diverse experiences to provide multiple perspectives for transmitting the results of the fieldwork to the reader, as a means of addressing transferability. Therefore, it was important for this study to provide a degree of contextual information from a broad group given the wide range of STEM-related professions.

According to Denzin and Lincoln (1994), *dependability* is the “stability of findings over time and confirmability to the internal coherence of the data in relation to the findings, interpretations, and recommendations.” Examples of dependability include the establishment of an audit trail, coding-recoding, triangulation, and peer examination (Anfara et al., 2002). The research study ensured *dependability* through the process of coding and recoding and established an audit trail that was frequently examined by experts in the field throughout the coding and recoding process. The dependability of the study relied on in-depth interviews outlining descriptive experiences in a variety of fields of science.

Confirmability refers to the “internal coherence of the data in relation to the findings, interpretations, and recommendations” (Denzin and Lincoln, 1994). The experiences and ideas of the participants reflected the confirmability of the study data. The documented data indicated findings based on reflective narratives gathered without a biased agenda. In the effort to build trustworthiness and confidence, a few key points were emphasized in each interview: 1) *the participants were encouraged to be frank,* 2) *iterative questioning was employed*, 3) *frequent debriefing sessions were held,* and 4) *member checks were utilized to ensure accuracy* (Shenton, 2004).

Ethical Considerations

Given the positions and organizations that the research participants represented, confidentiality and protection of their identities were significant ethical considerations. It was important to create rapport with the twelve STEM professionals by welcoming their expression of their experiences during the interview protocol and process. No psychological harm or risk to those involved was anticipated or presented during the study, and the participants’ perceived discomfort during the interview was taken into consideration. The research study met all ethical considerations by a) *creating a safe space* for each participant; b) developing a sense of *rapport*; and c) *supporting* the participant through the interview protocol. As a result, each participant was willing to candidly reveal her experiences. This building of trust created a level of comfort that allowed for honesty and provided a supportive interview space.

Table 1. Respondent Characteristics

Code name	Age	Field(s)	Level of education	Years in the field	Professional experience
Marie	57	Aerospace engineering	PhD	32+ years	Senior executive, NASA
Silvia	62	Aerospace engineering	MA	30+ years	Analyst, United Launch Alliance
Helena	46	Hydrogeology	MA	20+ years	Geologist, Leonard Rice Engineers
Kim	62	Chemical engineering	BA	35+ years	Chemical engineer, Phillips Petroleum
Heidi	48	Mathematics education	PhD	19+ years	University professor
Pam	34	Technology	BA	16+ years	CEO, technology company
Julie	59	Engineering	MA	30+ years	Municipal utility engineer
Heather	66	Neuroscience	PhD	40+ years	Neuroscientist, NIH and NSF
Carissa	40	Structural engineering	MA	18+ years	Martin/Matin, STEM teacher
Daisy	83	Physics	BA	20+ years	Botanist
Milli	52	Zoology	PhD	25+ years	University professor
Sarah	41	Technology	MA	18+ years	IBM, STEM teacher

Descriptive Analysis: Participant Backgrounds

Through their journeys, the twelve participants had well over 300 combined years of field experience. The women's field experiences ranged from secondary and postsecondary education to industry. Among the women, there were two STEM teachers (both former industry professionals), two university professors, and eight professionals in STEM fields. **Table 1** shows the descriptive characteristics and brief overviews of the respondents by *code name*, *age*, *field of science*, *level of education*, *years in the field,* and *professional experience*.

Of the twelve participants, only two had been raised in households in which the parents had earned a four-year degree. For these two participants, only one of their parents worked in a STEM field. Heather stated, "Dad graduated from Cornell University with a degree in civil engineering. Mom graduated from Duke University Phi Beta Kappa in the 1940s. I think her major was English." The other ten women mentioned that their parents' levels of education varied, e.g., coursework toward a high school diploma, GED or equivalent, and some college. Sarah mentioned, "Both of my parents are in India; they live in New Delhi. My mom finished her bachelor's in Sanskrit, and my dad, he is not that educated. My dad finished eighth grade."

Regardless of parental education level, there was a focus on the importance of education and an overall strong work ethic. Although the way in which the responsibility to pursue education and have a strong work ethic was expressed and taught varied among the participants, it prefaced their persistence in their academic journeys. Heidi explained as follows:

> In terms of education and occupation, [I] don't really feel like there was a ton of expectations for me. I mean, they expected that I'd graduate from high school, but I never really was encouraged beyond that. Grades in school, if I passed, did well enough, and didn't cause any trouble, that was generally the expectation for me. Like work ethic, I mean work hard. So, I had to balance…like the work ethic was more about being a human who was responsible and respectful, and you take care of other people, and you try to think of other people more so than yourself.

Importantly, these women were not only highly educated but also did not follow traditional STEM pathways; rather, they forged their own paths.

RESULTS

Math Efficacy

The first research question—*How does self-efficacy shape during adolescence among women leaders in STEM* —revealed the themes of math efficacy and shaping of mental exploration, which were shared by ten of the twelve participants. The literature emphasizes that more research is needed to explore pathways of the development of girls' overall STEM identities. As claimed by Koch et al. (2014, pp. 142-143), "gender identity and STEM identity do not come together for many girls, and researchers have begun to explore how to address identity as a critical pathway to the STEM pipeline for girls." According to the research participants, STEM identity is shaped through practical learning and exploratory experiences.

