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Women's Reflections on Learning 10 Years After a Middle School STEM Program

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Abstract

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MS, University of Wisconsin Eau Claire, 1995

BS, University of Wisconsin Platteville, 1992

Dissertation Submitted in Partial Fulfillment

of the Requirements for the Degree of

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Abstract

A lack of understanding of how women perceive their learning continues to hinder efforts to design educational experiences that prepare women for STEM disciplines. The purpose of this basic qualitative study was to explore women's perceptions of their learning from a middle school STEM program a decade earlier and other learning experiences they had into their adulthood. Semistructured interviews were conducted with 10 of 26 women who participated in that STEM program when they were in middle school. Belenky et al.'s women's ways of knowing provided a unique lens for examining participants' understanding of their development as learners. Key findings from coding analysis were that participants preferred active learning in groups; they were engaged by dialogue; they were motivated by hands-on activities, especially activities they were not typically exposed to; and they understood themselves as learners. Belenky et al.'s women's ways of knowing provided a unique lens for examining participants' understanding of their development as learners. Study participants exemplified strong self-awareness by describing important developmental growth: moving from silence to finding their voices; understanding their strengths and weaknesses as learners; and recognizing their increased confidence. Further qualitative and longitudinal studies are needed to identify the most effective active learning approaches, and increased resources are needed for equitable implementation of those programs. Results may provide academic leaders with a better understanding of the educational influences on women during an important developmental period. This understanding may aid in designing more effective programs, thereby promoting positive social change and improved outcomes for women.

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Dedication

This research is dedicated to my husband, Steve, my mentor, Dr. Rose Marie Lynch, my mom; and to all the girls who dream big, get knocked down, and persevere despite the deck—at times—being stacked against them.

Acknowledgments

There are many people responsible for the fact that this acknowledgement is being read by anyone. Conducting interviews and finishing my research during the COVID-19 pandemic was challenging, and I learned a lot about myself in that period from March 2020 until the summer of 2021. I would like to thank my Walden chairperson, Dr. Patricia Brewer, and Walden methodologist, Dr. Alice Eichholz, who have provided the firm guidance and direction I needed to finish this. I am also grateful to my form and style editor, Dr. Joe Gredler, for his excellent editing suggestions.

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Thank you to my husband for being so patient as I was working on this lifelong goal. Now you and my mom will never have to ask me again "How much longer?"

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Chapter 1: Introduction to the Study

This study addressed women's perceptions of their learning by having a small group of young women reflect on their learning experiences, beginning with a science, technology, engineering, and mathematics (STEM) program they participated in during middle school nearly 1 decade ago. Due to the rigorous nature of STEM education, strong learning and cognitive skills are necessary to pursue these disciplines. A better understanding of how STEM programs influence women's perceptions of their learning experiences could help address continuing shortfalls in women's participation and success in STEM fields.

In 2009 I designed a STEM program, funded in part by the National Science Foundation (NSF), for a select group of middle school girls living in a rural area in a Midwest U.S. state. The program incorporated hands-on learning activities in a variety of STEM disciplines as a way to encourage girls to consider pursuing a STEM pathway in high school and college. The women participated in program activities each week over a period of 2 and 1/2 years (2009–2012). A subgroup of participants in this NSF-sponsored program constituted the subjects of this study, and all of the young women who participated were of college age at the time of this study.

Despite decades of targeted interventions to increase the number of women in STEM, women continue to be underrepresented in some fields, such as engineering, physics, mathematics, and computer science (NSF, 2019). In 2016, women earned over 57% of all bachelor's degrees and 50% of all science and engineering degrees (NSF, 2019). In 2017, women made up only 29% of the science and engineering workforce

(National Science Board, 2020). Women's representation in some disciplines has improved; however, women have not gained parity in engineering (NSF, 2019; Tao & McNelly, 2019), computer science (DuBow et al., 2016), and physics (Lewis et al., 2016). Women's representation is less than 30% in these three disciplines despite the availability of STEM jobs (NSF, 2019).

The foci of previous research about women and STEM have shifted from student deficits and attempts to make women fit with STEM to attempts to change the academic cultural landscape (Dewsbury, 2017). Although much of the recent work has focused on teaching, another important area is the influence of participation in STEM interventions on women's perceptions of their learning experiences (Carpi et al., 2017; Morton & Beverly, 2017; Rincon & George-Jackson, 2016). A cognitive framework such as that suggested by Belenky et al. (1986) has the potential to transform what can be rigorous STEM academic pathways into more inclusive ones that are attractive to and more supportive of women, particularly as they enter higher education. The implications for social change in educating girls and women toward meeting the needs of a rapidly changing STEM workforce are at the heart of this research. The study I conducted addressed that framework in this context.

This chapter includes the background, problem statement, and purpose of the study that provided a basis for the research question. I include a detailed description of the conceptual framework that provided the lens for this study. I also include the nature of the study, key definitions, assumptions, scope and delimitations, limitations, and the significance of this research.

Background

For the past several decades, researchers have focused on STEM opportunities designed for women and girls with the goal of encouraging them to consider nontraditional STEM careers (Cloutier et al., 2018; Olsson & Martiny, 2018; Ononye & Bong, 2018). Women have been a major target population of these studies due to their continued low numbers in disciplines such as engineering, physics, math, and computer science (DuBow et al., 2016; NSF, 2019; Tao & McNelly, 2019). The plethora of outreach efforts involving women and STEM has failed to provide a rich understanding of women's learning experiences because this line of inquiry has been quantitative in nature. Quantitative research about students' abilities often involves analysis of standardized test scores, and little is known about how students perceive their learning. Longitudinal and qualitative approaches could provide more insight into these ways of knowing (Alexander & Herman, 2016; Lykkegaard & Ulriksen, 2019).

After a thematic review of women and STEM research from 2007 to 2017, Blackburn (2017) asserted a need for more studies that would examine the "holistic lived experiences of women in STEM" (p. 251), which could be gathered through qualitative inquiry. Qualitative studies designed to highlight women's lived experiences around learning would add to this body of knowledge. There is also a need for more qualitative studies that follow students over time in STEM education (Alexander & Herman, 2016; Lykkegaard & Ulriksen, 2019). More follow-up studies of women who participated in STEM learning experiences could help researchers understand the broader influences of such programs on learning for women (Ihrig et al., 2018; Kurz et al., 2015).

The current study addressed the gap in understanding of women's learning through a qualitative analysis of women's perceptions of their learning after participating in a STEM educational program and other formal learning experiences. A feature of this study was that it addressed women's perceptions of learning over the span of 1 decade of formal learning beginning with a middle school STEM program. I chose Belenky et al.'s (1986) women's ways of knowing (WWK) as the conceptual framework for my study, and few researchers have used WWK as a framework to understand issues around women's cognition or learning. This study was intended to fill this gap by viewing women's educational experiences through the WWK lens, which may contribute to the body of knowledge about women's learning that has occurred over a 10-year span of time.

The data from this study may inform the academic community about the influences to learning that may have shaped these women's perceptions of their educational experiences in middle school and through emerging adulthood. STEM careers require high levels of academic and technological training. Understanding how women view their learning may provide insights to help educators design more effective learning experiences for women during the years when they are building an important foundation for their careers.

Problem Statement

The problem this study addressed was an insufficient understanding of how women perceive their learning within the context of their educational experiences, particularly after several years have passed. Designing effective educational experiences without this understanding is problematic, particularly in STEM fields in which diverse approaches to supporting girls in STEM have been a priority. Many studies about learning have targeted college and high school level students; however, many were too narrowly focused. Moreover, developing women's skills and interests may not be enough to increase women's participation in STEM fields (Falco & Summers, 2019). Several STEM programs designed for girls were assessed quantitatively with surveys that included questions about participants' levels of satisfaction and engagement with the content (Falco & Summers, 2019; Hyllegard et al., 2017; Master et al., 2017; Phelan et al., 2017; K. Roberts & Hughes, 2019; Shahali et al., 2017). Moreover, many of these studies neglected to verify whether those students ended up pursuing STEM majors or careers or to investigate the paths women chose to pursue and why (Ihrig et al., 2018; Kurz et al., 2015). Asking women to reflect on their learning in these educational experiences might allow researchers to better understand the cognitive processes at work at different points in the developmental timeline. This required a qualitative research approach. Additionally, there was a need for more research on the long-term influences on women who had participated in STEM experiences targeting women, and how women's perceptions of these experiences shaped their decisions about education and careers into the future (see Olsson & Martiny, 2018; T. Roberts et al., 2018; Siegler, 2016; Wang & Degol, 2017). Lack of research about long-term influences on women related to their learning limits understanding of the broader influences on young women's college and career choices.

Despite the plethora of STEM programs offered each year in the United States, the understanding of how girls perceive and reflect on their learning experiences that occur during critical periods of their education—from middle school into early college years—was limited. Survey data can lack context and fail to include explanations and reflections of the participants' experiences. Qualitative data may help shed light on young people's perceptions of their learning. The current study was designed to explore women's perceptions of their learning, beginning with an educational experience they had in middle school and throughout the following 10 years.

Purpose of the Study

The purpose of this basic qualitative study was to explore women's perceptions of learning by asking them to reflect on their middle school STEM experience and other learning experiences through high school and into emerging adulthood. This study provided young women an opportunity to describe their perceptions and beliefs regarding their formal and informal learning experiences over time and provided rich data about the changes in their learning during an important developmental time frame. Examining how women understand their learning experiences may help the academic community design more effective educational programs for women.

Research Question

The research question for this qualitative study was the following: How do young women who participated in a middle school STEM program describe its influence and that of other learning experiences on what they know about their learning processes as they moved into adulthood?

Conceptual Framework

I employed a conceptual model using WWK, as described by Belenky, et al. (1986), which built on the Perry et al. (1968) study about intellectual and moral development in college students. However, Perry et al. framed their cognitive development theory using only male participants. This implied a need for a broader understanding that would build on the cognitive work of Perry et al. but would also include women participants. WWK, a credible model that has not often been used in peer-reviewed literature, was developed as a framework that included women's voices. I investigated how women perceive their learning in educational settings; therefore, WWK was a suitable lens for this research. Belenky et al. viewed their work as unique by including women's voices, which were absent in discussions framing learning because a male-dominated view of learning persisted in academia at that time. From their research, Belenky et al. outlined five epistemological perspectives:

- silence (mindless, voiceless, and subject to authority)
- received knowledge (listening to the voices of others)
- subjective knowledge (the inner voice and the quest for self)
- procedural knowledge (separate and connected knowing)
- constructed knowledge (integrating the voices)

These perspectives on the nature of knowledge and knowing may provide an important way to understand the ways in which young women perceive their beliefs about and their own contributions to knowledge creation. I chose to use WWK as the conceptual framework in this study, which included only women participants to provide a structure for understanding how women perceive the nature of their knowledge. The five perspectives of cognition provided a construct for understanding how women see themselves as knowledge creators and, more importantly, the intersection of women's relationships with others with ways of knowing. A more thorough examination of WWK is found in the literature revie, in Chapter 2.

This study was a follow-up to a STEM program that took place during middle school and allowed me to interview a small group of women with a shared learning experience about their perceptions of their learning. Using the WWK lens allowed me to examine these women's perceptions through the fluid nature of the five perspectives along the participants' journeys from adolescence into emerging adulthood. According to Belenky et al. (1986), women's perceptions of their cognition, or ways of knowing about the world, are interwoven with their relationships with others. Other theorists of the time overlooked this perspective on cognition; therefore, a key aspect of this study involved the inclusion of interpersonal relationships between participants, participants' views of themselves, and how these views related to what participants understood about their learning. Previous research has shown that women view their intellectual abilities in more critical terms than men, creating a barrier to their participation in STEM (Bian et al., 2017; LaCosse et al., 2016; Rice et al., 2015). Belenky et al. found that women's cognition cannot be separated from how women feel about their abilities and the knowledge they possess, which made WWK an appropriate lens for the current study. Using WWK also helped me frame learning in a more comprehensive manner than in a quantitative analysis. The five ways of knowing outlined by WWK provided a framework for understanding the decisions women make that relate to their perceptions of their cognitive abilities.

Nature of the Study

A basic qualitative approach including individual interviews allowed the women who participated in a middle school STEM program 10 years ago to reflect on and describe the influences they felt were important to their learning. This approach provided thick, rich data about participants' learning during the formative years of their education, and it captured unexpected data about their learning, data that quantitative methods might have failed to uncover. I analyzed the data and coded them to define themes by recognizing repetitive words or phrases that related to women's learning and the women's perceptions of their learning. I analyzed the interviews using the WWK lens and the five stages of cognitive development as reflected in participants' experiences since their participation in the STEM program 10 years prior to when they were interviewed.

Definitions

Cognition: "The thinking and the mental processes humans use to solve problems, make decisions, understand new information or experiences, and learn new things" (Weinstein & Acee, 2008, p. 2).

Cognitive development: "The process of reasoning, thinking and problem solving, which changes over the course of the lifespan" (Salkind, 2008, p. 275).

Formal learning: Structured learning that takes place in an organization that defines, designs, and controls the learning experiences. For the current study, an example would be the STEM middle school program, an experience shared by all participants.

Knowing: From the WWK conceptual framework, knowing is a person's own conception of knowledge or truth (Belenky et al., 1986).

Learning: An active process that builds on prior knowledge, occurs in a complex social environment, is situated in an authentic context, and requires learners' motivation and cognitive engagement (Berkeley Center for Teaching & Learning, n.d.).

Assumptions

My first assumption was that using a population of middle school girls who participated in a STEM program would be a good choice for a study about learning because of the rigorous nature required in STEM education and training. My second assumption was that participants in this study would have accurate memories and provide truthful accounts of their experiences in the STEM program 10 years prior to the interviews, and that they would cooperate and give honest answers. Finally, I assumed that interviews with women who participated in a middle school STEM experience could be understood using the lens of the WWK, and the data from this study could provide a richer understanding of how STEM programs influence how women feel about their own learning.

Scope and Delimitations

The scope of this study was defined by the research question, and I confined the study to a purposeful sample of young women who participated in a middle school STEM program, which was funded in part through a NSF grant 10 years prior to the data collection for this study. I included only young women who actively participated in this program. College STEM educators, parents, and middle school science teachers associated with this program were excluded from this study. The perceptions of anyone other than the young women who were the focus of the STEM program were beyond the scope of this study. Because I limited this study to a specific and select group of young women, the findings from this study should not be considered transferrable to similar demographic groups.

Other STEM studies in the last 5 years have addressed women's learning as related to STEM decision making and related educational choices through the lenses of social cognitive career theory (Lent et al., 1994). Social learning theory and self-efficacy theory as developed by Bandura (1977) have also been widely used. However, I did not use these cognitive theories as a framework.

Limitations

This study included a small sample of a select group of young women; therefore, generalization of the results to a broader population is not possible. Another limitation of this study was that two participants had difficulty in remembering some of their experiences within the context of the STEM program that took place several years ago. Additionally, my bias needed to be kept in check throughout the study because I was the one who designed and implemented the STEM program with the participants for this study. I took a postpositivist stance, which posits it is not possible to be absolutely neutral (Rubin & Rubin, 2012). However, my awareness of my internal biases helped alleviate any interference with the participants during interviews. I kept the interviews as formal as possible and created an environment that encouraged the participants to be honest and open with their answers. As a way of reducing researcher interference, I allowed participants to speak uninterrupted and used my voice to clarify and ask appropriate follow-up questions (see Creswell, 2009). I kept a journal reflecting on my experience interviewing the women to help me stay cognizant of my potential to improperly influence the responses of the women or my analysis of the results.

Significance

This study was intended to inform the academic community about perceptions of women about their own learning. This study allowed women to reflect on their learning and describe their perceptions of that development beginning with a STEM program 10 years ago and other educational experiences since that time. Educational interventions targeting women have included numerous strategies to attract women to STEM; however, after 50 years of research and outreach attempting to encourage women to choose fields such as engineering, physics, and computer science, women have not reached parity with men in these areas (NSF, 2019). This study provided a greater understanding of women's learning during the most formative years of their educations. A greater understanding of how women perceive their learning has the potential to inform academic leaders about strategies that best serve women as they move through difficult STEM curricula and into higher education. Exploring such learning experiences through the WWK lens uncovered other influences important to women's cognitive development that occur during adolescence through emerging adulthood.

Along with informing teachers and other education leaders, this study may also inform policymakers involved in the design and implementation of STEM programs targeting women or girls, and may inform them about the cognitive journeys these young women traverse in the educational landscape of rigorous STEM coursework. There is a widely recognized lack of and need for more women and in general greater diversity within certain STEM disciplines (Blosser, 2017; Bonham & Stefan, 2017; Cheryan et al., 2017; Lewis et al., 2016). A better understanding of women's learning and how they perceive their learning could lead to more effective interventions or strategies to encourage more women to pursue STEM-related disciplines, thereby providing a greater benefit to society.

Summary

There were several aspects of this research that set it apart from other studies about learning. This study was a qualitative investigation of women's perceptions of their learning over a long period of time. Most studies related to learning, particularly those in STEM learning, have been quantitative in nature and have not involved any type of long-term follow-up of students. The current study included a purposeful sample of women who shared their learning experiences during middle school, and additional data were collected about their learning experiences that occurred through high school and college. Formal and informal learning from adolescence to emerging adulthood is an important developmental period for young people, and the data gathered from these participants may add to the understanding of young women's perceptions of what they know about their learning. WWK provided an appropriate and unique lens in which to understand the experiences of these young women.

Chapter 1 provided the background for this study, the problem researched, and the purpose of this study. The conceptual framework, research question, definitions, assumptions, limitations, and significance of the study were also included in this chapter. Chapter 2 includes a discussion of the literature search strategy, a detailed description of the conceptual framework, and review of the relevant literature that informed this study. I also highlight the gap in the literature focusing on the previous 5 years of research.

Chapter 2: Literature Review

This chapter focuses on literature from the past 5 years that related to women's perceptions of their learning and factors that influence those perceptions. The literature indicated an insufficient understanding of how women perceive their learning within the context of their educational experiences, particularly after several years have passed. Asking women to reflect on their learning within the context of their educational experiences might allow researchers to better understand women's learning processes and at different points in the developmental timeline. This required a seldom-used qualitative approach, which I used for this study by listening to the stories of a small group of women who had participated in a middle school STEM program 10 years ago. The purpose of this basic qualitative study was to explore women's perceptions of learning by asking them to reflect on the middle school STEM experiences and other learning experiences through high school and into emerging adulthood.

This chapter begins with a restatement of the problem and purpose of the study and is followed by a synopsis of the current literature that established the relevance of and need for this study. The problem this study addressed was an insufficient understanding of how women perceive their learning within the context of their educational experiences, particularly after several years have passed. The remaining major sections of this chapter include the literature search strategy, conceptual framework, and literature review of relevance to the problem. The chapter concludes with a summary of the rationale for the study.

