TEACHER SELF-PERCEPTION AS A PEDAGOGICAL STEM CONTENT EXPERT AND ITS INFLUENCE ON CLASSROOM PRACTICE

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Abstract: Providing a positive atmosphere for growth in STEM can elevate female middle school students towards seeing themselves succeeding even through short-term failures and cognitive dissonance. Yet, through negative gendered discourses, females can be easily persuaded against the challenging curriculum of STEM and move down a path of least resistance. A teacher confident in their content and proficient in their pedagogy is one that can provide a role model showing students how to push forward even when things get complicated. This study aims to understand how female middle school teachers in a mid-western American city self-identify as pedagogical content experts in STEM and how their identities influence their practices in the classroom.

Grounded in the theoretical framework of poststructural feminism, this study works to uncover how teachers consistently navigate and transcend the gendered cultural norms that impact how they identify as pedagogical STEM content experts. The case study methodology was used to study the gendered discourses, with four cases representing one female middle school teacher. Upon completion of each case analysis, case and cross-case analyses were used to identify the tension and juxtaposition between cases.

Upon analysis, the most noteworthy takeaway from this study was the continued presence of gendered norms and contradictions towards self-identifying as an expert. Highlighting the teacher's gendered and socially displaced role, the terms expert and teacher continued to be viewed as opposing identities. Numerous times, each participant described expertise in both content and pedagogy but refused to self-identify as a pedagogical STEM content expert in the interviews, focus groups, or writings.

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CHAPTER I

INTRODUCTION

Equity is best achieved through diversity

Peter Hershock, 2012

Deep in the South American Rainforest, there is a tree called the Brazil nut tree (*Bertholletia excelsa).* Stretching toward the sunlight at a distance of 160 feet tall, it towers over most other rainforest trees. Aside from its size, it looks like most other rainforest trees, with a tall, grayish-brown trunk with smooth bark and broad, simple, alternate leaves. A unique feature of this tree is its life cycle. This tree could not exist independently, and humans have tried to cultivate it with little success outside its natural environment. The Brazil nut tree heavily depends on numerous plants and animals to develop a seed and grow into the towering giant of the forest. The interdependence of these species results in this tree's ecological importance to the rainforest community because so many organisms depend on its complex life cycle for survival.

The brazil nut tree depends upon many organisms for its survival, including an orchid flower that takes up residence on its trunk. This delicate orchid emits a sweet fragrance to attract a pollinator, most often the euglossine bee, to pollinate its flowers. It is no coincidence that the tree provides a habitat for the orchid because the euglossine bee is also the primary pollinator of the brazil nut tree flower. This more giant, strong bee is perfect for navigating the complex hood of the flower and depositing pollen while gathering nectar. After pollination from the bee, the tree is able finally, generate a seed after fifteen months of development. Over a year later, the seed, entombed in a hard husk, falls from the tree.

The grapefruit-size capsule can sustain a tremendous 160-foot fall without cracking. It is harder than a coconut, unbreakable to the human hand. Now, the only chance of survival for the seed depends on the world's largest rodent, the capybara. Its large rodent incisors can break through the thick shell and release the seeds from its prison. Now free, the seed must overcome one more obstacle—it depends on another, smaller hard shell.

Adapted to protect it from being consumed by numerous rainforest animals, this shell can also be detrimental to the germination process due to its durability. The seed must now wait, yet again, for its shell to wear down from decomposition over time, or perhaps, a hungry, messy macaw takes interest and starts to crack the shell and drops the seed, thus finally releasing it into the soil. Twelve years later, the seed grows into a fully mature tree awaiting its first visit from the euglossine bee to start the life cycle again. All this process is possible by assisting at least four species of plants and animals. Unbeknownst to them, they are indispensable parts of the tree's life cycle.