The *a priori* code "self-efficacy beliefs" captured the participants' own knowledge about their abilities and capacities, as opposed to other people's judgments of their capabilities. The excerpts support a continuum of comfort levels with problem-solving and how their degrees of comfort shaped their worlds. Bandura (1986, p. 391) stated that self-efficacy beliefs refer to "people's judgments of their capabilities to organize and execute courses of action required to attain designated types of performances." Bandura's definition of self-efficacy beliefs does not fully support the comments provided by the participants. Some of the participants emphasized that their families affirmed their math ability. Again, ten of the twelve participants described their ability as natural, innate, and/or something unexplainable. The term *efficacy* is defined by Merriam-Webster as a "capacity for producing a desired result"; efficacy fully supported the participants' experiences and beliefs. While the aim of the *a priori* coding was to capture all aspects of self-efficacy, when the excerpts were later examined, it was clear that the driving force for these women was *math* efficacy, not *self*-efficacy.

Math efficacy (which refers to how one sees the world through patterns, shapes, and numbers to shape a desirable outcome) was mentioned by ten of the twelve participants. In answering the first research question (*How does self-efficacy shape during adolescence among women leaders in STEM?*), determining the shaping of self-efficacy required tracing the participants' awareness of their capacity for math, referred to as *math efficacy*. The participants consistently emphasized their overall ability and capacity for math. Interestingly, the participants did not attribute their math ability to any direct influence from their environment, family, or school. Additionally, while some of the participants noted that parents and teachers had affirmed their abilities, others indicated that their abilities were challenged. Heidi revealed, "My algebra teacher, maybe in the eighth grade, would tell me that I did stuff weird; that I should do it the right way." The participants' propensity for math was eventually unpacked through their provision of multiple examples, such as examples of what began to shape their interests in STEM.

The research participants indicated that their *math efficacy* as adolescents introduced them to the experience of seeing the world from a mathematical perspective (e.g., in terms of patterns, shapes, and/or numbers) and of seeing how their ability could lead to a desirable outcome. The participants distinctively communicated their capacity for math through its distinct forms and association (e.g., patterns, shapes, and/or numbers) as a natural phenomenon. The participants specifically commented on how their capacity for math began with a distinct liking of an individual type of math (e.g., shapes, patterns, and/or numbers).

The participants' reflections reiterated that their experiences in math were shaped by a distinct form of math that captured their interest and that they understood better than other forms. For example, Marie explained as follows:

> Even my dad showing me how to take a motor apart and inner stuff, and whether they call it science or technology, whether you call it hands-on skills, all that stuff. He only had an eighth-grade education, but he taught me trigonometry and geometry. We did it by looking at trees and shadows and things like that. He was very practical; [quoting her dad] 'You can find this distance by this; you can see the sun, and you measure in the shadows of space,' and it was a good way to learn.

Marie's comment demonstrated and explained her connection to shapes and geometric forms. Marie's father illustrated a practical application of trigonometry and geometry. Her understanding of math took shape through her father's practical introduction of trigonometry and geometry by referring to trees and shadows. The experience she recounted became a segue in further advancing her curiosity and science literacy. Transformative learning, interest, and curiosity regarding shapes, patterns, and/or numbers were consistent topics across the participants' reflections. Helena provided the following reflection:

> So, my geometry class was transformative for me. I ended up in that class with 100 percent, you know, at the end. And that is when I realized that I could really, that I understood complicated shapes and complicated depths. And I think those concepts—I mean, calculus and DiffEq—that just helped affirm it. But geometry, really, I could see in my mind the angles and see how it related to each angle, each deformation fitted together.

Helena's experience of understanding how patterns and shapes fit together affirmed her math ability by revealing her connection to shapes. Her reflection explained how her interest in shapes created and further developed her capacity to sustain interest.

It was interesting to hear how the participants explained math logically through the practical connection of patterns, shapes, and/or numbers. For example, Carissa noted, "Mine isn't so much science as much as numbers. Like, I just loved numbers and problem-solving. I would do logic problems, those logic puzzle books—I would get one every year, and that would be something I would enjoy doing." Carissa's love for numbers prefaced her interest in patterns, as it affirmed her interest and curiosity about how things connect through problem-solving.

The word "natural" was associated with math ability in the reflections of ten of the twelve participants. Each experience illustrated how the participant's understanding of specific forms of math (e.g., patterns, shapes, and/or numbers) had taken shape throughout adolescence. These findings indicated that the participants' understanding of math was shaped by a distinct form of math (e.g., patterns, shapes, and/or numbers), which nurtured their capacity for interest in math. The participants' reflections on math efficacy determined how each viewed the world through patterns, shapes, and numbers in ways that shaped desirable outcomes.