Literature Search Strategy

The databases I accessed for this research included ERIC, Education Source, Academic Search Complete, Thoreau, EBSCO, PsycARTICLES, PsycINFO, and ProQuest. I also conducted direct online searches from the NSF, the National Center for Education Statistics, the *Journal of Women and Minorities in Science and Engineering*, PubMed, and the National Economic Research Association (NERA). Key search terms included *learning*, *STEM learning*, *perceptions of learning*, *hands-on learning*, *active learning*, *cognitive development*, *cognition*, *ways of knowing*, *intelligence*, *visuospatial/spatial cognition*, *math cognition*, *verbal cognition*, *gender differences*, *gender stereotyping*, *gender bias*, *women and girls*, *STEM gender gap*, *career pathways*, *STEM education*, *outreach in STEM*, and *gender barriers*. This literature review includes articles published within the last 5 years, and key review articles were also used to identify major shifts in the focus of research objectives as part of this review. Databases that yielded the most relevant articles for this topic were ERIC, Academic Search Complete, and Education Source. An iterative process that included searching the databases multiple times using new and at times identical terms was beneficial. Both seminal and the most recent peer-reviewed articles were used for this research. Few peer-reviewed studies including WWK as a lens had been conducted in the last 5 years. I chose WWK as the conceptual framework for the current study in part because it helped to fill a gap in the understanding of women’s learning using this unique lens.

Conceptual Framework

I chose Belenky et al.'s (1986) WWK, a cognitive development theory, as the conceptual framework for this study. WWK has contributed to the understanding of human development and was developed out of the cognitive theories of Perry et al. (1968) and the moral development theory of Gilligan (1982). Gilligan formulated her critical theory highlighting a theme from previous research on cognitive development that included only male participants, which Gilligan stated had essentially silenced women. Belenky et al. developed five cognitive perspectives, most of which were modeled after Perry et al.'s theory. However, Belenky et al. determined that the findings from their research with women did not fit completely with the Perry model, and specifically cited the absence of one cognitive perspective that was distinctive: the silence perspective. The addition of the silence perspective was important, and it was one reason why the WWK model of adult cognitive development was unique from other cognitive theories.

WWK is not simply a theory about mental processes existing in isolation of other factors like environment and experiences, but one that positions women's cognition as firmly intertwined with women's beliefs about self and others (Belenky et al., 1986). In the next section I describe this theory of women's cognitive development and how it formed the cognitive lens to investigate young women's perceptions of their learning experiences that informed this study. A more thorough discussion of how WWW has been applied in the literature is included in the last section of this chapter.

Women's Ways of Knowing

The early work on developmental theory was informed by the established notion that men's experience and competence are the baseline against which men and women are judged (Belenky et al., 1986). The participants in the Belenky et al. (1986) study were 135 women, including 90 female liberal arts majors from six different academic institutions and 45 women working in human service agency jobs providing services and support to women and children. The human service agencies were referred to as the "invisible colleges" (Belenky et al., 1986, p. 12), which were defined as the "human service agencies supporting women in parenting their children" (p. 12). The latter group of women were included because Belenky et al. were interested in examining how these women's cognitive development might have been shaped by the maternal practices in which they were engaged. The human service agencies were thought to be one of the few types of agencies that were organized and staffed by women, and the experiences of the women associated with these agencies were unique to women. Moreover, by including participants from the out-of-school experiences provided by the invisible colleges, Belenky et al. increased the diversity of their sample population more than did Perry et al. (1968), who included only college men in their study.

Despite having included only women participants, Belenky et al. (1986) rejected the notion that WWK was a theory restricted to women's development. Belenky et al. described their framework as one that added to the understanding of adult cognitive development and described it as "embedded in a larger context of feminist theory about voice and silence" (p. 19). Within a cognitive framework, and after having put "flesh and bones on theory by tracking individual lives" (p. 19), Belenky et al. stated women's voices are interconnected with their beliefs about their intellect. Belenky et al. also stressed that although knowledge is constructed, its meaning depends on context, an important aspect of WWK that differs from Perry et al. (1968) in that context can cause the perspectives of women to shift. Belenky et al. asserted that the socialization that took place among the male participants in the Perry et al. study was confirmation of a more linear sequence of development because context was held constant as the men made sense of the "system of values, standards, and objects" (Belenky et al., 1986, p. 15).

To understand how context might have influenced how women perceived their knowledge, Belenky et al. (1986) conducted a contextual analysis, which they assembled into 10 bimodal dimensions. These dimensions were referred to as "educationaldialectics" (Belenky et al., 1986, p. 16) and were designed with the intent that they could be used in educational settings. In compiling these modes, Belenky et al. "suspected that in women one mode often predominates whereas conventional educational practice favors the other mode" (p. 16). Belenky et al. did not state which mode is more tied with the female gender. The educational dialectics include

- process oriented versus goal oriented
- discovery versus didacticism
- rational versus intuitive
- discrete versus related
- being with others versus being alone or on own
- breadth versus concentration

- support versus challenge
- personal versus impersonal
- self-concern versus responsibility and caring for others
- inner versus outer
- listening versus speaking

Belenky et al. argued that both modes within each dimension could be valuable and, in an ideal educational setting, each would be promoted. However, Belenky et al. recognized that in education this may not happen, and that “both modes could be valuable and adaptive and, under ideal circumstances, both would be promoted in educational practice” (p. 16). More importantly, Belenky et al. noted that “when the women’s mode is treated as deficit, women come to believe they cannot think as well as men” (p. 16). In examining the various dimensions, Belenky et al. attempted to discern what psychological or social forces promoted women’s growth or limited them.

Building on the Educational Dialectics, Belenky et al. (1986) formulated their rationale for what became five ways of knowing. These ways of knowing were described as five epistemologies, also termed perspectives: (a) silence, (b) received knowledge, (c) subjective knowledge, (d) procedural knowledge, and (e) constructed knowledge (Belenky et al., 1986). These five perspectives of women are briefly described in the next sections.

Silence Perspective

Women with this position of knowing see the world in terms of black and white, or right and wrong. Authority figures are unquestioned, which can reinforce powerlessness, mindlessness, and voicelessness. In silence, women are not aware of their inner voice. Fear can be a powerful part of constructing meaning for women with this perspective (Belenky et al., 1986). The silence perspective is the one most affected by cultural expectations, particularly sex roles and stereotypes. This perspective was a common theme in Belenky et al.'s (1986) study.

Received Knowledge Perspective

Received knowledge is a perspective in which women can receive and reproduce knowledge that comes from an external authority. However, the ability to create knowledge is not possible. Women with the received knowledge perspective require one correct answer and often associate knowing with the way peers think (Belenky et al., 1986). Quieting a person's own voice to hear others also defines this perspective.

Subjective Knowledge Perspective

The subjective knowledge perspective sees truth and knowledge as personal, private, and subjective (Belenky et al., 1986). Relationships with others are important and influence a person's beliefs positively and negatively. The subjective knower is beginning to hear their own inner voice during this stage as they are less influenced by what others say. Unlike the silent and received cognitive perspectives, the subjective knower for the first time recognizes they have their own truth and are less influenced by the words of others.

Procedural Knowledge Perspective

This way of knowing is focused on how a person decides rather than what they decide. Women who exemplify the procedural perspective are practical problem-solvers who want to learn and apply objective procedures (Belenky et al., 1986). Women with this perspective are systems thinkers. It is this perspective in which Belenky et al. (1986) incorporated the aspects of the separate and the connected self as put forth by Gilligan (1982) and Lyons (1983) as two ways of experiencing the procedural way of knowing. Separate knowing is autonomous, detached, and critical, and there is an assumption that anyone may be wrong. Connected knowing relies on understanding the truths of others from their perspective, and empathy and intimacy are important as a person collaborates with others to find truth.

Constructed Knowledge Perspective

Constructed knowledge is exemplified by strong self-awareness and the person's ability to listen to their inner voice as well as listen to others. Knowledge is understood to be provisional, and it depends on context. The constructed knower insists on considering all perspectives and is comfortable tackling difficult questions, ambiguity, and complexity. With a constructed knowledge perspective, women understand they can create knowledge (Belenky et al., 1986).

The intent of Belenky et al.'s (1986) study was to uncover "women's assumptions about the nature of truth, knowledge, and authority" (p. 14). Belenky et al. did not view the five perspectives in their model as being hierarchical stages because they reasoned that the diversity of the participants in terms of their ages, life circumstances, and other characteristics made identifying what they called "universal developmental pathways…far less obvious" (p. 15). As a result, Belenky et al. stated they would leave a determination about whether fixed stages exist within their framework to future researchers. A principal theme of WWK is that women cannot separate what they know from who they are in relation to others.

Why Women's Ways of Knowing Was Appropriate for This Study

This basic qualitative study benefited from a WWK conceptual framework because allowing women to reflect on their educational experiences provided a way of discovering how women understand their learning. This conceptual model was appropriate for this study for three reasons: (a) the participants of this study were all women; (b) WWK was designed for exploring cognitive development within the context of educational settings and other learning experiences; and (c) this study addressed women's perceptions of their learning from middle school through emerging adulthood, a time when their educational experiences are most important.

Literature Review Related to the Key Concepts

The literature review focused on the following areas: Women and STEM research, women's learning, women's cognition, and WWK research. I synthesized the literature and the conceptual framework around my research question.

Women and STEM Research

Women and STEM became a focal point of researchers in the 1970s, but the most emphasized areas of research have changed throughout the decades. Scholars who studied women and STEM have suggested numerous theories positing why women fail to make inroads into certain STEM disciplines, such as engineering and mathematics (Falco & Summers, 2019; Olsson & Martiny, 2018). Early theories about why women were not well represented in STEM educational pursuits are addressed in the next section. For the purposes of this study, women's learning was informed by research about gender stereotypes and biases; women's visuospatial, verbal, and mathematics ability; and sociocultural influences such as family, friends, and cultural norms. Research on learning methods to influence women's engagement in STEM is also included.

Early Models

Earlier research was focused on women's cognitive and skill deficiencies. In a meta-analysis of research spanning 40 years, Kanny et al. (2014) found that researchers highlighted women's lack of ability in mathematics and related disciplines and how these deficiencies prevented women from pursuing STEM careers. In later years, there was a shift toward investigating the larger systems thought to be keeping women from these fields, which addressed the larger contexts in which women encounter and participate in STEM (Dewsbury, 2017). In the 1970s, research emerged on K-12 structural barriers, psychological preferences and values, and family influences (Kanny et al., 2014). By the early 2000s, there was more interest in characteristics and perceptions of STEM fields (Kanny et al., 2014). Because barriers can influence learning, gender stereotypes and biases are relevant considerations.

Gender Stereotypes and Biases

Although a gender deficit view of women still exists, more recent research involves examining the stereotypes and biases women encounter as they progress through the education system. This section highlights the general themes of gender stereotypes and biases and how they are thought to influence women's thinking and mental processes such as decision-making, their understanding of information and experiences, and learning new things. Synthesis of this research is used to underscore the gaps in our understanding of women's learning.

Perceptions of Intellectual Ability

Biases about women's intellectual ability for rigorous STEM academic pathways continues to be an obstacle. Meyer et al. (2015) used the field-specific ability beliefs hypothesis, which asserts success in a particular field relies on raw ability or aptitude and found that women are underrepresented in fields that are perceived to require brilliance. Moreover, they assert the field-specific ability beliefs hypothesis combined with cultural stereotyping of gender and ability leads to gender gaps in academic fields. To show this type of gender bias exists, Bian et al. (2018) developed two experiments – one in which job applicants were selected primarily on their intellectual ability. Results revealed the odds of participants selecting women candidates were 38.3% less than the control condition, and the male was more likely to be perceived as a better applicant. In a second experiment they discovered that gender bias favoring males for brilliance exists at a young age. Children aged five to seven were told to select teammates for a game meant for "really, really smart" children, (p. 1146). Over time, the children became more likely to select males for their team. These results suggested gender bias regarding intellect begins at a young age. Master et al., (2017) assessed stereotypes held by 6-year-olds and supported the assertion that gender stereotypes develop early. They found that 6-year-olds -- both boys and girls -- thought boys were better than girls at robotics and programming, and that this gender stereotype was stronger than the children's gender stereotypes about other STEM fields.

Another study in which 111 college student volunteers (62% men, 38% women) completed an online tutorial to write their first computer program found women performed better in programming than men, which suggested stereotypes that men are inherently better at programming may be false (Du & Wimmer, 2019). The results of this study are interesting considering data which shows persistence of the gender gap in computer science and a decline in women earning bachelor's degrees in computer science (from 28% to 18%) in recent years (National Science Board, 2019). Studies also document that women have the cognitive abilities needed to master technical skills needed to pursue computer science-related fields; however, the gender stereotype that persists is women lack technical skills and ability (Berg et al., 2018).

How women perceive their own abilities differs from that of men. LaCosse et al. (2016) conducted two quasi-experimental studies with 85 STEM majors (46 women) that revealed men attributed their failures to factors beyond their control while women attributed their failures to internal factors related to ability. Additionally, women internalize their perceptions differently. In an analysis of students' competency beliefs in science, Vincent-Ruz and Schunn (2017) found that by eighth grade girls' competency beliefs about science predicted their science achievement, but that was not true for boys. In a study on stress, perfectionism, and STEM majors, Rice et al. (2015) found perfectionism led to stress about grades in STEM courses more for women students than for men. Kugler et al. (2017) also found a gender difference in sensitivity to low grades. They discovered that college women were more likely than men to switch majors because of poor performance.

Although positive perceptions of ability are important to choosing academic pathways, even when women do perform well in areas such as math or science, they often choose career paths that are already dominated by women. For example, after analyzing responses from 10,200 tenth graders (7,300 girls and 6,800 boys) Perez-Felkner et al. (2017) found that girls who performed best in mathematics were most likely to declare a major in social and behavioral sciences, and not choose to major in physics, engineering, math, or computers sciences (PEMC). They did find, however, that the two most powerful predictors of majoring in PEMC were math ability and perceptions of math ability. In a recent longitudinal study of Swedish students aged 16-32, Dekhtyar et al. (2018) found that boys and girls followed a career path in line with their relative academic strengths. Moreover, they found women with high math and technical abilities did not enter fields requiring theses skills suggesting that math and technical abilities alone cannot explain why fewer women choose these career paths. Justman and Mendez (2018) found that women who completed advanced level math in secondary school had lower perceptions of their math ability than their performance indicated.

Teacher Perceptions

Teacher perceptions have also been shown to affect boys' and girls' self-concept of their math and reading abilities (Upadyaya & Eccles, 2015). A sophisticated quantitative analysis utilizing data from the Early Childhood Longitudinal Study – Kindergarten, found that elementary teachers rate girls' proficiency in math lower than boys (Cimpian et al., 2016). As cited earlier, a study indicated teachers tend to attribute male underperformance to lack of effort whereas female underperformance to lack of ability (LaCosse et al., 2016). These data show that self-perceptions along with the perceptions of teachers and others influence the way women think about their own capabilities for math. Math anxiety, which leads to poorer performance and a dislike of math, is also influenced by negative teacher perceptions of women's ability and stereotypes (Luttenberger et al., 2018).

Perception that STEM Is for Men

Gender stereotypes create subtle barriers to women in STEM which in turn are thought to influence their educational and career choices. One example is the scientist stereotype. The societal stereotype of a STEM professional holds that scientists are socially awkward and unattractive, yet they have natural intellectual ability (Starr, 2018). Starr defined the stereotypical scientist as the nerd-genius. In a study tracking the gender gap in computer science over a 40-year period, the researchers identified the field becoming "gendered" and the continuing male-nerd stereotype emerging in the mid-1980s (Sax et al., 2016).

In addition to looking like a scientist, gender biases about how scientists act are also present in our culture. For example, using an online survey highlighting judgments about personality traits, Carli et al. (2016) found both men and women perceived that women lacked high agency traits -- those associated with being a scientist – and as a result, "women are perceived to lack the qualities needed to be successful scientists" (p. 244). In a survey of 379 first-year undergraduates students Stout et al. (2016) also found that careers in physical sciences, technology, engineering, and mathematics were characterized by self-direction and self-promotion, traits associated with agency, and not with wanting to help others. Studies about perceptions of what a scientist looks like and what personality traits characterize scientists have provided evidence of existing biases that inform young people that women often fail to live up to the expectations of what a "real" scientist is, and as some researchers propose, make women (and men) less likely to choose some careers. Many of these examples of bias are unfavorable towards women and are pervasive among men and women, and among STEM and non-STEM majors (Farrell & McHugh, 2017).

According to Killpack and Melón (2016), a better understanding of how implicit biases and stereotype threat negatively impact underrepresented students in STEM is warranted. Women's own implicit biases about whether a STEM field is more appropriate to men than women can influence their educational choices. For example, Ganley et al. (2018) developed a quantitative scale for 20 popular college majors, which included measurements of perceptions of how math and science-oriented the major was as well as a gender-biased measure of the field. Their results showed the orientation of a field towards math and science was less important in predicting women's college majors than perceived gender bias against women in that career.

Some researchers have also suggested stereotypes about certain STEM fields as well as stereotypes about the people who select those fields have a negative impact on the recruitment of women (Martin, 2016; Savaria & Monteiro, 2017). In one study, even hanging Star Trek posters and displaying pictures of electronic objects and items thought to be more associated with men had a negative effect on women feeling a sense of belonging in a computer science classroom (Master et al., 2016).

Lack of Women Role Models in STEM

A lack of female role models is a continuing problem in many STEM areas. According to data from the National Science Board (2020) women make up only about 16% of the engineering workforce, 20% in the physical sciences, 27% in computer science, and 27% in mathematics. The limited number of role models in these STEM fields assumes greater importance because research reveals that women are more influenced by other people than are men (Mishkin et al., 2016). Studies have demonstrated that exposure to female role models, especially long-term and frequent, has a positive effect on young women's choices of STEM courses and career fields (Krayem et al. 2019; Shin et al., 2016). Research also reveals positive effects of role models on women's persistence and completion of STEM programs (Herrmann et al., 2016; Olsson and Martiny, 2018).

Preferences and Values

Research about educational choices reveals that women are influenced by their preferences and values. For example, Chopra et al. (2018) found that women who applied to engineering school wanted to help society and were likely to have had personal influences over their choice of engineering as a major. Longitudinal studies have also found women's choice of STEM careers are influenced by work-life balance issues and the perceived value of STEM careers (Banerjee et al., 2018).

Performance on mathematics standardized tests has also been shown to correlate with how individuals feel about mathematics. For example, according to a survey given by the National Assessment of Educational Progress (National Center for Education Statistics, 2019), the more positive students' views of mathematics, reading, or science, the better they performed on the exam. Additionally, the NAEP survey results indicated that more males had a preference for and choose math and science as their favorite subjects than females. Cunningham et al. (2015) also reported women liking math significantly less than did men.