Shaping of Mental Exploration

The *a priori* code *shaping* referred to excerpts that reflected the development and cultivation of participant STEM-driven interests, thus *shaping* their STEM identities. According to Bandura (2005, p. 12), "choices made during formative periods of development shape the course of lives. Such choices determine which aspects of their potentialities people cultivate and which they leave undeveloped." His explanation describes the causal meaning of shaping and is consistent with the participants' experiences. The excerpts supported Bandura's definition and brought meaning and awareness to the formative periods in girls' lives by detailing the experiences of women in STEM. The participants' formative periods of development began with exploration—that is, their development started when they began to wonder how the world works.

The theme of *shaping of mental exploration* consisted of a variety of exploratory experiences that might be expected, including music and experimentation, as well as others that were somewhat surprising, such as cooking, ranching, and even rock collecting. These experiences provided the participants with an explorative sense of wonder that framed their STEM-driven interests and enjoyment. Marie, an aerospace engineer, reflected as follows:

> I would say that the most formative moment was watching Apollo 11. And I still remember being seven years old; that made me want to work for NASA. Being seven years old, watching Neil Armstrong and Buzz Aldrin walk on the moon, and I can still remember telling my mom and dad that's what I wanted to do. And then, from there it became aviation and science and space and astronomy and all those things—it became my focus from then on.

Heather, a retired neuroscientist, was raised around animals and noted that she translated practical applications into scientific practices. She stated,

> And the training for the horses and making sure that everyone is behaving properly…I realized that there's a real scientific way to do this properly. And yet I kind of learned some of it in an ad hoc way.

Heather's experience of having responsibility for taking care of animals to meet a need—and/or gain impromptu practice—shaped her capacity to translate common practice into scientific understanding; in other words, it shaped her science literacy. She further described,

> The biology combined with the psychology [class] gave me the basic biological control of behavior of thought. World events or behavior is not random—there are causes. There's a stimulus and a response type of activity that goes on for people, for animals, and in nature generally. And that kind of gave me a concept of putting order onto my worldview.

Heather's experience of taking care of animals shaped her curiosity into a scientific understanding of how people and animals respond to stimuli. The shaping of mental exploration, as explained by Heather, is not necessarily associated with a physical location. Instead, the experience is intellectual and involves scientific exploration.

Mental exploration takes the shape of exposure, imagination, and curiosity, but more importantly, it allows the imagination to ask questions, formulate answers, and discover possibilities. Mental exploration, as explained by the participants, served as a contextual framework for development that hastened their eagerness to learn, explore, and develop the humility to wonder and consider extensive possibilities.

Self-Discovery through Problem-Solving Regarding Why and How Things Work

The second research question—*What qualities and/or experiences are considered to shape self-efficacy and therefore influence persistence among women leaders in STEM?*—revealed the common theme of self-discovery through problem-solving to determine why and how things work and through connection to an encouraging learning community, which were experiences shared by eleven of the twelve participants.

The participants' responses described self-discovery and its importance in influencing persistence throughout their academic and/or professional experiences. Each participant noted that she understood and preferred the logic of math and science courses over courses in the liberal arts. The participants' general curiosity about why and how things worked created a platform for navigating their academic journeys. Specifically, persistence was influenced and/or developed by establishing self-awareness and by approaching problem-solving through logic and measurable outcomes.

Of the twelve participants, eleven shared the theme of *self-discovery through problem-solving to determine why and how things work*. The women's capability to understand "why and how" and not just "what and when" influenced their academic journeys. Among the participants, problem-solving took the form of realizing that through their STEM-driven interests, they were drawn to efforts that required or developed a logical outcome (e.g., problem-solving applications, math, logic books, puzzles, and science experiments). Self-discovery supported their STEM-driven interests and framed their STEM identities. Self-discovery regarding the desire to solve problems in order to understand why and how things work provided the women with explanations, reasons, and purpose and encouraged them to continue in their efforts. They shared similar reflections of experiences that opened the door to inquiry, problem-solving, and the questioning of why and how things worked. Helena provided the following reflection:

> I think that my first was curiosity and then just the overall driving need to understand how it worked. And then once I figured out how it worked, having the sense of satisfaction and well-being and say[ing], 'Okay, now the next problem' [laughed]. And I think, too, the need to fix things, you know, and problem-solving that…How do I…Here is the need and the want; what are the solutions to fix it? You know, like the need to figure out how to cook macaroni and cheese [laughed]. My sisters and I were hungry [laughed], and we wanted mac and cheese, but we weren't allowed to use the stove [laughed]. So, was there another way [laughed]? There was not at the time [laughed].

Helena's comment demonstrated her driving need to know "how," emphasizing how problem-solving had a practical connection to science through the mundane process of cooking macaroni and cheese. Helena recognized that this drive began with curiosity and then developed into practical problem-solving. Learning how to cook macaroni and cheese was a practical task born from a sense of curiosity and developed into an internal need to continue solving problems. For Helena, "having the sense of satisfaction and well-being to say, 'Okay, now the next problem'" indicated her desire and ability to negotiate a task and her instinctive willingness to persist to the next problem.

Milli acknowledged that problem-solving was associated with determination, learning how to navigate, and seeking the necessary resources to obtain the answer:

> So I was still operating like, 'Oh, I'm great' and all that, and slowly, like, we had a physics teacher, he'[d] just come and do stuff; I just couldn't keep up with it. And I could see, but I could see the boys, especially the boys were able to. So, I would, like, ask them, 'How did you do that?' And then they would just show me, and I was like, 'But the teacher didn't show that step that you did.' So I didn't know where they were learning. And so I struggled with, especially with physics, I think, in the eleventh grade.