Family, Friends, and Cultural Influences

Family and cultural factors can influence women's career choices related to STEM. Maltese and Cooper (2017) analyzed a quantitative survey of 7,970 adults and found females cited the importance of parents and parent involvement to their interest in STEM. However, more females reported parents as not being supportive of STEM than males, even though parent participation in STEM activities in middle school was higher for females than for males. Similarly, a longitudinal study of 6,492 students found that parental influence was important but complex; parents appeared to support but not encourage girls to study STEM (Lloyd et al., 2018). Another study found that parents who thought their child had higher spatial skills were more likely to encourage them into STEM, but the parents tended to evaluate boys as having higher spatial abilities than girls, even after the results were statistically adjusted for actual abilities (Muenks et al., 2019). Looking at the influence of friends and family from a different approach, another study found that when women were questioned by friends and family about their career choice of engineering, the women began to doubt their ability. (Mozahem et al., 2019).

For women in higher education in France, while choice of major was influenced in part by test scores, they were more influenced by individual preferences and the influences of family and peers (Rapaport & Thibout, 2018). A study by Raabe et al. (2019) of nearly 5,000 students indicated that adolescents' subject interests were influenced by their friends.

Justman and Mendez (2018) determined cultural factors were more influential than high mathematics ability in women's choices of a major. In their study, which analyzed data from 66,686 seventh graders who completed Australia's National Assessment Program, they did find that as numeracy skills increased, more girls and boys chose STEM subjects. However, life sciences were dominated by women and physics, computer science, and mathematics were dominated by men. Rapoport and Thibout (2018) found that in women's choices of courses and majors, mathematics performance mattered more in high school, but in higher education choice seemed more aligned with cultural beliefs and norms.

Measurements of Abilities

Measuring abilities in academic disciplines is one aspect of cognition and learning; however, high ability in science, mathematics, and visuospatial are particularly important to STEM fields. Intelligence tests typically include numerical (mathematics) and visuospatial, as well as verbal components (Liang et al., 2020). In this section, I will examine the current research about multiple aspects of cognition, which will include the most common tests used with young people today.

The Programme for International Student Assessment (PISA) was developed to measure reading, math, and science literacy in 15-year-olds (National Center for Education Statistics, n.d.). Stoet and Geary (2018) analyzed PISA science test data that included 519,000 students ages 15 and 16 from 72 countries. They found that overall, boys outperformed girls in science, and the gap was most pronounced in more gender-neutral countries. Reilly et al. (2019) found similar results in a study of eighth graders utilizing the Trends in Mathematics and Science Survey. They identified a small gender gap in the U.S. that favored males. They also found that globally boys outperformed girls in more gender-equal countries and conversely girls outperformed boys in countries with less equality. To determine how early a gender gap emerges in the U.S., Curran and Kellogg (2016) analyzed results of the Early Childhood Longitudinal Study-K data from 18, 174 students. They did not find a gender gap in science achievement in kindergarten, and by the end of first grade only a small gap. They do note that the gap seems to develop during the first years of school.

Standardized Math Tests

The preponderance of the research into test scores has focused on math, because math ability is considered critical to choosing a STEM field (Le & Robbins, 2016; Perez-Felkner et al., 2017). There is an ongoing controversy as to whether women are as proficient at mathematics as men. A substantial gender gap was uncovered by Benbow and Stanley (1980) as early as 1980. After a careful review of numerous reports about performance on standardized math tests, studies indicate that the math ability gap has closed for women in recent years except for the upper tiers of performance where more men place than women. For example, after an analysis of 9 years of data from the Indiana Statewide Testing for Educational Progress math exams for grades three through 10, Beckman and Ober (2017) concluded that the math gender gaps were small. They also noted that the results indicate young women have the ability for STEM careers that require advanced math. Additionally, 2018 Scholastic Aptitude Test (SAT) results show men outperformed women in the upper two levels in mathematics, where the highest range of scores (700-800) showed men outperformed women 1.6 to 1.0. The gap is much smaller in the second highest tier (600-690) where men outperform women only 1.1 to 1.9 (College Board, 2018).

Overall, research on standardized math test scores has indicated that more male students score at both the upper and lower extremes of the distribution, which supports the “variability hypothesis,” – men have a wider variation in math scores than women, which has been suggested as the reason why male students outperform female students in the upper tail of the distribution (Baye & Monseur, 2016). O’Dea et al. (2018) investigated whether this effect would be seen when comparing grades. In their meta-analysis of data from 1932 to 2015 that included over 1.6 million students (half women, half men) in 227 studies, results showed girls’ grades in STEM were slightly better and more consistent than boys’ grades, and far fewer girls than boys scored in the upper tail, supporting the variability hypothesis. However, O’Dea et al. found less variability in both mean and variation between boys and girls in STEM subjects than non-STEM, which suggested the variability hypothesis may not be a valid explanation for the lack of women in engineering, physical and computer sciences.

Researchers have suggested a variety of potential influences that may explain the gap. For example, Reardon et al. (2018) posit test question format may explain why women tend to perform worse on multiple-choice exams and better on written exams than men. They suggest that if the mathematics portion of standardized tests is weighted heavily to a multiple-choice format it could be a factor contributing to women not performing as well as men. Another explanation emerged from a study of second-generation immigrants using PISA data. Rodrigues-Planas and Nollenberger (2018) discovered the math gap for women narrows in more gender-equal countries. However, this study also concluded that general gender stereotypes were a stronger influence than math stereotypes. In another study, Reardon et al. (2019) found the gap more pronounced in schools which enrolled more students in higher socioeconomic classes.

Women's Learning

In the few recent studies that investigated young women's learning, the primary focus of the research, particularly within STEM education research, has been the young women's self-reported engagement in the learning topic or activity as revealed in surveys administered during and/or immediately after a course or program. The literature shows that inquiry-based learning activities such as problem-based or project-based activities can be effective ways to promote engagement, motivate and challenge women, and increase confidence and self-efficacy in women and girls. Much of the research is a shortterm look at learning in either formal learning settings or short workshops that occur as informal learning experiences taking place after school or over the summer.

Some of the more popular learning programs involve introducing girls to technology-related activities they normally would not be exposed to in formal learning settings. Middle school girls from rural Pennsylvania participated in art courses in digital animation and making digital games at a Tech Savvy camp (Liao et al., 2016). The girls created animations and games on the topics of social justice and women’s leadership. Pre and post survey results indicated the girls felt the project increased their teamwork skills as well as their appreciation of the value of teamwork especially in projects that require creativity. Riedinger & Taylor (2016) used a case study approach with middle school girls at an ecology camp in Virginia who explored marine science using hands-on activities that reflected the work of professional scientists, ecologists, and oceanographers. Analysis of the girls’ journals revealed benefits from the activities, which included being able to see themselves as scientists, learning in a comfortable and meaningful setting, and learning through social interaction at the camp. These benefits allowed the girls to develop a positive science identity. Roberts et al. (2018) conducted a one-week summer program to expose middle school girls to a variety of STEM experiences, such as robotics, using a naturalistic approach to examine the girls’ lived experiences with the activities. Analysis of student responses revealed the girls recognized they were part of something unique that formal learning, due to lack of funding, was not able to provide, and the experience improved STEM content knowledge and engagement.

A few studies involve STEM that is embedded into the middle school curriculum. Alemdar et al. (2018) studied sixth through eighth grade students in Georgia public schools where problem-based engineering design courses are offered. Utilizing test scores, surveys, and interviews the researchers compared eighth graders who took at least one engineering course to those who did not. The students who took at least one course had increased self-efficacy, increased engagement, and greater ability to translate their new skills to the math and science courses. A middle school problem-based learning approach on the topic of heat was utilized with 16 seventh grade girls in Indonesia (Putri et al., 2018). In response to surveys administered at the end of the project, 75% of the girls reported being highly motivated to learn, and they credited the hands-on and problem-solving methods utilized in the project. A quasi-experimental study of 30 Turkish public secondary students conducted by Tural (2020) compared traditional textbook teaching to the use of additional hands-on activities to teach the concept of pressure. Posttest results indicated students in the experimental group had a significantly higher preference for this method of learning than that of the control group using textbook methods. Interviews with students in the experimental group indicated they perceived they learned the concepts better using active-learning techniques.

High school and middle school students participated in a program in which they designed, built, programmed, and tested robots (Ziaeefarda et al., 2017). Researchers reported survey data on a total of 26 girls who participated in the program in two different groups. The first group rated programming and wiring as their favorite and most engaging activities. The second group rated programming and gaming as their favorite and most engaging. The girls also indicated they were engaged by activities that were hands-on and challenging. High school girls participated in a project on space science that incorporated hands-on learning and teamwork (Isaacson et al., 2019). Through a survey administered at the end of the project, the 20 Israeli girls reported that the project increased their interest and confidence in learning.

In an undergraduate science course, researchers investigated whether a research-based focus contributed to students' science identity (Anthony et al., 2017). According to student self-assessments, students felt real-life, real-world research was a good preparation for later classes, and it was useful in validating them as scientists and confirmed their choice of career was the right one. In another college level course in engineering design and manufacturing, Stanford University students designed and built a product, giving them hands-on experience through the manufacturing of the product (Brubaker et al., 2019). Pre and post surveys were administered, and students wrote reflections throughout the course. For the 36 women in the course, the results revealed increases in the women's self-efficacy or their belief/confidence in their abilities. A study of 447 women and 394 men at 11 colleges explored the levels of motivation of students enrolled in introductory STEM courses (Stolk et al., 2018). Each course was categorized as (1) traditional, which meant lecture and lab, (2) non-traditional, which means project based, or (3) mixed, which meant a combination of lecture and project. In response to the Situational Motivation Scale administered weekly, women had more positive views of the non-traditional courses, indicting the active learning environment of the project-based courses promoted engagement. In analyzing the data, the researchers noted that several responses from the men and the women were similar; however, nontraditional pedagogical methods seemed to make more difference to the women, and to have more influence on their motivation and engagement than to men.

One area of women's learning particularly relevant to STEM education is robotics. Robotics has been used to engage girls and young women in learning activities that are more traditionally associated with the male gender. Brown et al. (2016) asserted learning experiences in the STEM disciplines can influence student perceptions of STEM. In a review of 147 robotics programs, Anwar et al. (2019) found research supports the view that active learning experiences contribute to students' ability to learn and can contribute to increased interest in STEM. Sullivan and Bers (2019) investigated learning outcomes from a seven-week long robotics curriculum with 105 kindergarten, first, and second grade students. Findings indicated girls' attitudes and beliefs about becoming an engineer significantly improved after completing the program. Although limited to 18 fourth through sixth grade students (6 women), Ching et al. (2018) who used challenging robotics activities in an eight week after-school program found students' attitudes towards math improved, and teachers indicated students persisted when the activities were challenging. Bampasidis et al. (2021) used underwater robots with secondary students and found that working with others promoted teamwork and positive attitudes towards science.

Research supports the use of group learning, or teamwork, as a component to active learning. Kressler and Kressler (2020) used active learning with a sample of 33 students in an undergraduate large lecture course. Qualitative data analysis revealed students felt active learning improved their higher order thinking skills, but challenges to learning and fear of failing were also cited. Among the challenges cited by students was working with unprepared students, a disadvantage of using teams in formal learning settings. Ng and Ferguson (2020) conducted a mixed method study of 357 Australian secondary school girls using project-based learning in STEM and art and found the program improved confidence and self-efficacy, and improved ability to work in teams, like the Bampasidis (2021) study.

Overall, results from this recent research in women's learning suggest that the strongest contributors to women's engagement in learning are active learning strategies utilized in project or problem-based activities in which they participate in teams. However, some studies have shown active learning strategies should be implemented with care because some students do not respond positively to active learning and group work. In a review of 57 STEM studies, Shekhar et al. (2020) identified poor design of activities, increased workload, and lack of guidance from teachers as reasons why some students disliked active learning. Responses from first generation college students were analyzed by Hood et al. (2020) and active learning was associated with anxiety and low self-confidence, particularly in underrepresented minority STEM students.

Women's Cognition

Cognition is defined as the "thinking and the mental processes humans use to solve problems, make decisions, understand new information or experiences, and learn new things" (Weinstein & Acee, 2008, p. 2). Bercht and Wijermans (2019) asserted it is difficult to communicate within the academic community about cognition because it may seem like an intuitive and familiar concept; however, it can mean different things – and sometimes many different things – to different people. While Alfred and Kraemer (2017) suggest scores on tests measuring cognitive abilities are important predicters of success in STEM, quantitative measures alone merely represent one avenue for understanding women's cognition. In isolation, test scores do not give a complete or descriptive picture of women's learning. Moreover, Kersey et al. (2018) assert that developmental factors related to cognition are not considered in relation to various ability tests in mathematics, which they argue is a limitation to using test scores alone when evaluating abilities. In this section, I will provide an overview of what is known about women's cognitive abilities, one component of cognition, in three areas: visuospatial, verbal, and mathematical cognition, and how other researchers have framed women's learning around them.

Visuospatial and Verbal Cognition

Alfred and Kraemer (2017) define visuospatial or visual cognition as a dimension of individual cognition requiring visual or spatial inputs for mental processing, and verbal cognition as a dimension of cognition that requires language in either covert or overt forms. The visuospatial cognitive dimension is measured using tests requiring mental rotation of objects. Visuospatial skills have been shown to improve with training (Uttal et al., 2013). Patt et al. (2018) examined ways to measure neurocognitive domains, such as visuospatial ability, in cognitively healthy individuals and found no significant differences between men and women for visuospatial cognition, which they defined as visuospatial memory and problem-solving.

No formal curriculum exists as a framework for understanding visuospatial skills and its importance to engineering education (Buckley et al., 2019). A study of 4,000 first year engineering students at Michigan Tech from 2009 to 2014 who were required to take a course that would help them improve their 3D spatial skills found that the course led to improved grades and retention, particularly for women (Veurink & Sorby (2019). They also asserted a need to narrate a common language by developing a universal test to measure visuospatial ability that could be tailored to each discipline under engineering education.

Mathematics Cognition

Stereotypes regarding intelligence are especially strong for math ability (Bian et al., 2018; Gunderson et al., 2017). Confidence in math ability would likely encourage one's entry into a STEM pathway, but stereotyping women as having lower math ability can set the stage for self-doubt. These messages can be passed on to students by others, including teachers and parents. Using data from the Education Longitudinal Study from 2002 to 2012, Perez-Felkner et al. (2017) found that 10th and 12th grade math ability beliefs related to subsequent course choices. Boys had greater perceived math ability beliefs than girls, especially in more challenging math tasks, which encouraged boys to take higher level math courses in the future, but not the girls.

For women, failure to enroll in higher level math courses makes majoring in math-intensive fields like engineering and physics far less likely, and some research has shown higher-level math courses are a significant roadblock for women to persist and choose some STEM disciplines. For example, in a quantitative analysis of over 58,000

Australian seventh graders Justman and Mendez (2018) found girls who took fewer of these math courses were much less likely to choose physics and computer sciences as a career path. Notably, the authors also suggested that female students "require stronger prior signals of mathematical ability to choose male-dominated subjects" (p. 282), and even though girls earned higher grades in math, this was a small fraction of what predicted gender differences in subject choice. Quantitative studies and an emphasis on test scores have provided limited information about women and STEM learning, but they fall short of providing richer data that could fill gaps in our understanding of how women perceive their own knowledge and abilities.

WWK Research

Although WWK has been used in many dissertations over the years, few empirical studies have used WWK as a conceptual framework, especially those published in the last five years. Moreover, some of the literature referencing WWK has been in the form of a scholarly critique. Older qualitative approaches have applied WWK to understand critical thinking in nursing students (Nelms & Lane, 1999), and to explore the cultural differences among adult education students (Luttrell, 1989). Some studies have shown a gender difference in the WWK separate and connected knowing perspectives, with women scoring higher in connected knowing while men score higher in separate knowing (Galotti et al., 1999; Marrs & Benton, 2009). Ryan and David (2003) investigated gender differences in how men and women acquire and process information and rejected the notion that cognition is intrinsically related to gender. Additionally, Schommer-Aikins and Easter (2009) determined that students who used separate and connected knowing show a greater willingness to argue, which the authors associated with higher levels of thinking. Among the few studies that have used WWK recently, Liu et al. (2013) examined women community college computer science majors to determine the cognitive perspectives exemplified by those students. Harkness and Stallworth (2013) used WWK to understand young women students' struggles in mathematics.

In a quantitative study by Aldegether (2017) WWK was used to examine how 190 female Saudi Arabian student teachers learn, with a focus on connected and separate knowing, the two types of procedural knowing. As defined earlier in this chapter, connected knowers are empathetic, considering the opinions of others; separate knowers use more analysis and critical thinking skills. Aldegether surveyed female elementary education students in their last semester using the Attitudes Toward Thinking and Learning Survey developed by Galotti et al. (1999) and refined by Galotti et al. (2001). The results showed connected knowing as predominant, which the researcher suggested might be related to Saudi cultural factors, beliefs about the teaching profession and the influence of teachers on the students.

The dearth of empirical studies about women where WWK is used as a conceptual framework illustrates a gap in our understanding of women's learning as they make important choices during the formative years of their education.

Summary and Conclusions

In this chapter I reviewed the problem and purpose of this qualitative study about young women's perceptions of their learning from middle school to emerging adulthood. The wealth of literature about women in STEM has shown a progression over the years moving from emphasizing women’s deficits related to higher level math and science courses to the systems where gender biases continue to influence women and their choices. Some major themes in the literature from the past 5 years relevant to this study include gender stereotypes, measurements of abilities related to STEM, inquiry-based methods and group work used to engage women in STEM learning, and how WWK can be used as a lens for understanding women’s learning.

The literature also reveals that women have failed to make progress in some STEM fields despite the many programs that target them. Additionally, the largely quantitative studies have not provided a long-term view of the influences on women’s perceptions towards STEM and their learning in general during their formative years. The recent research on WWK, which was the conceptual framework of this study, was also sparce. This study provided important insights about women’s perceptions of their learning, in part within the context of their STEM learning experiences as well as other educational experiences, and how those experiences shaped the women they became. In the next chapter, I explain my methods for conducting this study.

Chapter 3: Research Method

The purpose of this basic qualitative study was to explore self-reported perceptions of learning of women by asking them to reflect on their middle school STEM experience. Specifically, this study addressed how these women used this STEM experience or other learning experiences to describe their ways of knowing. In this chapter I describe the research design and rationale, the role of the researcher, and the methodology including participant selection logic, instrumentation, and procedures for recruitment, data collection, and data analysis. I also review issues of trustworthiness and disclose applicable ethical considerations for the study.

Research Design and Rationale

I chose to use a basic qualitative design as described by Merriam and Tisdell (2016) for this study to explore the perceptions of the young women from the time they were in late middle school through the present time. At the time of this study, these young women were in their early 20s, a period referred to as adulthood, which is defined as individuals in their late teens through 20s (Arnett, 2000). The research question that guided this study was the following: How do young women who participated in a middle school STEM program describe its influence and that of other learning experiences on what they know about their learning processes as they moved into adulthood?

The central focus of this basic qualitative study was to understand how a middle school STEM experience and other learning experiences influenced young women’s understanding of their ways of knowing. A qualitative approach was the most appropriate research design because my goal was to listen to the women as they described their participation in a middle school STEM program and other important learning experiences over a 10-year period. Quantitative methodology that included surveys with closed-ended questions would not have enabled me to identify deeper meanings behind the influences on women's learning (see Creswell, 2009). My goal was to gain an in-depth understanding of a specific group of young women who shared a common learning experience, so the use of quantitative methodology, such as surveys, would have restricted the overarching aim of this study.

Additionally, many researchers conducting STEM initiatives with young people did not conduct follow-up studies with participants, and the follow-up studies that were conducted rarely went beyond 1 year after the initiative ended (Falco & Summers, 2019; K. Roberts & Hughes, 2019). This study gave me the opportunity to further explore the experiences of these women during and after a 2-year educational program, which was conducted 1 decade earlier. Using a basic qualitative approach (see Merriam & Tisdell, 2016), I conducted in-depth interviews to understand these young women's perceptions of any influence the STEM program or other formal educational experiences may have had on their perceptions of their learning as they moved toward emerging adulthood.

I selected a basic qualitative approach because it provided for a richer understanding of the phenomenon of the women's experiences related to their ways of knowing. Hearing the influences of the shared experiences of the women, particularly in terms of how they felt about their participation in science and math courses, had the potential to provide additional insights into why women fail to choose certain STEM career paths such as engineering. A basic qualitative study is a modified version of a phenomenological study (Merriam & Tisdell, 2016), and I chose this design because my focus was on the experiences and meanings of learning experiences (the STEM program and others) on a specific group of young women. The depth of responses using qualitative inquiry along with a relative lack of qualitative studies justified my use of a basic qualitative method.

Role of the Researcher

I was responsible for designing the methodology, contacting participants, conducting interviews with participants, analyzing the data, and reporting the results. From 2009 to 2012, working with two middle school science teachers I designed, implemented, and oversaw an NSF STEM experience for 26 middle school girls. The girls who participated in that program represented my participant pool of women, a purposeful sample. My role with the girls during the time of the STEM experience would be considered *emic*, the insider view (see Patton, 2015), due to my direct role in conducting STEM activities with the participants. The STEM-related activities centered on Lego robots and were conducted during an allotted time on Friday afternoons, when the girls worked under the supervision of two middle school science teachers. I also conducted additional science experiments once per month with the girls. However, because I had not interacted with the women for 5 or 6 years, my role the current study was *etic*, or the outsider looking in at the present time (see Patton, 2015). This circumstance created a unique perspective for me as the researcher; however, my biases also needed to be kept in check throughout the study.

There were benefits and limitations to this study because of my prior work with the sample population. I was hopeful that because I had worked with the women for a significant part of their middle school years, they would remember this and trust my motivations for reaching out to them again. I assumed our shared past would put the women who agreed to be interviewed at ease and make them feel secure in doing the interviews. I also assured them that they would be in a safe and confidential environment if they chose to disclose sensitive information, and I reminded them that they could rescind their consent at any point during the process.

Due to my extensive prior work and commitment with this group, it was important that I remain neutral and open and without preconceived ideas as I listened to the participants' experiences. Over the course of my teaching career, I have worked with a variety of girls with the goal of getting them excited about STEM; therefore, it was critical for me to avoid asking leading questions and avoid making any unjustifiable interpretations of the responses from participants, such as stating outcomes that did not exist in the data. According to Sutton and Austin (2015), I needed to be reflexive, which means being cognizant of my biases as I reflected on the data and when I revealed my worldview to my readers. This required faithful awareness on my part through journaling as I collected data. I also developed essential interviewing skills by reading the literature available on this topic.

An additional concern I had was for the safety and confidentiality of the women who agreed to participate in this study. To protect participants' confidentiality, I reached out to them through private messaging apps online, I used pseudonyms instead of participants' real names, and I did not disclose my participants' identities to others. I also let all participants pick the location for their interviews. Finally, I kept all identifying participant information in a secure location.

Methodology

One of the most important parts of designing a study is choosing appropriate methodology. Egbert and Sanden (2014) defined methodology as "a reasonable plan for gathering and analyzing information that responds to a line of research inquiry" (p. 75). The following sections include information about the participant selection process, instrumentation, and procedures for recruitment, participation, and data collection.

Participant Selection Logic

A key aspect of this research was that this study was a follow-up study. My sample population was a specific group of young women with whom I engaged in the past, the 26 young women who participated in a middle school STEM program that I directed from 2009 to 2012. Accordingly, the participant pool for this study was limited to those 26 women. I attempted to contact and request interviews with all 26 women using lists of names of program participants and their parents, which had been kept in a secure location since the beginning of the STEM program. I contacted former teachers and community members and used telephone listings and social media. Once I reached a sample of five women, I utilized snowball sampling, a method in which a participant in a study reaches out to another potential participant to increase the sample size (see Creswell, 2009). This method was beneficial because these women shared a common experience and some were still in touch with each other. As I located the women, I attempted to contact them by phone, email, and social media to determine what avenue they preferred to receive an official invitation letter to be part of this study.

I wanted to have a minimum sample of 10 women who agreed to be interviewed, which would be 38% of those who participated in the middle school program. Determining an adequate sample size for this study was problematic. Guidelines about sample sizes for qualitative studies lack the specificity of guidelines for quantitative studies, but some researchers recommend saturation of data rather than number of participants as the standard (Baker et al., 2012; Guest et al., 2006; Mason, 2010; Morse, 2015).

Saturation is related to the stated purpose and indicates that no new data are being gathering from participant interviews (Baker et al., 2012; Mason, 2010). Morse (2015) noted that researchers do not saturate their data, but rather they saturate the categories into which the data fall. As Morse suggested, the sample size for a qualitative study is less important than uncovering the truths of the participants as related to the research question. Guest et al. (2006) suggested one way to determine the saturation point is to identify the point at which the researcher is unable to uncover any new themes.

The validity of qualitative studies relates in part to the type of sample and the way in which the researcher decides how many participants are necessary to answer the research question. The validity of the current study hinged less on sample size than on uncovering what influences were important to the learning of the participants. If more than 10 women consented to be interviewed, I planned to conduct interviews with all of them until I determined saturation had been reached. Patton (2015) noted that validity is dependent on the richness of the data and the analytical abilities of the researcher. Therefore, the depth and validity of the current study would require that I remain open to the participants' reflections when interviewing them. Furthermore, I was cognizant of the fact that I needed to remain neutral when coding and analyzing the data and in reporting the findings, and to remain open to all possible interpretations of the data because I had worked with these women in the past.

Instrumentation

I used semistructured interviews with a purposeful sample of participants from a pool of 26 women who had participated in the middle school STEM program. Interview questions were open-ended, and I remained cognizant of not asking leading questions. Turner (2010) suggested including a phrase such as "how did this influence or not influence you?" to avoid leading the participant, and these phrases were incorporated into some of my questions. I developed and wrote interview questions that were informed by my literature review and my conceptual framework. My questions were designed to elicit (a) how the STEM program and other learning experiences influenced participants' understanding of their abilities as learners, (b) participants' feelings and attitudes toward science and mathematics subjects, (c) participants' decisions about college or jobs, and (d) whether and how participants decided on a career path in high school and college. Interviews were recorded with participants' consent and were transcribed by me. I conducted pilot interviews with two friends prior to the start of this study to address content validity, and I used these pilot interviews to revise my questions prior to the start of the study. The data gathered from the two pilot interviews were not included with the data gathered for my study. When data collection began after I obtained Walden University Institutional Review Board (IRB) approval, I took brief notes during interviews to supplement the responses of the participants. The interview guide is included in the Appendix.

Balance was important to the quality of the design of the interview questions. Rubin and Rubin (2012) suggested that conclusions should be balanced, thorough, credible, and accurate, which meant it was important for me to get the views from a variety of participants. For example, I interviewed women who were attending college as well as those who were not so that I could obtain richer data.

Procedures for Recruitment, Participation, and Data Collection

From my list of 26 STEM participants, I sent an email request and a letter requesting their consent to participate in this qualitative study. I hoped to get a minimum of one third of the individuals to agree to be interviewed, and as participants committed to be interviewed, I asked them to encourage the others in the purposeful sample to also agree to an interview. If I failed to get enough participants from my sample, I planned to use a process known as snowball sampling (see Patton, 2015) in which I asked other individuals, such as teachers, if they knew individuals like those in my purposeful sample whom I could interview on the topic of my study. However, I was able to get 10 participants from the purposeful sample, so this was not necessary.

I gave those who committed to the interview a copy of the informed consent form along with my contact information so participants could reach me if they had additional questions or concerns about the study. I asked participants to consent to one 30- to 60-

minute interview. I planned to have one interview with each participant. All interviews took place by phone due to the COVID-19 pandemic and the necessity for social distancing to ensure continuity. I conducted interviews and recorded the data.

I transcribed the interviews into a Word document. At the conclusion of each interview, I debriefed participants and informed them that transcripts would be made available to them and they would be given an opportunity to make corrections if needed. I maintained participant confidentiality by using pseudonyms for the names of all participants. Real names are on file in a locked cabinet, and I will keep this file for a period of 5 years before destroyed it.

Data Analysis Plan

From the transcribed interviews, I summarized each interview into a single document for each participant and identified relevant themes. Rubin and Rubin (2012) suggested sorting themes and resorting them within and between participant files before determining the final themes. To ensure validity, I used an additional method, the comparative method for themes saturation proposed by Constantinou et al. (2017), to determine the saturation point of my data. This method involves comparing themes between interviews and a second round of reordering of interviews to reduce the chance of order-induced errors in concluding that saturation has been reached. This method is recommended for studies with smaller and more homogeneous samples. The themes in the current study were related to the research question: How do young women who participated in a middle school STEM program describe its influence and that of other learning experiences on what they know about their learning processes as they moved into adulthood?

Issues of Trustworthiness

In qualitative research, rigor is an important consideration. For qualitative research to be trustworthy, it must have credibility, transferability, dependability, and confirmability (Toma, 2011). According to Tracy (2010), credibility is best accomplished through thick, rich data from diverse participants. I used in-depth interviews with 10 participants, and this number of participants from the total pool provided a richness and meaningfulness to the data and gave greater credibility to the study. Tracy also asserted that credibility is dependent on detailing the responses and analyzing the content in an unbiased manner. My earlier work with the women participants made it especially important for me to be cognizant of my potential biases.

Transferability in qualitative research is akin to generalizability in quantitative research (Toma, 2011). Although transferability is more difficult to accomplish with respect to qualitative studies due to limitations in sample size, the richness of the data and the specificity of my participants—young women of college age with a common background—could be illuminating to other researchers interested in the same type of phenomenon. The longitudinal nature of this study, and the fact that the period being explored was during some of the most critical years for learning also potentially adds to the knowledge base around women’s learning. To improve upon transferability, I included the most detailed descriptions in my methods section, as well as a thick, descriptive discussion of the findings.

Dependability is represented by the fluidity of the design in qualitative research (Toma, 2011). This is one of the greatest benefits to qualitative studies because the researcher can evolve with the research, and modifications to improve the study can be made as it is conducted. The changes I made to this study are discussed in Chapter 4.

Finally, confirmability requires the researcher to disclose as well as to eliminate as much potential bias to the audience and participants as possible. According to Toma (2011), this requires confirmation of how data were collected, archived, and analyzed, revealing biases, and considering alternative explanations. In a thorough discussion of this research, each of these points as outlined by Toma is addressed.

Ethical Procedures

Prior to contacting the participants, I obtained IRB approval through Walden University (IRB approval #06-04-20-0397268). Additionally, because Illinois Valley Community College, my employer, was the NSF grant holder I thought I might also need approval from our own IRB, but I did not. I sent an email invitation to participants that included an informed consent document that included specific information as required by Walden's IRB. This email included the following items: (a) explanation of the general purpose of the study, (b) interview procedures and estimated time commitment, (c) voluntary nature of participation and that they may opt out at any time, (d) risk assessments, (e) confidentiality, and (f) contact information.

Because I have done previous work with my sample participants, I planned to be especially sensitive to whether the participants want it to be known that they are included in this study. To prevent their identities from being disclosed within the dissertation and during the actual data collection phase I planned to change the names and locations of the participants, and not disclose the specific middle school where the STEM program took place. Furthermore, I planned to speak with one of my committee members or an IRB official to ascertain the appropriate action that should be taken if any unexpected sensitive information was disclosed during the interviews.

Transcribed data and recordings are being kept in a secure location in my home for a period of 5 years and will then be destroyed. Only my committee members and I will have access to the data. I had planned for the possibility of conducting some of the interviews at my work office, in which case I would have needed approval from my employer. However, this was not necessary due to the pandemic and the need to conduct all interviews by phone.

Summary

In Chapter 3 I outlined a basic qualitative research plan to interview women who participated in an NSF STEM program during middle school between 2009 and 2012. Semi-structured interviews with this purposeful sample of 26 young women who shared a common experience were used to gather rich, thick data to understand whether and how this experience and other formal and informal learning experiences since then have influenced the women’s learning. I planned to interview a minimum of 10 participants in person or online using an interview guide that I developed. The interviews were recorded, transcribed, and coded manually. Because I had a former relationship with these women, I was cognizant of the potential for bias in my interpretation of the results. Additionally, I informed participants of their rights and ensured the privacy of their data, which was essential for this study. Results of the data collection and coding are included in chapter four.

Chapter 4: Results

The purpose of this basic qualitative study was to explore women's self-reported perceptions of learning by asking them to reflect on their middle school STEM experience and other learning experiences through high school and into emerging adulthood. I examined women's perceptions of learning by asking them to describe their experiences in the STEM program as well as other experiences. I designed the interview questions to encourage participants to discuss their ways of problem-solving, their decision-making processes, and other influences on their learning. The research question that guided this study was the following: How do young women who participated in a middle school STEM program describe its influence and that of other learning experiences on what they know about their learning processes as they moved into adulthood? In this chapter, I describe the setting for this study, demographics of the study participants, data collection procedures, data analysis methods, processes used for ensuring trustworthiness, and the findings from my data analysis.

Setting

For this study, I conducted all interviews by phone in a private setting to ensure the safety of participants due to the COVID-19 pandemic and to protect their confidentiality. I allowed the participants to choose the time and day of their interview. As a result, the participants controlled the physical location in which they did the interview.

Demographics

The setting for the STEM program I led 10 years ago was a rural, Midwest U.S. middle school. At the time of the current study, all 10 participants were between the ages of 21 and 25. Additionally, at the time of the study, all of the participants had completed some college and had attended or were currently attending a college or university located within 2 hours of the rural Midwest region in which they grew up. Two participants were currently working to complete an online degree, one in nursing (Bachelor of Science) and the other in special education. Four of the women majored in nursing, one majored in biochemistry, two majored in business, one majored in liberal arts, and two majored in education, meaning that half of the participants had chosen STEM careers. I included health professions such as nursing as a STEM field because these types of careers require higher level science and math courses for the postsecondary degrees. At the time of the current study, one participant had earned a bachelor's degree, one had earned an associate's degree, five were working to complete their college degrees, and three had stopped attending college. Five of the 10 participants were White and five were Hispanic, which was similar to the ethnic composition of the middle school STEM participants I worked with the original study. Two participants had children under the age of 5. Table 1 lists the pseudonyms for the participants, their highest level of education attained, and their current occupational status.

Table 1

Demographics of Participants at the Time of the Interviews

Participants (pseudonym used)	College status	College major	Occupation
Emily	Attending college	Nursing	Student, certified nursing assistant
Hannah	Some college	Early childhood education	Customer service
Isabella	Attending college	International business	Student
Katie	Completed bachelor’s degree	Biochemistry	Unemployed due to pandemic
Kristin	Completed associate’s degree; taking break from college	Nursing	Unemployed due to pandemic
Lisa	Some college	Business	Maintenance
Maria	Attending college	Nursing	Student
Morgan	Some college	Liberal arts	Event organizer
Natalie	Completed associate’s degree	Nursing	Nurse
Sofie	Attending college	Special education	Student, teacher aid

All 10 participants attended some college, and three of the 10 participants had stopped attending college. Emily was working as a certified nursing assistant while attending college to earn her associate’s degree in nursing. Hannah had completed some college and left because she became disillusioned with early childhood education after having her second child. At the time of the interviews, Hannah’s two children were both under the age of 5, and she was working part-time and considering going back to school for art. Isabella was an international business major who indicated she expected to graduate in the fall of 2020. She is trilingual and speaks Spanish, English, and French. Katie earned a bachelor’s in biochemistry in 2018 from a private liberal arts college. She was working in quality control but was laid off in May of 2020, 2 months after the pandemic began. Katie was considering looking for other chemistry positions outside of quality control or possibly going to graduate school to gain skills that would allow her to go in a different direction. She indicated a strong desire to work in a hospital so she could help with the pandemic. Kristin earned an associate’s degree and had 1 year left in her Bachelor of Science in Nursing program. She decided to take the semester off due to the pandemic. She was also unemployed due to the pandemic.

Lisa was a business major in college but decided college was not good for her. She was working in maintenance while raising her young child. Maria was enrolled in an associate’s degree nursing program at the time of the study. She was living with her parents while working to complete her degree. Morgan, who had completed some college, could not justify the cost of continuing their education. Morgan identified as non-cisgender and was employed as an event organizer. Natalie graduated with an associate's degree in nursing and was working as a nurse while helping raise her sister's 3-year old daughter. She was planning to complete her Bachelor of Science in Nursing online but was taking a break from school at the time of the interview. Sofie moved away to attend college and returned to the community. She was working two jobs: one as a teacher's aide and one helping her father with his business. Sofie was pursuing a degree in special education in an online school. She was married with a young child.

Data Collection

There were no variations to my original data collection plan as presented in Chapter 3. After Walden's IRB granted approval for my study, I began reaching out to as many of the 26 women who were on my list of middle school STEM participants as I could find. I used social media, local telephone books, and Google searches to find potential participants, and I asked the two middle school teachers who were involved with the STEM program if they were still in touch with any of the STEM group participants. Using these methods, I located nine of the 10 young women who agreed to be participants in this study. I located one additional participant through snowball sampling when one of the nine women who already agreed to be interviewed gave her friend, one of the STEM group participants, my contact information and informed her about the study. Although I was able locate 12 women, one did not want to be interviewed and one did not respond to my two separate requests. I was able to get my approved minimum number of 10 participants.