Milli realized that during her adolescent experience, she required more than just basic classroom instruction to grasp the necessary information to excel academically:

> And I…I just went, and there was a place in Delhi called Nai Sarak, which is where you get, like, supplementary books. And so I told my mom I needed to buy some books because the schoolbooks are not explaining. And so I got some extra books, and I started to read a little bit, like learn a little bit more on my own and to see what was going on.

Milli's experience demonstrated her rigid determination to further her learning by any means necessary. She acknowledged her difficulty in the classroom and sought out the necessary reading materials outside the classroom, but most importantly, she proved that she was willing to continue despite the challenges she faced.

This shared theme explicitly indicated the similar ways in which the participants navigated their academic journeys. The participants' reminiscences consistently showed that their problem-solving stemmed from their curiosity and desire to question why and how things worked. Their self-discovery of problem-solving to understand why and how things work created a favorable pathway for academic and professional choices, which resulted in their willingness to continue solving problems. This self-discovery created an internal eagerness to question, query, wonder, and uncover why and how things worked. The participants had one factor in common: the shared desire to solve problems by applying logic and reason. Their eagerness to question and problem-solve cemented an internal logic that provided order and explanation. Silvia affirmed, "It's just seeing all kind[s] of things in your world and having that background to understand what you see, right…not everybody cares about that [laughed], right?…But I do; I want to understand why."

Connection to an Encouraging Learning Community

Based on the women's reflections, connection to an encouraging learning community was important. Eleven of the participants noted a connection to an encouraging learning community consisting of, e.g., family, school, or environmental influences. In the participants' responses, the *a priori* code 'connection' was applied to human interaction with family, teachers, and the environment. Pajares and Urdan (2006, p. 359) stated, "For instance, if a young person can be helped to realize that increased effort and perseverance will result in academic progress and greater understanding in mathematics, connections will be made to achieving success in other academic areas." In line with Pajares and Urdan (2006), Marie stated, "I think if I had not had a family that told me I could do anything, that would have made a major difference." The human connections expressed by the participants influenced their personal journeys, professional careers, and academic pursuits. DePaulo (2010) stated, "Relationship, though, is a great big word. It covers all sorts of human connections, including ties to friends, parents, children, siblings, other family members, coworkers, neighbors, mentors, and more." For the participants, "connection" included influences from both inside and outside the home (e.g., teachers, parents, extended family, coaches, supervisors, and professors) that significantly impacted their own personal journeys. The connection emphasized by the participants gave meaning to their learning and provided encouragement, thereby influencing their journeys. Daisy emphasized, "You know, I was always…as I said, my mother was incredibly supportive, and she wanted me to succeed."

The adolescent experiences that the participants shared in their reflections supported their willingness to pursue academic interests and make life-changing decisions, while messages from their family, friends, and/or communities gave meaning to their journeys. Kim recalled the following:

> Yeah, so, that particular teacher and my math teacher suggested I go into mechanical engineering. The fact that it was a woman, maybe [it] was helpful that she was interested specifically in what I was doing. I do not know…I had no idea she made a habit of that whole semester, just going around chatting with each student [and] finding out where they were going forward. I had absolutely no idea. But I know I sort of appreciated that.

The participants' reflections and connection to an encouraging learning community put into perspective the importance of an educative foundation, including where and how it begins.

Helena said that the messages she received provided her with real meaning:

> So I think middle school, and I think it was a specific science teacher and their influence on me. But my seventh-grade science teacher, he was a male. My eighth-grade science teacher was female; I can't remember their names right now. But they, I think they specifically fostered me and said, 'Here, you can do better.' And I think that really honed my interest, and then I made sure all through high school [that] I had science classes. I didn't *not* take science. And I think, too, just those conversations with my grandparents, and my grandfather was a general contractor. And he said, 'Don't be the general contractor; be the "-ist."' Whatever, you know, the biologist, the geologist, the engineer…be that person.

The participants' reflections revealed how the connection to an encouraging learning community can make a difference. Each of the women emphasized what an encouraging learning community meant to her personally and how it came to influence her journey. The comments shared by the participants emphasized that intentional acts of support from professors, parents, and teachers who advocated for their success helped guide their decisions by helping them realize that anything and everything was possible if they just believed. Marie recalled, "I always thought I could, and I did well, the teachers always said that I did well. So that gave me the belief."

Visual Explanation of Findings

The research study comprised the analysis of two research questions: a) *How does self-efficacy shape during adolescence among women leaders in STEM?* and b) *What qualities and/or experiences during adolescence are considered to shape self-efficacy and therefore influence persistence among women leaders in STEM?* The analysis of these two research questions led to the identification of four themes shared by the twelve participants, demonstrating that significant journeys can and do align.