Data collection involved semistructured interviews using interview questions that were developed with my research question in mind. I also used the conceptual framework and my review of the literature to determine the best questions to ask. I began conducting interviews in early June and completed the last interview on July 1, 2020.

In information I shared with prospective participants, I indicated that interviews would be 30–60 minutes in length. All 10 interviews were between 30 and 63 minutes in length. Interviews were recording using an iPhone and a recording app downloaded to the iPhone. Participants were reminded they were being recorded at the start of each interview. During interviews, when participants began sharing information of a more personal nature, I reminded them that they were being recorded. Additionally, I took brief notes during each interview, and after each interview I typed the notes and saved them as a Word document. Immediately following each interview, and as identified on the informed consent form, I sent the participant a thank-you email with a $25 e-gift card as compensation. I transcribed all 10 interviews and emailed the transcripts to participants for review. None of the participants indicated any changes to their transcript were necessary.

Two interviews could be described as occurring in unusual circumstances. Two participants indicated they were home with young children, and there were a few instances when the participants needed to attend to the children during the interviews. This resulted in minor distractions during the interview; however, when the participant returned to the interview, I repeated questions to get her back on track with the interview. Although the interruptions could have interfered with the interviews, neither participant indicated this to be a problem. In another interview, the participant had to suddenly stop the phone interview and we had to reschedule to complete the interview at another time. I completed this interview in two separate phone calls, which disrupted the flow of the interview.

Data Analysis

After I transcribed the interviews, I began the process of data analysis by coding. I went through an iterative process as I performed four rounds of coding. During the first round, I highlighted words, similar statements, and similar experiences from the interviews that were most relevant and important. From this first round of coding, I was able to modify my codes and create categories to align better with the research question and conceptual framework.

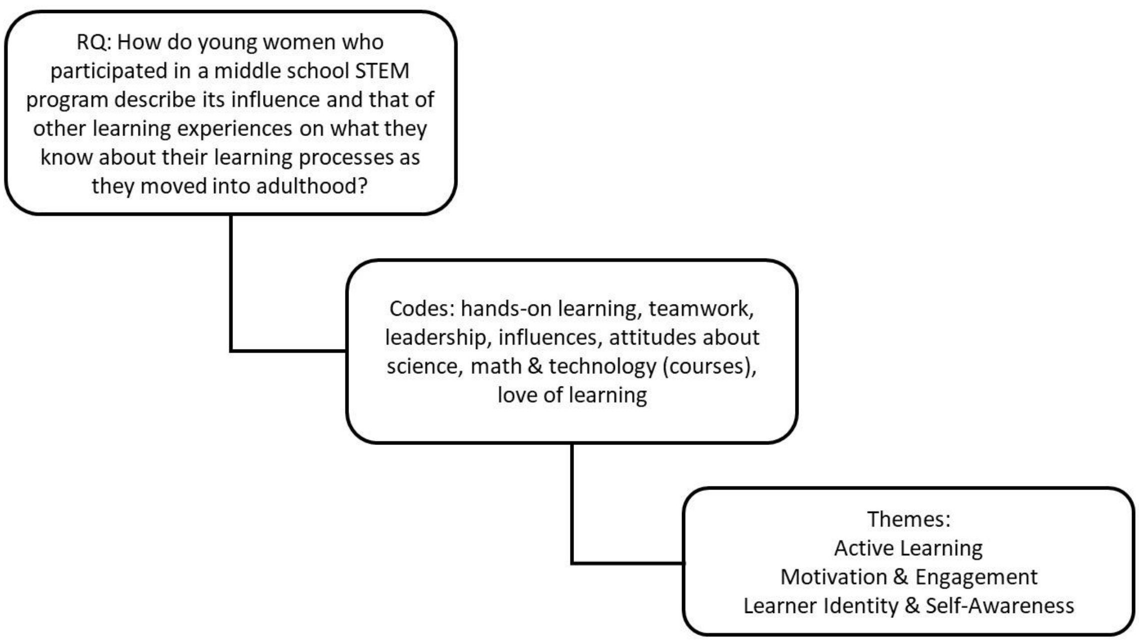
I also looked at the frequencies of codes and categories both within and across interviews. As described in Chapter 3, I sorted and resorted material both within and between participants before determining final themes, as suggested by Rubin and Rubin (2012). Because my study had 10 participants, I went through a third round of coding in which I reordered the interviews, which was a method suggested by Constantinou et al. (2017), to help determine the saturation point of the data. During a fourth round of coding, I continued to sort and resort material within each file and compared the data among interviews. I eliminated categories that seemed to not cross over among the interviews and condensed categories that seemed similar. I combined my final categories into themes.

Codes and Themes

After four rounds of coding and analysis, I identified themes from repeating ideas for the research question. I wrote my research question to explore participant perceptions about their learning within the context of the middle school STEM program and within the context of how other learning experiences influenced participants' beliefs about their learning since middle school. Due to the possible overlap in responses, I decided to separate the STEM program comments from participants' recollections of other middle school formal learning experiences. A continuum of shared experiences from elementary to secondary to postsecondary learning culminated in codes that described the STEM experience as well as other learning experiences. The codes and themes are shown in Figure 1.

Figure 1

Codes, Themes, and Their Relationship to the Research Question



My analysis process involved looking for repeating words and phrases throughout the interviews. I analyzed themes within the data about the middle school STEM experience and then again for data related to middle school, high school, and college experiences. I included data for learning experiences that occurred outside of the school setting, which emerged as important as well. My definitions for the themes are listed in Table 2. Two participants remembered little about the STEM program and could not discuss learning experiences with it. As a result, my saturation points for themes related to the STEM program were based on a total of eight participants rather than 10. My saturation points were based on when at least half of the participants spoke about a common experience. I determined saturation for other learning experiences using the same procedure.

Table 2

Definitions of Themes for the Research Question

Theme	Definition	Subtheme
Active learning	Process of engaging in and manipulating objects and specimens, experiences, and/or engaging in conversations to build mental models of the world	Hands-on in STEM Hands-on in other learning Dialogue with others in STEM Group learning in STEM
Motivation and engagement	Teachers, subjects, classes and/or topics that sustain or increase learner interest and persistence in learning; also motivation to persist in pursuing a particular career path	Cognitive engagement in STEM Career engagement in other learning Teachers as motivating forces
Learner identity and self-awareness	How one describes oneself as a learner; how one describes oneself through reflection and self-evaluation	Confidence building in STEM Confidence building in other learning STEM program leaders as role models Teacher influences from other formal learning experiences Perceived strengths/weaknesses from STEM Perceived strengths/weakness from other learning Shifts in learner identity by STEM participation Shifts in learner identity and self-awareness in other learning

Discrepant Cases

I analyzed the data for discrepant cases by reviewing any unexpected responses that did not fit with the themes for this study or that were dissimilar to most participant responses. Two participants, Maria and Lisa, were unable to remember their experiences during the STEM program in any detail and their responses were minimal for the STEM learning experience.

At the time of the interviews, two participants' responses did not illustrate the ability to self-reflect. Maria's interview responses throughout were centered on the influence of her friends, even to the extent of following a friend into a career path she had not considered. Hannah, who was a mother of two and not attending college at the time of the interview, was unsure of her life choices about her education.

Evidence of Trustworthiness

Rigor in qualitative research requires that researchers show evidence of credibility, transferability, dependability, and confirmability. I was responsible for collecting and analyzing the data for this study. I followed a strict set of protocols to ensure trustworthiness for this study.

Credibility

Credibility is enhanced when rich, thick data is produced. I was able to interview 10 of the 26 participants from the STEM program. Each of the 10 interviews lasted more than 30 minutes. Because I was the person who coordinated the STEM program, I was cognizant of my potential for researcher bias. I used a journal to remind myself that I had to stay open-minded to the data during my analysis, particularly because this study was tied so closely to my previous work on the NSF grant. I also took notes during each interview for review during the analysis. I produced my own transcriptions and sent completed transcripts to each participant soon after the interview to allow them to make corrections. No corrections were requested. When reading through the transcripts, on occasion I would go back to the audio interviews to check for inflection and tone of participants, and to clarify what I had written in my notes regarding participants' responses to certain questions during the data analysis. I did this to avoid making inaccurate assumptions about participant responses.

Transferability

Although qualitative studies are not designed to be transferable to other studies, the details I provided regarding my methods, the details of the participant demographics, and the rich, thick data described in the results make it possible for the reader to determine the extent to which results of this study may be transferable. I wrote interview questions with follow-up probes for each question for depth of responses. Additionally, because this was a follow-up study from a program that I conducted during a specific developmental period for the participants, it may provide insights into student engagement, pedagogical design of authentic learning experiences, and equity and access in STEM education other researchers can explore, although readers can make this determination for themselves.

Dependability

I designed the details of my methodology, interview guide, and analysis process with my committee members to ensure dependability. My committee chair gave me valuable feedback to help me improve my technique as an interviewer after I had conducted my first few interviews. In addition, I kept a research notebook where I compiled notes about my protocols at each stage of my research, including thoughts before and after interviews, during the analysis when coding and categories were developed, and notes about my final conclusions.

Confirmability

In this study I have disclosed my potential biases to address confirmability. I kept a detailed research notebook that included how I reached out to participants, how I archived my data, notes about my analysis, and notes about when I questioned my assumptions throughout the research process. I recorded instances of when I questioned my assumptions that could have been due to my biases. I did this to ensure the objectivity of my study.

Results

I organized the results section around the three themes: active learning, motivation and engagement, and learner identity and self-awareness. The data included in this section came from participants' perceptions about their experiences with a middle school STEM program, learning experiences that occurred during formal learning through college, and other learning experiences spanning 10 years. Overall, the participants described their participation in the STEM program as positive and the responses revealed understanding and perceptions about their own learning. Responses from participants about their learning outside of the STEM program revealed important changes over time, particularly those related to their understanding of self, their perceptions about formal education, and their career choices.

Active Learning

Active learning included the subthemes of hands-on in STEM, hands-on in other formal and informal learning, dialogue with others, and group learning. All subthemes emerged as important to the STEM program learning experiences, but only hands-on learning emerged as important to other learning experiences. Participants describing how they learn was a common thread within active learning. Participants described specific STEM learning experiences and how they understood through those experiences what learning methods worked best for them. Participants also described their feelings towards STEM subjects, which activities they liked, and how the structure of the learning experiences influenced the way they learned.

Hands-On in STEM

All eight of the participants who remembered specifics of the STEM program described the importance of a variety of active learning experiences they engaged in and how those activities influenced their learning. The hands-on learning activities participants cited as memorable included laboratory dissections, experiments, and robotics and technology activities, which followed a problem-based format. Emily, Natalie, Isabella, and Morgan remembered working with robots. Morgan recalled the importance of this activity on their learning:

> You guys [would] give us a computer program and say okay code for the robots to do something. Then that gives us the tools to accomplish the things that you

> want us to learn but also the freedom to experiment and do things that we find interesting or entertaining with the tools that you give us.

Isabella proudly recalled describing her experience to her college friends her freshman year by telling them, “We did the robots and they all looked at me like ‘You did that?’ and I was like “Yeah, I did that!”

Emily and Isabella also recounted rebuilding computers. Kristin, Natalie, and Maria remembered doing activities in a college science lab. Emily recalled visiting the anatomy lab, “They [the teachers] were speaking of a little bit of anatomy, a little bit more like high school level and at the time we were middle school and exposed to that.” Emily also remembered seeing a cadaver, “That’s something I will always remember. … That was the very best one [memory] for me.”

In general, participants indicated during that time they felt they were being challenged and encouraged to ask questions and that the experiences with hands-on activities would be useful to them in the future. Kristin remembered how important the dissections were to her future when she stated, “Dissecting is fun. ... From that initial cut … I’m like ‘Oh yeah, I can’t wait to go’ [to the college] ... it all builds. ... Every reason why you do something, it’s in there.”

Seven of the 10 participants revealed strong memories of college visits, which led them to reflect on the many hands-on experiences they had in the college labs. They remembered handling and dissecting [sheep] brains, dissecting cats, and fetal pigs, and visiting the cadaver lab. The experiences were strongly rooted in participants’ memories and perceptions of how the hands-on learning activities influenced their learning and influenced their abilities to solve problems.

Natalie described vivid memories of the dissections and said why she felt they were more important to her learning than other types of activities:

> I definitely remember dissecting the pig. … I liked learning about [the] anatomy of animals and people. I mean I was always interested in learning more about the human body. Especially cause [*sic*] I'm not too big into the computers and technology kind of aspect of it. I was more interested in the hands-on.

Natalie's prior interest in learning about anatomy supported her preference for hands-on experiences.

Emily recalled building Lego robots, entering an edible car contest, and working in the college anatomy lab. She described her learning prior to the STEM program and how the hands-on activities of the program led her to reconsider what was effective for her:

> When I learn ... it helps me to write things [down] and read. I was never a visual learner. It [STEM] was a lot of hands-on which was very new for me and kind of intimidating. … But it actually helped me learn better. … It made me think more, and it also improved, I guess, my thinking skills.

Emily understood that being challenged led to learning and cognitive growth.

In contrast to Emily, Katie spoke of herself as a visual and hands-on learner and had known those methods were most effective for her learning. The Challenger landing simulation was Katie's memorable hands-on activity and she described how it influenced her understanding about her own learning processes:

> I remember doing [a] simulation of landing it [Challenger]. I like that one the most because for me [I am] a visual learner and asking us to do things mostly hands on ... that's how I mostly figure out … certain things. … [It] helps me learn a lot better than just like reading everything online or even in a book. … To me it's kind of harder to learn that way [reading].

While Katie and Emily had contrasting views about the value of reading and writing to their learning, both women recalled the hands-on and visual aspects to be more valuable than simply reading or writing about a topic after participating in those types of learning activities. Hannah also related how she had "always been one that likes being hands-on because it helps me learn a lot better than just reading."

Morgan's vivid memory of a laboratory dissection demonstrates the power some hands-on activities had for some participants. The participants had been told they would be dissecting brains, both goat brains and human brains, that afternoon. Morgan described grabbing a brain out of a bucket filled with formaldehyde, and noticing its small size:

> It was just a very tiny, shriveled up little brain, and I knew we were going to have both goat brains and human brains. So, I said, "I'm excited for the human brains." and then you guys told me those were the human brains. They were just a little smaller than we like to think that they are. … We tend to have this grandiose idea of what our own internal structures look like especially when we say we have

> bigger brains than any other animals. That's what makes us far superior to them but we're just animals as well.

Morgan's analysis of the differences between human and animal brains elucidated how this hands-on activity allowed for practicing critical thinking skills.

Kristin described a key moment from a trip to the college science lab when she performed her first dissection of a brain:

> We were in the anatomy lab, and we were cutting I think sheep or goat brains … and we were instructed to do it midsagittally. … The lady who was with me, she stuck out to me the most because when I did make that cut of course I didn't know what I was doing – I'd never done it before, and she was like "Oh my gosh, you should be a brain surgeon!" And it threw me into this "Oh my God, I could be a brain surgeon! I can do almost anything!" I know it sounds crazy, but just her comments and I was having that experience in that lab. It's kind of veered me towards the path of going down the science field.

Kristin was experiencing this type of hands-on activity for the first time which broadened her view of her capabilities and developed her belief that she could be a science major. Kristin described this memory as her "most imprinted memory" during her STEM experience.

Isabella described how proud she was of having had hands-on experience with computers when she was in the STEM program. She told a story about when she went away to college and she lived in a dorm with other information technology majors, most of whom were men. She told the men about the STEM experiences she had in middle school that involved taking computers apart and putting them back together as well as building and programming Lego robots. "I always found a way to bring that up," Isabella recalled, and it was something she called a "little humblebrag."

Hands-On in Other Learning Experiences

The data I used for this section related to participants who described hands-on activities in science, math, and career-related courses in middle school, high school, and college, or in other settings such as work. Eight of the 10 participants mentioned specific classes with hands-on components, especially classes which had labs, as important to their learning.

Kristin recalled hands-on experiences in middle school with a technology class. She also remembered her dissection experiences in high school classes. Rather than graduate early from high school, she decided it would not be a good idea if she wanted to be successful in college, "In high school I could've graduated junior year, and I stayed senior year because I knew that if I took anatomy senior year … it wouldn't be so tough and foreign to me [in college]."

Isabella said her technology class in middle school taught her valuable hands-on computer skills like podcasting that she was still using at the time of her interview. Isabella described her high school class choices as diverse and recalled the importance of a forensics class to her when she said, "I think that was probably one of my favorite classes. And I still use it today."

Lisa had fond memories of her time in middle school and recalled the hands-on experiences in her art class. Lisa also recalled enjoying experiments in high school lab classes, and she credited technology classes with what she believed was one of her strongest skills: “Taking technology when you’re younger and doing the tech class, that was always exciting for me. And to this day I like to be tech-savvy.”

Natalie indicated she became more engaged with learning due to working on dissections. She indicted a preference for dissections to other traditional methods for learning. She described how influential her senior year in high school was because of the hands-on nature of the certified nursing assistant (CNA) class:

> We learned a ton of stuff that year. … We learned how to take vitals. We learned how to care for patients, do bed baths, bed changes, everything like that. I would say my senior year in my CNA class is where I learned the most. [It was] the most helpful, hands-on, real-world experience.

Sofie also said high school chemistry, biology, and the CNA class helped her learn. She said, “I liked the challenge [of honors classes]” and she described her struggles with math, “I just kind of had to learn to let go of the perfectionism of having all A’s and having good grades.”

Emily said the hands-on nature of the CNA class and her anatomy labs were an effective way for her to learn. She described how her learning was tied to doing and to teaching others:

> If I don’t dissect that cat, then I’m not going to know how to learn the anatomy of the cat. And if I don’t change that colostomy bag then I’m not going to learn how to do it. But I have to do it to learn. It’s intimidating at first and you might not understand it right away. … But the more I do things the more comfortable I get

> and the better I get. Then I am able to teach someone how to do a certain thing or teach someone "this is the brachial artery of the cat." I am able to help someone, so I teach someone how to do something [and it] helps me too.

Hannah described the importance of a block algebra class, a hands-on class in which one-on-one teacher support helped students learn:

> And that [block algebra class] really helped me get more into math and kind of figure out a lot of the equations. And without that course I don't think I could have – I'm not like not trying to think negative -- but I don't think I would have gotten past going into the next math course if it wasn't for block algebra.

In contrast to the other participants' responses about hands-on learning experiences, Katie felt anxious when comparing herself to others when they were coding in a college physics class:

> I had a physics class [and] I would always have [a] professor code a lot and then also had friends who code a lot. And I actually wanted to do it, but I was scared. I was feeling how fast they typed it and they never seemed like [pause] they never made mistakes. Then for the program to, [it] always seemed to work.