The model visually represents the participants' narratives of how their innate ability for math was influenced during their formative periods of development. The participants emphasized that their distinct liking for a particular form of math was nurtured through real-world exploratory experiences derived into interests and shaped by family, school, and environment, inevitably empowering them to explore, dream, and question how the world works. The concentric images surrounding math efficacy indicate three important factors that shaped their STEM-driven interests: a) introduction to problem-solving, thus creating a distinct liking and curiosity through self-discovery; b) connection to family and community, which nurtured STEM interests and influenced their confidence in solving complex problem-solving applications; c) mental exploration, which developed a sustainable desire to question, query, and wonder how the world works, thus shaping their STEM identity.

Figure 2 provides a visual analysis of the findings, accompanied by contextual constructs that give meaning to the information that the participants expressed throughout their reflections. The visual model below presents three concentric images central to math efficacy that frame how the participants' adolescent self-efficacy took shape and, in turn, what qualities and/or experiences in adolescence influenced the participants' persistence throughout their journeys.

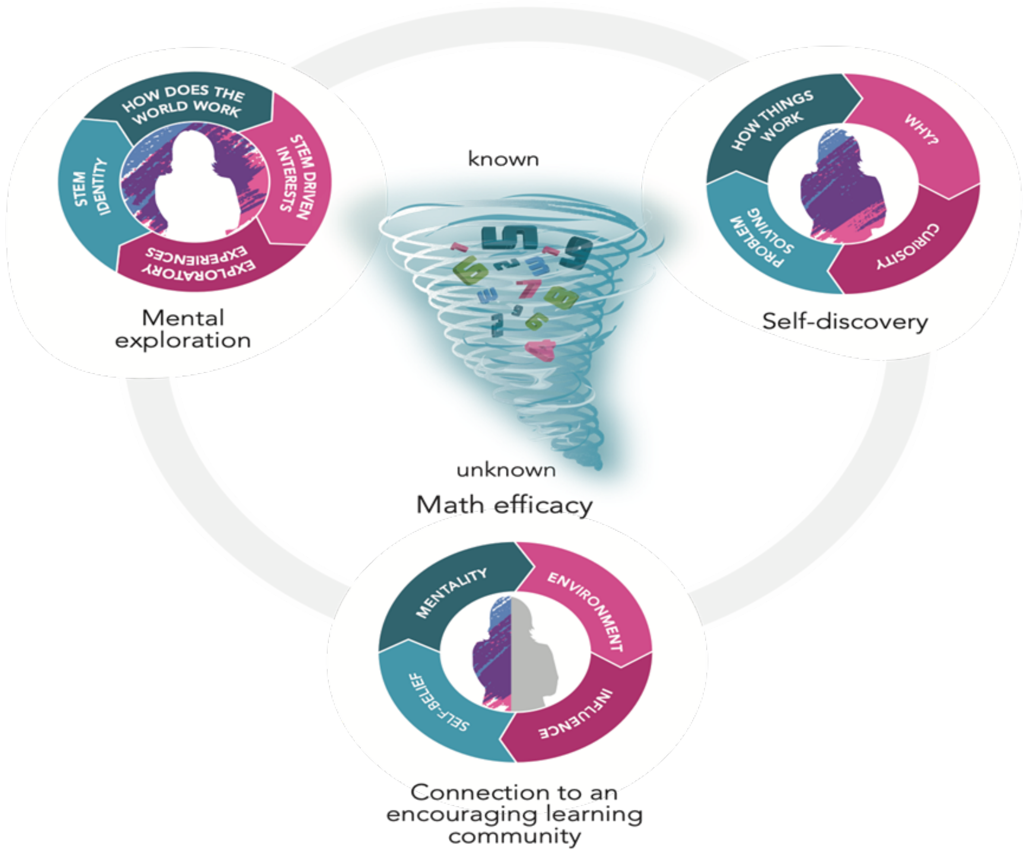

Figure 2. STEM Efficacy and Persistence Model

Visual Description: STEM Efficacy and Persistence Model

The STEM efficacy and persistence model provides a visual analysis of the four themes shared by the twelve participants. The model shows how the shaping of mental exploration, self-discovery of problem-solving to understand why and how things work, and connection to an encouraging learning community often work in concert with math efficacy. All four themes were relevant and vitally important to shaping adolescent self-efficacy and its influence on persistence among women in STEM. The first theme, *math efficacy*, reflected how the participants' views of the world, through patterns, shapes, and numbers, shaped their desired outcomes and appeared to begin during their formative periods of development. As Heather said, "That kind of gave me a concept of putting order to my worldview." Her reflection was consistent with the other participants' emphasis that patterns, shapes, and numbers brought order to chaos, helping to shape the world around them. Examples of math efficacy shared by the participants included their preference for math and science, logic games, puzzles, and problem-solving over the liberal arts.

The second theme, *shaping of mental exploration,* showed how the participants' sense of logic took shape through exploratory experiences (e.g., music, rock collections, ranching, cooking, and experimentation). The exploratory experiences through which the participants sharpened their STEM identities through STEM-driven interests were prompted by the question, "How does the world work?" The third theme, *self-discovery through problem-solving to understand why and how things work,* was central to the formative development of the participants' curiosity. Their curiosity led them to ask questions and seek answers through problem-solving. Carissa stressed,

> Even though I really wasn't very good in English, they all were amazed at my problem-solving abilities and my math abilities. And it just came easy for me, like I didn't have to try hard to…so I didn't really learn how to apply myself either in school at a young age…or it wasn't really until grad school that I really had to figure out how to work hard at school.