Dialogue with Others in the STEM Program

The dialogue participants had with each other and with the STEM leaders was a second aspect of active learning significant to how they described their learning. Being encouraged to ask questions was cited by four of eight participants. Emily said "I sometimes don't like to ask questions. After doing the STEM program I realized … you won't learn if you don't ask questions." Katie recounted "If we just didn't understand we could ask one-on-one questions." The questions did not always come from the students, but sometimes came from the teachers. Sofie remembered one STEM leader frequently asked her opinion about STEM activities and whether the rest of the group would like what activities were being planned:

> I remember he would pull me aside and say "Hey, this is what we're planning. What do you think?" And then I would run it through the group of girls, and I would say "Hey, what do you guys think?" So, for me what I recall is that I was always being the leader, always asking the girls for their opinions along with giving my input and trying to work all together. but also trying to be a leader and saying like "Hey, guys this is what we need to do. This is what the plan is."

The conversations between Sofie and her STEM teacher were important to Sofie's understanding of her role in the STEM program, which she credited as being a "leader," but also exemplified how the teacher treated Sofie as an equal partner in the educational process.

Morgan had a similar view of the relationship between the students and the STEM teachers, who Morgan credited with having a "conversational" style of dialogue which benefited the learning process:

> I got a lot more questions and explanations, and we were able to have that kind of back and forth so that we could have a deeper understanding of what we were learning instead of having it be strictly lecture based. … The teachers were more authority figures due to their particular field of expertise and not necessarily due to an inherent class difference. … It was less about a social role and more about

> what they knew and what sort of information they could bring to the table to share with us kids.

Morgan viewed this dynamic between teachers and students as an important way to expand learning beyond what could be gained from a traditional classroom.

Kristin remembered one STEM teacher taking her aside to answer her questions which sometimes went beyond the scope of the activities being discussed when she said, “I remember raising my hand a lot. And be like “Why?” and he would keep me after and then explain everything to me.” Isabella reflected on how her STEM experiences brought more questions to mind when she stated: “It increased my curiosity and I think it … gave me more questions about how things work and why they work.” In addition to encouraging questions, the dialogue outside the learning experiences sparked curiosity and encouraged participants to think beyond the content discussed.

Group Learning in the STEM Program

Working with others was a third aspect of active learning commonly cited as important to participants learning. Most of the hands-on activities were completed in pairs or slightly larger groups among the girls, and participants described these group learning experiences as teamwork. All eight participants who remembered details of the STEM program said they felt working together was an important aspect of their learning experience. Participants described the benefits of working together to solve problems, including learning to work well with others, having a diversity of ideas to consider, and the general camaraderie that resulted from the group spending significant amounts of time together on learning activities.

Emily recounted "I found out at the time my closest friend got chosen … to be part of the same group … which made it even more fun." Katie said she was happy at the time "because I was chosen out of all the rest of the grades and got the opportunity to do it with a handful of girls" and that "I felt more comfortable after being with the girls." Maria said being with friends was important both to her confidence level and, like Emily, it was important to her ability to have "fun." Natalie said what stood out to her from the experience was working together:

> I do remember we had a lot of good teamwork. I do remember that because we were all like "We don't know what the heck we're doing, so we're just gonna [*sic*] kind of help each other until we all figure it out." I do remember that, and I did enjoy being a part of the group … because we got to do certain things that other people didn't get to do.

Sofie recounted "we always worked as a team, and we always used each other's ideas." Sofie also said the most important thing to her during that time "was the teamwork and always helping each other to find the answers." Morgan described the benefits of learning in groups: "We all had our different sorts of strengths and weaknesses and fields of interest. … It was a very nice kind of educational all-encompassing sort of thing that very different students could bond over." Kristin noted learning a lot from the experience "with all the girls in there ... I learned a lot of collaborative ways of getting my message across."

Participants described working with teams and watching peers in the program accomplish tasks as beneficial to their learning. Isabella described how the peer groups advanced her learning when she said:

> We would do all these projects and all these new things we would always work with other people. It definitely helped me learn how to work well with others and how to be a leader … how to work in a group … how to lead a group and how to be a part of a group and work together.

Katie recalled learning by watching other girls demonstrate how to build rockets. She described how that influenced her when she said: “It was more interesting because two other students … that did that program were also two other girls. It was pretty cool seeing that they made this, then showing us how to do it also.”

Learning with peers also brought out a competitive spirit in some participants. Maria recalled visiting the college and doing a cheek cell slide preparation which prompted the group to begin a friendly competition for the teachers’ attention:

> I remember it because when we looked under the microscope some of us, I guess, scraped harder than others, and at that point it became a competition to who could get more so the teacher would say something about it.

Hannah recalled what stood out the most for her was the importance of being able to “talk to those girls” and “get close to them” during the STEM program. She declared not liking school; however, she did like STEM learning activities.

To summarize this section on active learning, participant interviews revealed that the significant aspects of the active learning theme were hands-on activities, dialogue with others, and group learning. Hands-on activities emerged as important in the STEM program and in other learning experiences. Dialogue with others and group learning were mentioned as important or significant in reference to the STEM program but not mentioned in reference to other learning experiences.

Motivation and Engagement

Motivation and engagement emerged as an important theme for the STEM program as well as for other learning experiences. Within the context of the STEM program, participants discussed motivation and engagement as important to cognition and how they were developing as learners. In contrast, learning experiences that occurred during high school and college were primarily attached to the desire to prepare for a career.

Motivation and Cognitive Engagement in the STEM Program

Active learning reflected how the participants learned, but motivation and cognitive engagement explained why the participants learned. For this study, I defined motivation and cognitive engagement as related to how the participants felt about the subject matter and how participants described teachers as motivators.

When asked how they felt about the subjects of science, technology, engineering, and math, nine out of 10 participants said they liked school and liked learning. Eight of 10 participants indicated they liked science, and six of 10 said they liked math or that they were good at math. Eight of the 10 participants recalled feeling “happy” or “excited,” and one participant felt “privileged” when selected to be in the STEM program, Katie said she felt happy because it was an “opportunity to actually learn about science stuff because I had always liked it." When Emily was asked how she felt about being selected for the STEM program she recalled "I felt it was an accomplishment cause [*sic*] I did really try in school and especially in science and math."

Five of the eight participants revealed how the activities motivated and engaged them; they described the STEM learning experiences as beyond the scope of their typical classrooms. Hannah, who admitted not liking middle school recalled "I looked forward most of going to school and being able to go to that program 'cause [*sic*] then we were learning so much more that didn't have to do with what we were doing in school." Morgan remembered being excited about the "school-adjacent program for people like myself to be able to learn in ways that we couldn't in the classroom" that spurred motivation and cognitive engagement. Morgan explained:

> I really looked forward to dedicating my time and energy towards [it]. … It was a deeply embraced challenge to have that extra outlet for the curiosity that I had that wasn't always being met in the classroom or at home.

Morgan was also motivated to learn by being in a lab environment:

> A lot of the time if I wanted to learn about something it was just from a textbook and not from another person who I could talk to and be guided by much less be actually able to go to a laboratory and see things in action hands-on.

Kristin recalled the influence of "being put into that college environment" as she described how it had motivated her to go to college:

> I always had to keep reminding myself that no matter what everyone else says or however else they get there, I know for sure I want to get to college. … I knew

> that I liked science and biology, but I didn't know where I wanted to go with it. So that's why that anatomy experience [dissecting a sheep brain] was the most impactful. … Just hearing that [I could be a brain surgeon] set my bar really high. I was like I can achieve anything.

Evidence of Isabella's motivation was clear when she said, "I always wanted to learn more than I already knew and learn different things and I think that STEM helped me even want to learn more."

All eight participants explained how their beliefs about STEM subjects, career interests, and class choices were motivated by the learning experiences. Katie described how her thinking about gender stereotypes and her motivation to pursue and persist on a STEM career path were influenced by the program:

> [It] helped influence [me] knowing that there could be more diversity and having more women in it ... that it isn't just male dominated. … Doing it [the program] helped me think that "Oh, I could also do this. I do have an understanding of these topics. I would like to continue and hopefully stay in it," which I did.

Natalie explained how her thinking about what career path she would pursue evolved:

> I think it [STEM program] definitely encouraged me to want to continue on in health care. I know I eventually did want to do something in the health care field. I just wasn't really sure it was something for me because blood originally used to freak me out a lot. So, getting that hands-on experience with dissecting the pigs and the cats … that kind of helped me open my mind a little bit to be able to encourage me to go into the field.

Motivation to learn, to believe in themselves and their abilities, and early considerations about a particular career path were important aspects of how the women described their STEM learning experiences. Their motivation tended to be centered on how cognitively engaged the participants were with the specific STEM activities at that time.

Motivation and Career Path Engagement in Other Formal Learning

As the participants described their later educational experiences, many described what motivated them to choose a particular career path along the way. Most participants described their career goals, which some stated having as early as middle school.

Only three of 10 participants mentioned liking specific classes or subjects in middle school; during that period, participants' focus was more on their teachers. However, in high school and college participants described more about specific classes as being motivating and important to their career preparation. Eight of 10 participants described liking specific classes in high school, and five of 10 mentioned specific college classes that influenced their learning. Participants cited general interest in the subject as well as getting experience related to a career interest as reasons why they liked a specific class. Participants mentioned a greater diversity of classes as influential from high school (10 different classes) than they mentioned from college (six different classes).

Among the limited comments made about middle school classes, Natalie described math as her favorite subject in middle school because there was "always one right answer." Sofie also indicated she liked her math and science classes because "if you try it again, the first time doesn't work, maybe the second time will."

Not all participants were strong in math. During Emily's time in the STEM program, she realized she had developed a strong interest in the medical field, but knowing she was not strong in math was not enough to keep her from choosing a medical career. She explained:

> Everyone has their own thing that they're not good at and math is not my strength. It doesn't stop me to go into the medical field because I know the medical field, math is involved in it and that doesn't bother me. That didn't drive me away from taking a career in a medical field.

Seven of 10 participants were career-focused as early as middle school. Natalie said, "I think it [middle school] definitely encouraged me to want to continue on in health care." Emily explained:

> Not a lot of kids at that age know what they want to do in life when they grow up, but I did. I didn't know what field specifically I wanted to go into, but it would be a science field.

Five of 10 described how high school courses and higher education were important to their career goals. Eight of the 10 high school classes mentioned by participants as important to their learning were math or science classes. At the time of the interviews, six of 10 participants were pursing or had obtained a degree in a science, technology, engineering, or math-related field.

Four of 10 participants indicated certain high school classes were a main motivating force in their chosen career path. Emily credited the high school CNA class experience as what confirmed her decision to pursue nursing:

> I'm glad I was able to take that [CNA] course … cause [*sic*] if I took that course and I realized oh no it's not for me, I would have known in high school, okay, this is not a good career for me. I'll find something else. But when I took that and I completed that course I was like okay, so this is really what I want to do. I really want to get into the medical field and help people. I realize that I really do like to help people.

Isabella said, "I'm very into statistics … and I think that that also influenced me to do accounting and business." Moreover, she realized a second class, business law, combined with her ethnic background and ability to speak multiple languages was a pivotal influence on her career choice at the time:

> My senior year I took a business law class and I fell in love with it. It was definitely something that I enjoyed a lot. But I had already spoken two languages - Spanish and English. Spanish was my first language. And I was like … I don't wanna [*sic*] just do business I wanna [*sic*] do something that I will always remember who I am and where I started how I started. And so, I wanted to do something with the Spanish language and languages in general.

Katie credited her science classes and her teachers with motivating her to consider a career in the medical field:

> When I first started high school, I still had the idea I wanted to do med school, or start at least in pre-med. So, I kept thinking I wanted to do it, still with the science classes I was still very interested with the teachers I had and the content that they

> taught to me. So, I kept pushing like "Oh, I do like this. I want to keep pursuing it." So that was one of my motivations.

Natalie's career choice changed to nursing as she began to understand how she felt about her science classes while she also weighed the total cost of her education:

> I knew I was committed in [high] school to go into medical school [which] is a very large commitment – It was hundreds of thousands of dollars, so that was kind of intimidating for me. So . . . my first year of college I took chemistry and some . . . general education classes. And I kind of realized that maybe veterinarian and physician wasn't necessarily for me because it had a lot more of biochemistry and earth chemistry and all of that other stuff that I wasn't a huge fan of, so then I started to look into the nursing.

Kristin's desire to learn despite obstacles came out when she described her response to performing poorly in her high school math classes:

> I got my first C, and my first C was algebra II, I think I was just so, so sad about it. But what influenced me? I think it was just looking forward to college and I knew that all the information that I was learning I either had to learn it now or I was gonna [*sic*] learn it later.

During high school, Maria credited her friends with helping her, "I know I got a bit more confident later on in high school and I really think it was having those stable friendships." However, Maria found the focus on career paths in high school to be difficult, "It was very stressful in high school have all these adults telling me I need to know what I want to do for the rest of my life within 4 years." In college Maria continued to struggle to find her way and was unmotivated to attend classes until she enrolled in anatomy class:

> Being in class really cemented that this is something that I can enjoy. I can enjoy being in school again, and learning again, and finding joy in studying and being excited for going to class the next day because "Oh what are we going to talk about today?"

Teachers as Motivating Forces

Participants gave rich accounts the influence teachers had on their level of motivation to learn. Emily said her middle school science teacher was "the most influential person who helped me learn." Maria described how her middle school science teacher eased her anxiety, and how this had a positive influence on of her own learning:

> He praised me more often and it just, I guess it made me work harder too because you know, I enjoyed getting that little bit of praise every now and then. And he was always a laid-back guy, and he never took everything too seriously, so it was easy to I guess relax more in that class and it encouraged me to ask more questions too.

Like Maria, Natalie described her middle school science teacher as the one who was most influential to her learning:

> He was just so laid back and calm … always positive about the way he motivated you. And he never downed on you, he never picked [favorites]. … But he always would go above and beyond if you needed help with something he was always

> there to help you and he would always be willing to talk to you. And he definitely made a difference in my life.

Like the others, Kristin also cited her middle school science teacher as one who influenced her desire to learn more when she said, “I remember raising my hand a lot. … He would keep me after and then explain everything to me … or he’d give me extra notes because I just wanted to learn more.”

Sofie described how a teacher in the math lab taught her that “even if you fail, you can always try it again and it would work.” Sofie also remembered words of encouragement from teachers, who she said she still remembered: “I can tell you who taught me how to speak English. I can tell you who were the people that translated for me. And I’m just so grateful to have so many people influence my education.”

To summarize the section on motivation and engagement for other learning experiences, participants were motivated by career path considerations, most of them as early as middle school. Participants spoke highly of middle school teachers as motivators to their learning. As participants moved through high school and college, they were more motivated by specific courses they were taking, many of which involved a lab component. When they spoke about their high school and college learning experiences, the women discussed how they understood their learning as related to what careers they wanted to pursue.

Learner Identity and Self-Awareness

Learner identity and self-awareness emerged from participant responses related to self-confidence, what they knew about their academic strengths and weaknesses, and important relationships with teachers and peers. However, some responses by participants related to this theme were experiences that took place outside of formal learning. Data included in this section relates to what participants understood about their own learning as well as how they described themselves. The participants revealed a sense of self-awareness and developmental changes occurring over time. Learner identity for the STEM program was supported by participants' responses related to self-confidence, the social influences of peers and teachers, and their academic strengths and weaknesses. Participants also revealed how their participation in the STEM program influenced how they saw themselves as learners. Participants described how they became more comfortable with STEM subjects, more confident in their academic performance, and had a better understanding of their strengths and weaknesses as learners. They also noted the role peers and teachers played in their development. From their responses a sense of learner identity and self-awareness emerged.

Confidence-Building in the STEM Program

When asked to describe what they remembered about the STEM program, six of 10 participants described themselves as "shy "less comfortable," and "not outgoing" when they were younger, but they credited the social aspects of the learning experiences with helping them become more comfortable and confident in learning situations. A self-described "shy" girl, Hannah explained how the social aspects of the program helped her become more self-assured when she said:

> I was always one that wasn't really outgoing, and I didn't really talk to many people. And in that program, it kinda [*sic*] helps me with my confidence in being

> able to be more out there. … They all were basically trying to help me with whatever we were working on and everything and it helped me try to put more words out and not be so shy.

Learner identity was also exemplified in statements related to how participants described their confidence, perceptions of their intellectual ability, and perceptions of their success. Isabella recalled:

> I think it was definitely a confidence boost for sure. Especially being at a young age. Like in middle school it's such a[n] interesting time 'cause [*sic*] you're developing and you're getting to know who you are. … And to feel like "Oh I'm somewhat knowledgeable" but I was chosen to be a part of this. I remember being super proud and being honored. I remember wearing those bright green shirts in the hallways in middle school and being like "yeah I'm a part of something like me and something new and different.

Emily recalled "I felt really great about myself. I felt it was an accomplishment cause [*sic*] I did really try in school and especially in science and math … and because not every girl got chosen … only a select few."

Confidence Building in Other Formal Learning Experiences

Emily's confidence continued to grow through formal learning experiences she had in middle school, high school, and college. Emily described herself in middle school:

> I was really shy and really, really quiet. I was afraid to ask questions. Like I just thought every question I had in my mind was not worth asking, and then in high school I was a little less shy, still shy but not as shy in high school. A little more

> confident in my schooling too. Not the best in social skills, like I didn't really know how to talk to people.

Emily then described how she had changed from a shy girl to a more collaborative learner as she grew older:

> I'm more social [now]. … I like to get to know more people. Overall, since grade school my social skills have improved and so have my thinking and learning skills. I know how to study for a test. In college classes, if I don't understand something or I have to raise my hand and ask questions or visit an instructor during an office hour and ask questions and stuff, me in grade school would never do that. I would never stay after class and ask or anything. I would just try to figure out everything on my own or prove everything on my own. And I realized teachers are there for a reason. They're here to teach you so you can learn. So now I feel a lot comfortable with all my instructors in college – to ask questions, stay after class and also asking the classmates, talking to them. Like projects- I never liked projects until I was like high school, and I realized projects helped a lot. Having a study buddy, working with other people on a project helps me learn.
>
> Isabella described herself in similar terms to Emily when she was in middle school:
>
> Before I grew into the person I am now, I was more of a shy [girl]… [who] just stood in the corner and did what I was told to do, and I like didn't really speak up even if I knew that it should be … done a certain way … or that a person was incorrect.

Isabella believed in high school "you can't really sit back and just because someone is older than you and wiser than you doesn't mean that they know more than you know." She equated her ability to give voice to her thinking with strong leadership. Isabella summed up her growth in this way:

> In high school I was the outgoing girl who was very outspoken and stuff. And I learned after high school [there was a] happy medium. I don't have to be the quiet girl that's just sitting there taking everything. But I don't also don't have to be the loudest person in the room and always take that leadership role. I think I found a happy medium in college.