Furthermore, the fourth theme, *connection to an encouraging learning community*, consisted of significant influence and/or support from, e.g., parents, extended family, teachers, professors, and coaches. The participants emphasized that an encouraging learning community provided a positive influence and an environment in which to learn, excel, and explore education. This support provided meaningful guidance that they attributed to their academic fulfillment in school, college, and/or the workforce. For example, Sarah described the influence of a woman role model as follows:

> I had the best boss ever when I started, and she was a woman. So she was my role model. And when I say role model, I think that helped for me as well, just seeing her, the way she worked, the way she handled stuff, multitasking, time management. I think I have learned a lot from my first boss just by the way she was working. And that is when I made my own way from there.

DISCUSSION

This study emerged from a "why" question, specifically, why women are underrepresented in STEM? I purposefully sought to represent the voices of women from various fields of science and organizations. In doing so, I wanted the study to be relatable; benefit a broader population; provide sustainable findings; and significantly impact all girls and women regardless of their journeys, ethnicities, levels of education, etc.

To do so, it was important for the study to include a descriptive model, e.g., the *STEM efficacy and persistence model*. The purpose of the *STEM efficacy and persistence model* was to provide a visual representation and framework of the detailed, specific adolescent memories of twelve accomplished women in STEM. The model illustrates how three important constructs work in concert with *math efficacy*, with each element having equal importance. The model was specifically designed to be used as a tool and/or guide and to visually describe how self-efficacy was shaped among twelve women in STEM and, in turn, influenced their persistence by detailing vital aspects of their formative periods of development, e.g., curiosity, interests, and STEM identities.

As the sole investigator in this study, I believe that there is a need for further qualitative studies to continue unpacking the role of self-efficacy during adolescence and thereby to help provide meaning to practicing professionals, educational settings, and potential future STEM professionals. Additional qualitative studies of women in STEM with larger samples would provide an extensive causal, in-depth understanding of the association between *mental exploration*, *self-discovery*, *math efficacy*, and the *connection to an encouraging learning community*.

The implications of this study contributed to increased awareness. It is important to note that the theme of *math efficacy* was shared among the participants even though none of the direct interview questions in the protocol pertained to math. *Math efficacy* has been explored in terms of how women connect to distinct forms of math, e.g., patterns, shapes, and/or numbers, therefore supporting their worldview rather than limiting it. The concept is consistent with the participants' reflections regarding experiences that prefaced their math ability and, more importantly, how their natural connection to math allowed them to see and shape their world. The connection between a person's math ability and judgments has been explored through the lens of math self-efficacy. Betz and Hackett (1983) acknowledge assessments in terms of individual judgments regarding how to solve mathematical problems. Each of the participants honed in on her math ability as central and significant during her formative periods of development. The participants referred to their math abilities as natural, innate, and/or unexplainable. It was understood that their capacity for math was formed through their interest in distinct forms of math, e.g., patterns, shapes, and/or numbers.

It is also important to recognize certain significant aspects of math efficacy: a) when the connection to math occurred; b) how the connection was influenced; c) why the interest emerged; and d) who affirmed the interest. In the women's narratives, all four components of math efficacy were equally important during their formative periods of development. The findings of this research study showed that math efficacy was not demonstrated by a behavior or measure but, rather, by a relative understanding of how each participant connected to math and sustained her interest in distinct mathematical forms, e.g., patterns, shapes, and/or numbers.

Math efficacy was included in this research study to explain how women allow their innate math ability to influence how they see and shape their world. It was introduced as a new concept in this study to provide insight into how relevant forms of math, e.g., patterns, shapes, and numbers, were present during the participants' adolescence and, in turn, shaped the participants' views of the world. This concept was not introduced to de-emphasize the importance of past and present studies of math self-efficacy, mathematics-related behaviors, or the definition of math as the ability to perform mathematical equations. Rather, it was intended to reveal how the participants' connections with math were shaped during adolescence.

Another implication that has the potential to benefit the broader population relates to self-discovery and awareness of innate abilities during formative periods of development. Throughout the research study, multiple women shared their early preference for math and science over liberal arts coursework, e.g., English, literature, and spelling. Carissa indicated, "I think the biggest challenges I had were reading and writing and not enjoying it…and spelling; I am still a horrible speller." After the analysis of similar reflections, academic journeys, and professional career choices, it was apparent that some, if not all, of the participants became aware of their innate abilities early on through self-discovery, which shaped the trajectories of their lives.

Marie shared an experience that she considered to be a life-changing event, as it sparked curiosity and led her to what she eventually considered a possible career pathway. This experience allowed her to dream, connect, and impact her academic trajectory. One moment, one experience, and one event can shape the life of an adolescent forever. During the interview, the questioning was paused as Marie listened to a broadcast over the radio commemorating Apollo's 50th anniversary—an indescribable moment. It was easy to see the excitement in her eyes and to understand how this event had shaped her personal journey and passion.