STEM Program Leaders as Role Models

Participants' recollections of the STEM leaders exemplified the importance of role models to learner identity. Seven of eight participants described how leaders were influential to them. When Hannah learned she was selected for the STEM program, she said "I got nervous trying to figure out what this program was all about," but she credited a STEM leader with making her feel more comfortable with being a part of it.

When asked about teachers, Kristin said "we were treated as learners." Morgan saw the leaders as role models and recalled "It was really incredible to have that in person experience where different educational role models were able to facilitate discussions about the models we were learning from." Sofie and Isabella credited the STEM leaders with helping them develop leadership skills.

Katie, who was motivated by seeing girls doing things she described as “male-dominated,” described how those interactions changed her thinking about her own abilities when she said:

> It changed a little bit thinking that um more girls can do it. Because mostly the amount of the classes was mostly guys doing science. Also having male teachers, too. So just seeing that “Oh, we can do this.”

Emily recounted one of the STEM leaders as formative to her love science:

> She was my favorite teacher in middle school. I remember her and will always remember her. I loved her science class, and I was very comfortable around her because she was also part of the STEM, the STEM group too. She helped me out a lot in school and I learned a lot from her.

Teacher Influences From Other Formal Learning Experiences

Participants mentioned their middle school teachers in a positive light more frequently than they mentioned high school or college teachers. Seven of 10 participants described the positive influence of a specific middle school teacher (four of the seven mentioned a science teacher; four of 10 participants cited high school teachers, and three of 10 cited college teachers).

Katie described how a college teacher influenced her assessment of her own performance as a learner and realizing that mistakes were not equivalent to failures:

> In college, there were times where I would take a quiz or exam and I didn’t get a good grade. So, then I’ll talk to a professor about it or she’ll want to talk about it. And she’s like “You’ll be fine. Your grade’s still good. Don’t beat yourself up

> over it. It happens to a lot of students." So, I think talking to her realizing "Oh, it's okay, kind of normal." To take a step back to see the big picture rather than focusing on one tiny little mistake.

Like Katie's experience, Sofie also described the effect a high school English teacher had on how she felt about herself as a learner:

> She [English teacher] gets a lot of credit for all the things that I've learned from her. She always was pushing me. … There are times when I do get discouraged with me not knowing something. I just feel like I failed and did not meet that expectation. But she would tell me it's okay, and she was always there. So, in high school she was one of my biggest cheerleaders because my parents were not really -- that's when I started noticing that they were kind of leaving me to be more independent and do things on my own.

When asked about experiences that influenced her thoughts about her abilities as a learner Hannah said "I've had a couple teachers that if I asked for help, they were right there. Like they seen [*sic*] that I was trying to better myself an get me like further in life than I did."

Perceived Strengths and Weaknesses of STEM Participants

How participants described their strengths and weaknesses as learners during the program was another measure of learner identity. Emily said:

> It made me more interested in the science field and specifically the medical field. And it did improve my math skills too in a way. Because math is my least … [my] worst subject. I don't enjoy doing math. I do enjoy math when I understand it."

Morgan explained how the program highlighted the strengths as well as the interests of each participant:

> We all had our different sorts of strengths and weaknesses and fields of interest so that came into play when we were working on things like, we had this one activity where we built these model rockets and set them out to launch so the people who were more skilled in mathematics were a lot more involved to do the formulas for figuring out the trajectories that we needed to launch the models at whereas other people who were more interested in theoretical problem solving really got a kick out of trying to solve hypothetical crime scenes…. I enjoyed math but it wasn't necessarily my strong suit. So I was able to look at my peers as being in more of a leadership role than myself for those particular activities.

Morgan recognized that one could enjoy math despite it not being their best subject.

Natalie also recognized technology was not her best subject when she recalled how she gained a fresh perspective on this one area of STEM:

> I think it definitely opened my eyes up a little bit more to the certain fields. Originally, I mean I'm still not a fan of computer technology and robots and all the technology aspect of it. But it does give me a little more respect for it because I see how difficult it is and how much work goes into it.

Some participants mentioned how being aware of their academic strengths and weaknesses allowed them to see themselves being successful in an educational or career path. Kristin described how the STEM program was responsible for her planning out her educational path:

> If I didn't take STEM and it didn't really put that seed of learning so early, [I] would have wanted to graduate earlier from high school and just zoom through college and just get through. But, I'm glad that I took the time. … It just helped me critically think … how I wanted to plan out my path.

Kristin also recounted that although her original decision to become a physician changed to nursing, her path has remained essentially the same, but her interests have broadened, and that the diversity of a nursing career would allow her to experience different things.

Perceived Strengths and Weaknesses in Other Learning Experiences

Some participants described significant learning that occurred outside of formal learning, most often in their job settings. Lisa, who was working in maintenance, felt she learned more on the job as she described the technology-related things she did at work:

> We do a lot of computers at work, repairing computers and fixing computers and we get into the electrical side of things, and we repair light fixtures. I'm maintenance and we do a lot of plumbing too. So, technology-wise the most that we do would be a lot of computer and laptop work. It's the building aspect that's fun for me. Putting it together, taking it apart, put it back together again.

Natalie, who described herself as open-minded and culturally sensitive, believed that living in a small area could at times limit one's ability to grow. However, instead of formal learning experiences, she explained she "learned quite a bit just in being a nurse for one year" and that even in a small town she described her job as a "good learning experience."

Morgan also felt that work-based learning was important. Morgan described how a job in an historical site gave greater insights into the learning experience:

> On-going learning for me was working at the … historical house museum and something that I grew up near but didn't really learn about until late in high school. … It definitely opened up my ideas about how I was able to learn, especially since it was a team of people that weren't about the subject, who were able to kind of walk me through what the tours were like.

Shifts in Learner Identity by STEM Participants

Participants also described ways in which the STEM program changed their way of thinking, which was evidence of shifts in learner identity over time. Natalie described the program as having "opened my mind and my eyes to we're not limited to certain things." Natalie decided living in a small town "doesn't mean that we can't expand and explore and open up the world to other possibilities or better options." Isabella summed up how she grew as a learner from the program when she said:

> STEM definitely helped me… learn that, the world is bigger than we think it is because I go back to me being the shy little girl in middle school and thinking now I learned so much … about technology and science and I gained so many experiences from that that I will cherish forever. And I learned that there's so much out … there to learn.

Isabella's statements depict an eagerness to learn and an awareness that learning continues throughout one's lifetime.

Sofie described the importance of recognizing that there could be “more than one answer” and to “not give up” as something she learned from the program. Morgan reflected that STEM stimulated thinking about “the capacity of an individual to take on different perspectives and look at a problem in different ways, often through trial and error.” This method of examination and consideration for multiple aspects of issues reflects a sophistication in the learner that goes beyond a need for one clear answer.

Shifts in Learner Identity and Self-Awareness From Other Learning Experiences

Participant responses about what they knew about their learning during middle school was sparce as compared to descriptions about their high school and college years. Moreover, when asked about high school and college, some participants spent more time describing learning experiences outside of school, such as workplace learning. Shifts in self-awareness and learner identity were reflected in participants’ responses about how they described themselves and the challenges they faced through the years, the influences of parents, and participants’ thoughts and decisions related to their education and careers.

When asked who influences how they think, eight out of 10 participants indicated being influenced by others, such as family (six out of 10) and teachers (two out of 10). Of the participants who cited family, five out of six cited parents, and one participant cited her grandparents, who raised her, as most influential. Lisa said in middle school, “I always wanted to make my parents proud. They were my influence as well. You want to be like your parents.” Lisa described her parents as “successful” and when asked what successful meant to her she said, “Average nice home, cars, food in the fridge, love. I’ve always been very simple.” Natalie said her mom was “My biggest role model. … My mom is very open-minded, just like me as well. She is very optimistic and positive, and she has a nice outlook on things."

Morgan, who was influenced by many people said, "I think it's important to know that you can learn from a lot of people who come in and out of your life." However, when discussing formal learning experiences teachers were mentioned more frequently as having an influence on learner identity and self-awareness than any others.

Participants' focus during high school was on charting a path to a career; however, at the time of the interviews, one participant had decided to take a semester off from college, and three participants made the decision to leave college. Of the three participants who decided to stop pursing a college degree, two were happy with their decision and one participant wanted to return to college. Kristin, a first-generation college student, made the decision to take a break from college over the summer "because not only is there a pandemic going on, but there's [*sic*] also a lot of riots going on." She was self-reflective when she described her thoughts about where she was in her life at the time:

> Sometimes you kind of have to pull yourself away and be like "Why am I here? Why am I doing this?" I've had to do that the whole time I've been in nursing school, too. … I ask myself that all the time. It's always the same answer.

Kristin was aware the mandatory switch to remote learning during the pandemic caused her lot of stress and challenged her learning. She was self-reflective about the situation by weighing the pros and cons of being isolated during the pandemic and, as she did throughout her interview, she ended focused on the positive:

> I think that we're worse – now we're secluded. We have to be in our houses, but when you are at work, and you're around school mates, and you're around other people's problems it's like "This class sucks!" … I also think it's beneficial to just still be in your own space. There is a benefit to being at home during this time honestly. But if we are quarantined in the fall, I would lack knowledge in how to physically do something. But I think that pulling away from stressful people … it's just, I am happy where I'm at.

Lisa was aware that the traditional college path was not what she wanted even though the expectation was to obtain a college degree:

> After 2 years [of community college classes] I felt that college was not that good for me. … I found passion and worked with the elderly, so I did some home health. I worked with that for a couple years and then I ended up working now at [a] nursing home and I do maintenance. And in that time I also had a child.

When asked who was most influential to her thinking, Lisa said "Myself. And the way my parents think -- I like to be like them but I also like to be like myself." Lisa was happy with her job, and she described how her secondary school years successfully prepared her for the world:

> The world is a very fast-paced thing … [In] middle school you kind of take your time to learn and you … can focus on a subject … as you age you know [the] things they want you to do, you just have to go-go-go. And they say when you go to college you're gonna [*sic*] go-go-go. And when you get to college you have to learn things and you have to be able to adapt quickly and move forward to new

> things. I feel like [school] really set us up in my age group for the world today and … your ability to learn you just have to get it and get it quick.

Morgan described how formal education was only a partial influence on one's overall identity:

> I like to think that the standard, slash, given part of my education serves as a background contact where it's a part of my identity that is inherent, but it is not the overall summation of who I am and how I look at things.

Morgan, like Lisa, also described the decision to leave college and how that led to changes in thinking about learning:

> Authority figures talk about college as if it was the next step in your required education because college is pretty compulsory. … Whereas now I've left college largely due to lack of funds and I recognize that not every adult has a college degree. And you can still be a good person without having those accolades. … Now I'm more concerned with trying to find things that make me happy or feel right rather than what is going to look the most impressive on paper.

Morgan did not believe failing to earn a college degree would influence life satisfaction or the ability to continue to learn. Moreover, Morgan understood informal learning was an option for gaining knowledge: "Research isn't something that you only have a right to once you have a degree."

Emily made the choice to attend a two-year school rather than a university because, "I realized I don't want to be in so much debt after I graduate from college."

Some participants described significant challenges that influenced their identity and self-awareness. These informal learning experiences were opportunities for growth and reflection. Kristin explained an important challenge to her learning during high school:

> My mother went through her divorce. So, during that time, a problem that I had to solve or at least be a part of was getting my siblings up in the morning for school because either she was down in the dumps, couldn't get out of bed, or you know life was a little bit slower for my mom. I remember seeing her like that. … [I was] taking on a different role and helping my siblings get ready for school, or do laundry, or clean the house. Things that needed to be done.

Kristin explained how this helped her plan for her future, "[Where] I grew up it was a very low-income area and my mom was, even though she was married, she was the only one working. So, I just knew I didn't want to financially struggle."

Lisa described a challenging period in high school when learning was no longer important to her:

> I did really good in high school and then about junior year I had met this boy and I was introduced to drugs and I kind of fell down a path of doing too much [*sic*] drugs, … and so we go straight from school to his house, hang out with a group of friends and pretty much do nothing but that. I feel like that was something that really kind of turned things for the worst. And my parents when they found out you know, "we don't care that you do it, but just don't bring it in the house." … Well then I took that as oh, I can do it whenever I want and however much I

> want." … That was when things really started to change, and the grades started to drop and the way that I felt, I just didn't care. … Then senior year I had done less of that. And then now I do none of that and I feel like that's really, it had an effect on how I thought, it had an effect on what I did. So now being clear of that and not doing that I am able to think about my actions rather than just do them.

As a result of Lisa's drug use, her relationship with her mother suffered during this time. She struggled to understand her choices in high school:

> I feel- like my mother and I have never gotten along. The last time that I remember her and I getting along well was when I was in middle school and junior high, when I was young. And then I felt like as I had gotten older, her and I just either we couldn't relate on things, or we just couldn't meet eye to eye. And then maybe sometimes I think about maybe that is the reason I rebelled in high school. Maybe like an attention-seeking thing. I try to think about that all the time. I'm not entirely sure. And then senior year and college you know as I'm getting a little bit older, I felt the need for my parents and you know I'm scared, I'm getting older, the world is big.

Lisa described how she worked through her problems at the time, and she was, "constantly reflecting back on life and seeing where you are and seeing the damage you can do to yourself." This was how she worked through her problems now.

Natalie explained how she remained focused on school even after suffering a painful breakup in high school:

> No matter how much it affected me emotionally or mentally I always still put my grades and my schooling and my job first. Because no matter what happens, I mean the world is going to still keep moving no matter what is happening in your life. So, I feel like it would have been wrong to put schooling and anything on hold really because of an emotional or mental angst. If that makes sense. So, I mean it's just you gotta [*sic*] kinda [*sic*] keep going through the motions even if you feel like crap doing it.

Natalie also described herself as "a little bit more mature for my age from the get-go." At the time of the interview, Natalie was helping raise her niece while her brother was deployed overseas. Natalie also described a love of helping others in her job as a nurse when she said "I liked the responsibility of caring for these people. I liked having the responsibility for being able to make a difference in these people's lives."

To summarize this section, the aspects of learner identity and self-awareness that participants revealed as significant to them included growth in confidence, program leaders as role models, teachers as influential, perceptions of their strengths and weaknesses as learners, shifts that had occurred in their learner identity, and self-awareness. Learner identity was connected to their participation in the STEM program and related to their increased confidence levels, their view of the program leaders as role models, their perceptions of their strengths and weaknesses as learners, and shifts they perceived in the learner identity. Leaner identity in other formal learning experiences was related to their comments about the influence of teachers, mostly in middle school, and their increased confidence levels from formal school experiences. Learner identity related to other learning experiences, mostly from work settings, was revealed in participants' perceptions of their strengths and weakness as learners, shifts they perceived in their learner identity, and their own self-awareness.

Summary

My data analysis led to key findings about how young women's learning was influenced by participation in a middle school STEM program and other learning experiences over a 10-year period. The findings were revealed by three major themes: Active learning, motivation and engagement, and learner identity and self-awareness. Participant preferences for hands-on activities, dialogue with others, and group learning were key features of active learning. Participants' cognitive engagement in the STEM program, career path engagement in other learning experiences, and through relationships with teachers as motivators were key aspects of the motivation and engagement theme. The third theme, learner identity and self-awareness, was supported by participants' changes in confidence during the STEM program and from other learning experiences, STEM leaders as role models, teacher influences, participants' perceived academic strengths and weaknesses, and shifts in learner identity and self-awareness.

In Chapter 5, I include an analysis and interpretation of these findings through the lens of the conceptual framework of WWK and the literature in Chapter 2. I also discuss the implications for social change and recommendations for future research and practice in the field of education.

Chapter 5: Discussion, Conclusions, and Recommendations

The purpose of this qualitative study was to explore the self-reported perceptions of women's learning by asking them to reflect on their middle school STEM experience and other learning experiences from middle school through college. The research question for this qualitative study was the following: How do young women who participated in a middle school STEM program describe its influence and that of other learning experiences on what they know about their learning processes as they moved into adulthood? The key findings from this study emerged from three themes related to women's perceptions of their learning: active learning, motivation and engagement, and learner identity and self-awareness.

All participants reported that hands-on activities, dialogue with teachers and peers, and group learning activities had a positive influence on their learning during the STEM program; however, only hands-on activities emerged as significant to participants in their other learning experiences. Perceptions related to motivation and engagement in the STEM program indicated participants were highly engaged in learning activities of the program. In other learning experiences from high school through emerging adulthood, participants described their motivation and engagement as related to career pathways. Participants described teachers as influential motivators in both STEM and in other learning experiences. For the third theme, learner identity and self-awareness, key findings related to perceptions of improved confidence as learners, acknowledgment of STEM leaders as role models, and teachers as influential in other learning experiences. Participants understood their strengths and weaknesses as learners in STEM and other learning experiences. Additionally, notable shifts in learner identity in STEM and other learning experiences were apparent from middle school through emerging adulthood. In this chapter, I report my interpretation of the findings, describe limitations to this study, discuss recommendations for future research, and present implications for social change.

Interpretation of the Findings

Findings Related to Current Literature

I interpreted the findings for the current study by reviewing the three themes that emerged from the data analysis in the context of the peer-reviewed literature discussed in Chapter 2 and through the lens of my conceptual framework, WWK. I organized this section around the three themes: active learning, motivation and engagement, and learner identity and self-awareness. The participants' responses were related to their recollections and perspectives of their learning during a middle school STEM program and for other learning experiences through emerging adulthood.

Theme 1: Active Learning

All participants described active learning experiences as their preferred method for learning and the way they learn best; the most significant learning experiences involved hands-on activities the women did together in teams. Active learning in the STEM program was important to learning because it challenged participants to solve problems, stimulated participants' curiosity and interest in STEM, improved their thinking skills, and taught them how to work in teams. Participants preferred active learning to more traditional methods for learning in STEM and other formal and informal learning experiences. The findings from the current study supported the positive influences of active learning on student perceptions of their learning, and this was supported by current literature. Stolk et al. (2018) found college women overwhelmingly preferred active learning methods to traditional lecture in introductory STEM courses.

Participants in the current study indicated liking the challenge of solving problems in the STEM program. Ching et al. (2019) found perceptions of learning STEM improved for elementary students when activities challenged them. Working with high school girls, Isaacson et al. (2019) used challenging concepts to teach space science and found it motivated students to learn. Additionally, Kressler and Kressler (2020) used complex problems to teach undergraduate STEM courses and found that students perceived their thinking skills improved.