Self-discovery among the participants was demonstrated in their realization that math and science courses stoked their curiosity and eagerness to know why. Their reflections also emphasized distinct boredom in non-math and science courses (e.g., geography, spelling, and English). Self-discovery, according to Summer (2017, p. 391), "requires a process of conjecture and refutation, a willingness to question and criticize received views and to welcome challenges and criticism to views that one holds dear and that may seem to be part of one's identity." For the participants, self-discovery was thought of as the curiosity to ask "why?", which led to problem-solving in search of a logical explanation for how things work. The participants' curiosity increased their eagerness and desire to solve problems. Many of the women shared interesting experiences they had in the classroom based on their awareness of abilities, advanced understanding of math and/or science coursework, and interest and curiosity.

Other participant endeavors (e.g., science projects, tactile problem-solving, music, board games, trips to the library, vacations, and rock collections) supported the participants' adolescent interests and later STEM identities. These experiences shaped their development through pragmatic opportunities to wonder, dream, observe, ask questions, and explore beyond the present day. Each of their experiences provided an opportunity to dream. Milli indicated, "We never had a lot of money, we never had luxuries, but we had dreams." To increase awareness, it is imperative to a) advance curricula that respond to and focus on the intellectual development of advanced learners in math and science; b) increase awareness of the differentiation between science and non-science coursework across educational settings; and c) develop educational practices to assist in understanding how science-literate students respond to both science and non-science coursework.

Based on the research study, the analyzed reflections offered additional insight that could benefit STEM education at all levels, including insight on a) the benefits of hands-on tactile learning; b) innate ability (sense of knowing) and its association with science literacy; and c) the positive influence of women, e.g., teachers, mothers, and professors, during formative periods of development. Hands-on tactile learning was mentioned in several reflections. The mention of hands-on learning stemmed the participants' interest early on and, in turn, helped them develop a sense of self-confidence. Pam mentioned,

> So, from building and tweaking and learning how to change light fixtures and things like that, I had this kind of hands-on…and I think science and that allowed for you to be hands-on and allowed for you to be kind of a tactical learner and that was something that helped me and until this day still helps me, I think.

The reference to science and its relation to hands-on tactile learning increases awareness of a) the shaping of science; and b) science literacy behavior early on.

The participants' awareness of their innate abilities during their formative periods of development, which were expressed through likes and dislikes, and the association of this awareness with science literacy were paramount. Pam mentioned,

> For me, when I likely could have been exploring and doing more with science and math, I think I spent time not trying to fail at English and writing and literature in those areas. So, I think there was an internal inside academia and outside academia of not letting that fall. Ultimately, the energy that could have been put into exploring and doing more of what I was good at and what I *liked* was shifted back into putting way more time and energy and effort into something just so I could, again, have good grades and [not] disappoint.

Helena shared a similar reflection,

> I think it was [an] *innate* feeling. It made me, and maybe that was developed by my mom giving me books and my constant questioning. And her taking me seriously and not saying oh…figure it out. But helping to foster my curiosity and my drive.

The reflections that the participants shared provide insight into a) how likes and dislikes were expressed and demonstrated through words, academic pathways, and career choices; b) when likes and dislikes were expressed during formative periods of development; and c) the academic outcomes and career pathways chosen based on the participants' senses of their likes and dislikes early on.

Several of the participants mentioned the last implication, the positive influence of a woman role model and/or mentor, e.g., a teacher, mother, coach, or professor. In their reflections, several participants concluded that the influence of a woman shaped their journeys as young adolescents. Milli mentioned, "So, yes, teachers and then, of course, my mother being a huge influence. In the sense that she herself, she just created a space in the house where it was encouraged to excel in school." The benefit of having a positive influence from a woman was consistent across many memories that detailed the significant contributions of such an influence on development, academic pathways, and career choices. The findings regarding the positive influence of a woman indicate how significant such an influence can be to academic success for girls during their formative periods of development.

Limitations

The findings in this study were generated from interviews with twelve women in various fields of science with various career paths and experiences. The participants were limited to women in the fields of science, technology, engineering, and mathematics who were identified through convenience and snowball sampling in the geographical study area. The participant sample was limited based on women in STEM who agreed to participate and who were recruited from my personal and professional networks as feasible candidates based on the research criteria.

CONCLUSIONS

The voices of twelve women, each with a unique journey, illustrate four themes significant to increasing awareness of how self-efficacy is shaped during adolescence and, in turn, influences persistence among women. The study a) provides insight to help increase the representation of women in STEM by welcoming narratives of women that would advance qualitative studies in this research area; and b) increases awareness of science literacy based on the reflective narratives of women in STEM to help shape educational settings and professional learning communities. This research study is dedicated to girls who may question their abilities, young women questioning whether to begin careers in STEM, and practicing professionals seeking support in sustaining a career. I would like girls and women to realize that their persistence does matter and that when girls persist, women will thrive.

LIST OF ABBREVIATIONS

STEM-Science, technology, engineering, and mathematics

DECLARATIONS

Availability of Data and Materials

The datasets, e.g., the interview protocols generated and/or analyzed during this qualitative phenomenological study and personal identifying information, are not publicly available due to the confidentiality of the interviewed participants but are available from the corresponding author upon reasonable request with consenting approval from the participant.

Competing Interests

The authors declare that they have no competing interests.