Research on robotics to spur interest in STEM is abundant. Anwar et al. (2019) reviewed robotics program studies and found that active learning experiences contribute to students' ability to learn and can contribute to increased interest in STEM. In the current study, all participants gave detailed descriptions of active learning experiences in the STEM program, such as building and programming robots and lab activities such as dissections. Participants remembered programming robots without the help of the STEM leaders, and Morgan reported this challenged them to think and solve a problem on their own. Participants recognized the unique nature of the STEM program activities, noting that many of these activities were challenging, and the challenges seemed to create an excitement for learning that extended to high school. Emily felt many STEM activities challenged her and improved her thinking skills. Sofie said she preferred challenge to activities that are easy, an indication that growth in learning had occurred.

Active learning experiences were important to current participants' learning because they stimulated curiosity and interest in STEM disciplines. Brown et al. (2016) found that student perceptions about STEM were affected by their experiences with those disciplines. Promoting curiosity and interest using more male-dominated activities was illustrated in comments by several participants in the current study. Isabella felt the STEM activities increased her curiosity and left her with more questions about the world. Like Isabella, Natalie also felt that STEM activities opened her mind to possibilities beyond her local community, which led her to believe there was a lot to learn in the world. Isabella and Lisa both felt technology, a discipline more associated with men, was their strength and it excited them. Katie credited hands-on activities with being the method that is most effective in satisfying her interest in figuring out how things work.

Active learning experiences were important to participants' learning because the activities taught them how to work in teams. Research supported the use of teamwork as a component to active learning, and Bampasidis et al. (2021) found that working with others promoted teamwork and positive attitudes toward science. Learning to work in teams has often been cited as a benefit to women. Ng and Fergusson (2020) incorporated research and design methods in an active learning experience with secondary school girls who indicated the program increased their ability to work in teams. Isaacson et al. (2019) taught high school girls about space utilizing active learning and teamwork, which increased the girls' interest in learning. Group learning, or teamwork, was a structured part of the STEM program addressed in the current study, and all participants cited group work as important to their learning, even though two described themselves as initially shy and hesitant about teamwork. Participants also felt they learned a lot in groups when they solved problems, and this was how they learned to appreciate a diversity of skill sets in fellow team members. Participants' comments about group work underscored how working together also gave them a sense of shared purpose.

Researchers have identified the benefits of active learning experiences in high school and college classes using a problem-based approach (Bampasidis et al., 2021; Ng & Fergusson, 2020). Anthony et al. (2017) found hands-on activities in college allowed biology students to connect to the real world, prepped them for later classes, and validated their choice of career. In my study, the structure of the STEM activities was very different than the experiences of participants in formal school, and the program fostered an eagerness and engagement in Hannah and Morgan that formal school did not. In high school, active learning, especially in lab-based classes, was mentioned by eight participants as a preferred method for learning in other formal and informal learning settings. Natalie, Emily, and Sofie mentioned the importance of the real-world experience of learning in the CNA class during the clinicals. Isabella demonstrated an appreciation for real-world learning when she said her forensics laboratory was still important to her even though her chosen career path was international business.

Although participants in the current study overwhelmingly enjoyed and appreciated the benefits of active learning from the STEM program and other learning experiences, active learning does not always provoke positive perceptions in students. In a review of 57 published STEM studies, Shekhar et al. (2020) identified the reasons why students do not like active learning, such as poorly designed activities, increased workload, and lack of guidance. Hood et al. (2020) found first-generation college students in an anatomy and physiology class had lower self-confidence when active learning was employed in class. In the current study, only two participants indicated negative reactions to any active learning experiences. Katie said that when she was in college, she was fearful of programming (coding) because the other students seemed to be proficient and rapid at the process. As a STEM participant, Emily was fearful of dissections in the beginning but later realized how important they were to her learning. These types of earlier experiences can leave students with a negative impression of the disciplines related to the activities or of their capabilities for being successful in those areas.

Theme 2: Motivation and Engagement

Current participants reported that they were highly motivated and engaged in the activities during the STEM program, and frequently described the activities as fun. In their other formal learning experiences, but especially during middle school, when they described a class as fun, they referred to a teacher making the class fun and not to the activities in the course. During high school and college, the participants were motivated by courses that contributed to their career goals. Research supported the importance of having appealing content and influential teachers to student motivation. T. Roberts et al. (2018) found that middle school students were motivated and engaged in activities they normally did not have access to, such as programming robots. Alemdar et al. (2018) found that tying foundational concepts of science and math within a highly engaging activity improved motivation in eighth grade students and improved their critical thinking skills.

Among the participants in the current study who were motivated by the STEM program, Hannah was the one participant who said she did not like school, but she did look forward to participating in the program. Her reason for liking STEM was because it involved learning that went beyond what she was learning in formal school. Morgan looked forward to STEM because it allowed the girls to learn in ways that students in formal school could not learn and it did not involve learning from a textbook.

Interesting data related to gender stereotypes and math abilities emerged from the current study. Research has shown that damaging gender stereotypes about math ability can influence women's choices throughout their education (Justman & Mendez, 2018; Perez-Felkner et al., 2017). According to Justman and Mendez, female students may need stronger encouragement than males to take higher order math classes. In the current study, however, math ability was not a limiting factor for choosing a STEM-related career for at least one participant. Emily said she was bad at math throughout school, but she was motivated enough by her career choice that this did not deter her from her career path.

Teachers were influential to current participants' motivation and engagement in other formal learning, especially during middle school. Middle school teachers made Maria and Natalie more comfortable, thereby improving their ability to learn by reducing anxiety. Teachers also taught Sofie, Katie, and Hannah how to deal with grades and to realize that a bad grade does not mean they failed.

Theme 3: Learner Identity and Self-Awareness

Aspects of learner identity and self-awareness emerged from the analysis of participants' responses, including increased confidence and understanding how they learned best. STEM leaders and teachers were also influential role models throughout participants' education. Increased self-confidence has been reported as an important outcome from active learning in STEM, particularly in disciplines where women are underrepresented (Brubaker et al., 2019; Ng & Fergusson, 2020). Studies of active learning in engineering courses and in STEM programs have shown that girls' self-efficacy and self-confidence increase because of those approaches (Alemdar et al., 2018; Isaacson et al., 2019). In my study, Kristin's belief that she could be a surgeon was triggered by her first experience with a dissection and the STEM leader's comment about her dissection ability. Isabella's self-confidence was revealed when she described how she took apart and rebuilt a computer as a middle school student to her male college friends. Emily gained confidence from repeatedly doing dissections in STEM and other formal learning experiences, which gave her the confidence to help teach science to others, which she said also helped her to learn. Some participants also revealed their self-confidence by recognizing their contributions to the STEM group. For example, Sofie considered herself a leader because she was able to gather the others together for a common purpose in STEM and in high school. Emily, Morgan, and Hannah recognized they were not as good at math, but in group learning situations they could contribute their skills in other ways. In college, Emily understood that if she helped others in lab, she was also helping herself. This awareness of strengths and weaknesses exemplified a sense of self-awareness as well as learner identity.

Extended exposure to female role models has been demonstrated as influential to women's choice of nontraditional STEM careers (Krayem et al., 2019). Van Camp et al. (2019) conducted an experiment in which women engaged with female STEM role models and found it reduced their susceptibility to negative stereotypes for women in STEM. In the current study, all participants had positive comments about the STEM leaders, with whom they worked for over 2 years. The participants valued them as role models and appreciated being treated as learners, and they perceived they were equal partners in the education process. Some teachers in high school and college also emerged as role models and contributed to some participants' sense of self-awareness. For example, Katie and Sofie credited specific teachers with helping them understand a bad grade did not mean they were a bad student. Instead of turning that setback inward and letting it define them, they were able to assess these situations as opportunities for growth. Participants also reflected on a 10-year span of their learning and how identifiable shifts in learner identity emerged. These shifts are discussed in the next section using the lens of WWK (see Belenky et al., 1986).

Findings in Relation to the Conceptual Framework WWK

I explored women's perceptions of their learning experiences over the course of a decade of learning. These women's perceptions can be understood through the lens of Belenky et al. (1986), who advanced the view that women's self-concept is intertwined with what women know. Belenky et al. described five perspectives in WWK: silence, received knowledge, subjective knowledge, procedural knowledge, and constructed knowledge. In the data analysis of the current study, I was able to understand participants' ways of knowing through parallels seen primarily within the silence, received knowledge, and procedural knowledge perspectives.

Notable shifts occurred in relation to voice throughout the participants' decade of learning experiences. Belenky et al. (1986) asserted that development of voice is a key element in what women know. Although comments from some current participants indicated they were quiet in learning situations before the STEM program, Emily and Isabella identified themselves as having been shy, and Hannah said she did not talk to many people before the STEM program. These women were what Belenky et al. would have called the silent girls. According to WWK, women in the silence perspective have not found their voice and do not question authority. WWK further posits that those in the silence perspective are not seen as learners because their silence prevents them from being active participants in the learning process. That some current participants were able to recognize the importance of asking questions indicated they were no longer acting from a silence perspective.

Belenky et al. (1986) described the connected class as one that provides a "culture for growth (p. 221). Belenky et al. asserted it is important for women to be allowed to voice uncertainty and to not be judged. Learning to speak up in classroom situations was mentioned by many participants. Emily and Katie realized that their learning was tied to their willingness to ask questions, that they felt free to ask questions, and that learning would not occur if they did not ask questions. Both Emily and Katie took these beliefs with them in high school and college and used them to be successful.

WWK (Belenky et al., 1986) asserted that the ability for women to speak up requires healthy relationships with others. Morgan viewed the dialogue with STEM leaders as conversational, comfortable, and one that led participants to feel valued as equals with adults overseeing the program. Morgan and Sofie felt the relationship of the STEM leaders with the girls was different than in formal schooling because STEM leaders treated them as equals who had valuable knowledge to contribute. Sofie recalled a STEM leader asking for her input into the STEM activities, and these conversations contributed to Sofie's development of her inner voice from the STEM program.

WWK (Belenky et al., 1986) described the value of relationships to women's development of voice and mind. Comments by some participants indicate they were aware of their inner voice. Katie was able to visualize herself in what she knew was a male-dominated field but being in lab classes and seeing other women role models in STEM helped her believe in her own abilities and listen to her inner voice. Natalie said her experiences with the STEM program encouraged her to understand there were possibilities beyond what her small community had to offer. These women were aware of their inner voice. For example, Katie, listened to her inner voice despite some contrary messages she received about her career choice. Each of these participants listened to their inner voice rather than yield to the external messages that could have made them question their choices. This is suggestive that the women were in a constructed knowledge perspective.

Data from the current study suggests that when the participants were in middle school, they exemplified either the silence or the received knowledge perspective, and received knowledge was exemplified in participants comments about their STEM leaders and teachers. The active learning experiences in the STEM program encouraged a procedural knowledge perspective, and participants' group learning experiences reflected a connected rather than separate knowing perspective. This perspective was predominantly reflected as connected knowing because participants learned to work well with their peers, and their relationships with STEM leaders nurtured them. Relationships with teachers, especially during middle school, were important as well. Belenky et al. (1986) described the connected class as one where "both teacher and students engage in the process of thinking, and they talk out what they are thinking in a public dialogue" (p. 219). Dialogue with others emerged as important in the STEM program as a way of making participants feel comfortable, encouraged, and to feel free to ask questions in the learning environment. Interestingly, dialogue with others did not emerge as influential in other learning experiences. Dialogue requires trusting relationships with both peers and STEM leaders, which was evident in the responses of participants. During middle school, participants respected their teachers as authority figures, while also expressing an affection for them. This emphasis on teachers was less notable as participants described their learning experiences beyond middle school. An emphasis on teachers would be suggestive of the received knowledge perspective where learners take what others say as truth and they have not yet developed a sense of being a contributor of knowledge;

however, these teacher-student relationships had a positive influence on participants' growth and development as learners.

Limitations of the Study

The purpose of this study was accomplished; however, I recognized some limitations. First, my sample population was from a specific group of women who shared a middle school STEM experience more than 1 decade ago and the sample of 10 participants was small. Because of the specificity of the participants, this study was not intended to be applied to broader populations. Instead, this study was limited to the shared experiences of the women from the STEM program and focused on that program and other important learning experiences the participants shared. Also, I designed the STEM program my participants were part of, and it was important for me to be aware of any potential biases and to mitigate them.

A second limitation was that 10 years had passed since the women were in middle school and accuracy of the participants' memories may have diminished over time. Two participants had difficulty remembering specific aspects of the STEM program, which limited data collection about the program to eight. The two women who did not remember the specifics of the STEM program activities did give rich accounts of their other learning experiences, which contributed to the data analysis in those areas.

The conditions imposed by the COVID-19 pandemic were an unexpected limitation. The pandemic restrictions might have adversely influenced the mental health of the participants. For example, midway through the spring semester just before I conducted interviews, participants who were attending college were forced to shift to remote learning. One participant indicated not liking remote learning. Another participant lost her job and decided to not attend college during the summer due to the pandemic. The stressful events surrounding the pandemic were not explored when I interviewed the participants; however, these events may have caused heightened stress in some participants' lives. Also, the pandemic forced me to conduct all the interviews by phone. Two participants articulated being nervous while interviewing by phone, which may have limited their responses to some questions. I acknowledged their concerns and tried to reassure them and get them to relax during the interviews.

Recommendations

Based on the findings from this study, I recommend further qualitative studies with larger samples from diverse populations and with more frequent follow-up periods. Further research on the lasting impacts of unique in-school learning experiences is needed to inform teachers and other school leaders how to leverage active learning in the classroom. While this study suggests that middle school is an opportune time to expose girls to active learning experiences in STEM, further research is needed to identify which age groups would realize maximum benefits from such programs.

Another line of inquiry I recommend is to explore the relationship dynamics between participants and STEM leaders needed to produce positive effects on women's learning. This study revealed that the STEM leaders apparently provided a safe, supportive, and nurturing learning environment that had positive effects on the participants. A better understanding of these relationships would allow other educators to replicate these types of positive learning environments.

Based on the findings from this study, active learning methods should be carefully designed and implemented with women to promote engagement, motivation, and growth, especially in areas that women are underrepresented such as engineering, technology, and math disciplines.

Roberts et al. (2018) suggests most middle schools need access to resources they do not have to provide STEM programs to students. The sample population for this study was from a rural school district with a high poverty rate. Impoverished school districts lack the resources necessary for these types of learning opportunities and students in these regions are falling behind in terms of STEM education and job opportunities in STEM fields. Federal, state, and local investments in these school districts are needed as a matter of equity, particularly to give young women the foundation needed to choose, to enter, and to succeed in STEM careers.

I recommend further research about whether young women view nontraditional fields like technology with stereotypical bias such as STEM is for men that are well documented in current literature (Carli et al., 2016; Sax et al., 2016; Starr, 2018;; Stout et al., 2016). Although the STEM program activities were primarily designed to expose girls to nontraditional STEM experiences, the participants in this study did not mention gender as often as I expected. However, the few examples are worth mentioning as they appear to be a shift towards empowered thinking for women when it comes to nontraditional tasks. Lisa described working alongside men in her maintenance job, a nontraditional field for women. She recognized at times she used a different approach in solving a maintenance problem than her male coworkers. Though, she said, it may have taken her longer, she described confidently that she still got the job done. Lisa was comfortable working in a nontraditional field and was proud of herself in another male-dominated area – technology -- when she described herself as tech-savvy. A second example was Isabella who said she bragged to men in college about taking apart and reassembling a computer when she was in middle school. Both women were proud of their technical abilities. A third example was Katie who several times during her interview described doing things in the STEM program and other formal learning experiences that were male-dominated activities. She felt being with other girls in STEM and with support from STEM leaders and her teachers, she was encouraged to continue along what she described several times as a nontraditional pathway.

Implications

This study provided insights into women's learning during a critical period – from middle school through emerging adulthood -- a time when life experiences shape who women become as well as help inform their educational and career trajectories. This study reveals the importance of active learning that includes engaging hands-on activities and group learning to increase women's confidence in their abilities and to encourage them to pursue nontraditional career paths. Exposing women to science, engineering, technology, and math is only part of the solution. Teachers must be properly trained to mentor young women and provide a rich learning environment where women are encouraged to use their voices and be part of their educational process. Without resources, mentors, and properly designed programs, women will continue to fall behind in a rapidly changing workforce.

Policy experts must advocate for broadening access to rapidly changing technologies, and state and federal lawmakers must provide the resources to local school districts that lack these essential tools to empower girls and women in areas like STEM where opportunities for high paying jobs are available. Without early exposure to active learning courses and programs, especially using activities more traditionally associated with men, women will continue to fall behind and their ability to contribute to solving today's global problems will be hindered. Positive social change may be possible if academic leaders and policy makers use knowledge gained from this study to design effective educational programs for girls and young women.

Conclusion

This study explored women's perceptions of their learning beginning with a shared middle school STEM experience, as well as other learning experiences that spanned 1 decade. In interviews, participants shared their preferred methods for learning which included a variety of active learning methods, and especially hands-on exploratory activities that were done in groups. Participants were motivated by the activities as well as the STEM leaders and teachers who acted as role models. Participants were also confident in their abilities, and they understood what their strengths and weakness were as learners. Learner growth was evident in the women's stories of their learning over the years. This study provided a unique glimpse into women's learning over an important period in their development from middle school to emerging adulthood and can aid education leaders and policy makers in designing, supporting, and implementing effective learning programs for women. Active learning experiences with opportunities for group learning that are directed by STEM leaders who act as role models to young women can increase women's confidence and skill sets. Initiatives like these can help alleviate inequities in our education system -- inequities that prevent women from pursuing certain disciplines like engineering and technology. Implementation of authentic learning experiences for women can promote positive social change by helping women gain parity in innovative STEM career tracks so they can add their voices and unique talents to the STEM workforce and help solve the serious problems that we face across the globe today.

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Appendix: Interview Guide

Interview Questions

1. Tell me about a strong memory you have about your participation in the STEM program in middle school?

   Follow-up question: Why do you think that has stayed with you after all these years?

2. What was most important to you about that educational experience?

   Follow-up question: Did it change the way you think about yourself, and if so, in what ways?

3. What people were most influential to you during middle school?

   Follow-up questions: Why were these people influential to you?

4. Thinking back on your days in middle school, how would you describe yourself?

   Follow-up question: How would you describe yourself as a student?

5. During your time in middle school, what other in-school experiences during that time influenced your feelings about yourself?

6. How did your middle school experience in the program influence or not influence your personal feelings and attitudes about these subjects at that time?

   A. Science B. Math C. Engineering D. Technology

   Follow-up question: Were there things you thought you could not learn?

7. When you entered high school, describe your strongest memories of your education during that time.

   Follow-up question: What experiences stand out most to you about your high school education, and why were they important?

8. When you were in high school, how would you describe yourself?

   Follow-up question: How have you changed since then?

9. How do you see yourself as having changed since middle school?

   Follow-up question: What led to the changes?

10. Think of a time when you had a difficult problem to solve. How did you go about solving your problem?