Funding

The research study did not require any sort of budget or funding.

Authors' Contributions

As the sole researcher and author of this study, I recruited participants from my personal and professional networks and among those whom members of my network identified as feasible candidates with regard to the research criteria.

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APPENDIX A: INTERVIEW PROTOCOL

Table 1. Women STEM Leaders Interview Protocol

Family Background	• What were your parents' levels of education and their occupations? • What were some of the messages you received from your parents regarding your work ethics, aspirations, and/or education? • Were there any family traditions that impacted you during your adolescence? • What type of responsibilities (i.e., chores) were required of you as an adolescent in and outside the home? • What types of activities and/or programs did you participate in (i.e., sports, school clubs, and/or afterschool programs)? o How did you enjoy them? o What did you enjoy about them? o How did the activities make you feel?
Adolescent Self-discovery	• How did you perceive yourself as an adolescent girl? • How were you perceived as an adolescent girl? o by others? in school? at home? in the community? • Please explain your journey of self-discovery as an adolescent girl. What specific experiences do you attribute to your self-discovery?
STEM Interests & Connection	• Please reflect on your initial connection to science and explain that experience? • How did the connection and experience make you feel? • What about science prompted your initial interest as an adolescent? • When and how did you realize you enjoyed science? • Explain what triggered your curiosity about science. o What was your initial takeaway from the experience? o How did it make you feel?
Middle School, High School, & Academic Performance	• What positive academic influences inspired you as an adolescent girl? o How did they influence your performance? Why? • Please share an experience you had as an adolescent in school when your academic achievement was praised in the classroom? o How did it make you feel? • What environmental influences (teachers, peers, family) could have contradicted your interest in science? • What environmental influences (teachers, peers, family) supported your interest in science? • Did you have any immediate family members and/or close relatives in science fields? o If so, how did it impact or influence your interest in science? • What environmental influences (teachers, peers, family) supported your interest in science? • How did you perceive your academic ability in science compared to that of other students?
Adolescent Experiences / Journey	• What were some of the adolescent experiences that helped shape your academic journey? • What experiences specifically shaped your effort to persist academically in and outside the classroom? • Please explain a situation during adolescence in which you experienced self-doubt that caused you to question your abilities and impacted your academic performance? o What contributed to your self-doubt?
Challenges & Influences	• What challenges did you experience as an adolescent? o in the classroom? outside the classroom? o What contributed to these challenges? • What environmental factors influenced your academic journey? • How did negative academic influences impact you as an adolescent girl in and outside the classroom?
Aspirations	• What career fields inspired you as an adolescent? • As an adolescent, what aided and/or nurtured your interest to pursue a career in science?
Reflection	• During your academic journey, did you persist by choice or circumstance? • Please explain your definition of academic persistence. o What or who influenced your academic persistence? How? • What were some of the experiences during adolescence that helped shape your academic persistence? • At what point during your academic journey did you achieve self-mastery? o What experiences do you attribute to your self-mastery? • If you had the opportunity to speak to an adolescent girl with self-doubt about her ability to persist in science, what would you say?

Probes to encourage respondents to further explain their responses and/or provide additional elucidatory information were administered as needed and consisted of "Please explain", "Why?" and "How?"

APPENDIX B: A PRIORI CODES

Code	Definition
Persistence	• "Voluntary continuation of goal-directed action in spite of obstacles, difficulties, or discouragement" (Peterson and Seligman, 2004, p. 229).
Performance	• "Refers to both behavior and results. Behaviors are emanating from the performer and turn the performance of an abstract concept into a concrete action" (Brumbach, 1988).
Self-efficacy beliefs	• "People's judgments of their capabilities to organize and execute courses of action required to attain designated types of performances" (Bandura, 1986, p. 391).
Self-discovery	• "Requires a process of conjecture and refutation, a willingness to question and criticize received views and to welcome challenges and criticism to views that one holds dear and that may seem to be part of one's identity" (Summer, 2017, p. 391).
Self-belief	• "People with self-beliefs of confidence have been shown to attribute failure to lack of effort; people with low self-beliefs of confidence ascribe their failures to lack of ability (Collins, 1982).
Self-mastery	• "The ability to take control of one's life without being blown off course by feelings, urges, circumstances" (Collins English Dictionary).
Success	• "That young people can fulfill individual goals and have the agency and competencies to influence the world around them" (Wallace Editorial Team, 2017).
Academic Achievement	• "Represents performance outcomes that indicate the extent to which a person has accomplished specific goals that were the focus of activities in instructional environments, specifically in school, college, and university" (Crede et al., 2015).
Connection	• "Relationship, though, is a great big word. It covers all sorts of human connections, including those structured across activities. For instance, if a young person can be helped to realize that increased effort and perseverance will result in academic progress and greater understanding in mathematics, connections will be made to achieving success in other academic areas" (Pajares and Urdan, 2006, p. 359).
Nurture	• "It is more likely that behavior is due to an interaction between nature (biology) and nurture (environment)" (Bandura, 1977).
Shape	• "Choices made during formative periods of development shape the course of lives. Such choices determine which aspects of their potentialities people cultivate and which they leave undeveloped" (Bandura, 2005, p. 12).