As a biologist, these relationships and communities in nature fascinate me. The tree is not responsible for the success of the euglossine bee, capybara, macaw, or orchid. None of

these animals nor the orchid are accountable for the success of the tree. Yet, they are all linked by survival as vital members of their community. Using ecological diversity as a metaphor, each obstacle the tree faces: pollination, the hard husk of the outer shell, and the toughness of the inner shell, all symbolize the challenges students, predominantly underrepresented students such as females, must overcome to be successful in Science, Technology, Engineering, and Mathematics (STEM) fields. The concept of mutually beneficial relationships in a community where multiple species benefit from interacting with each other mimics the social and cultural diversity needed for the success of STEM. The evolution of advancements in STEM is not possible without this diversity. Society does not occur in a vacuum. As individuals, we are entangled with each other whether we want to be.

The cross-pollination of ideas and experiences from both males and females from varied backgrounds contributing to the current body of knowledge of STEM is necessary to continue the progression of all areas of STEM. When females are underrepresented in STEM, their perspectives are lost. At the time of this study, scientists and engineers continue to work to solve some of the most complicated problems of our time and design many things used in everyday life by both males and females. As Corbett (2011) points out, the experiences, needs, and aspirations that are unique to females can be neglected when females are not involved in science and engineering work. Unfortunately, the gender-related intellectual gap in STEM continues to widen. Females make up nearly half of our country's workforce but work in less than 25% of STEM occupations, with trends showing females are becoming disinterested in STEM by 8-11th grade.

Peter Hershock (2012) talks a great deal about diversity. He states, "diversity is an index of self-sustaining and difference-enriching patterns of mutual contribution to a

meaningfully shared welfare" (p. 51). Like the tree, if the bee becomes nonexistent, the tree has a decreased chance of survival. The more diversity surrounds the tree, the greater the chances of its survival. The relationship between diversity and the well-being of an ecological system has implications for us to consider females' contributions to STEM as essential. Without females, STEM lacks a valuable social and cultural resource. Societal and cultural differentiation means a "lack of sameness - a lack without which the dynamics of mutual contribution would be effectively short-circuited" (Hershock, 2012, p. 51). The lack of sameness and a positive direction of differentiation allow for growth in innovation through embracing varied cultural perspectives, including those of the female perspectives.

Background of Problem

The brazil nut tree indirectly depends on its community to survive. Similar to how it depends on a pollinator such as the euglossine bee to pollinate its flower, STEM indirectly depends on the school to educate its future generations of the STEM workforce. The euglossine bee is not the only pollinator that can pollinate the brazil nut tree flower; there are others. There are a small bat species and a few other insect species, but all are specialized to fit under the hood formed by several staminodes. These stamens do not produce flower pollen and move down towards the nectar they desire while transferring pollen on the receptive stamen. In nature, diversity is the key to survival. Plants and animals that are more successful at survival are not exclusive to only engaging in interactions with only a couple of other organisms; success depends on diversity and collaboration.

It is important to note that the human race is outside the relatively straightforward laws of nature, but we can draw some similarities. STEM, the acronym describing the combined industries of science, technology, engineering, and mathematics, was first coined

by Judith Ramaley in 2001 as the assistant director of Education and Human Resources at the National Science Foundation. STEM education is pivotal in increasing diversity and disrupting the current norms of excluding underrepresented populations from engaging in the conversation and progression of STEM. At the center of STEM education are the student and teacher. Large canons of literature have been dedicated to the issue of what motivates students to pursue STEM. Areas of motivation include mentorship, parental involvement, peer relationships, out-of-school time, and teachers (Faulk, 2018; Walkerdine, 2004).

Now, encompassing the areas of agriculture, economics, environmental industry, education, and medicine, STEM covers a wide range of occupations in the global economy (Zollman, 2012; Vilorio, 2014). In the United States, STEM skills are required for nearly 71% of all jobs in the 2018 American economy (Female Quick Facts, 2017). Social and cultural diversity provides many skills necessary to compete in the American and global economy. STEM has evolved by promoting diversity of thought from people of diverse backgrounds and experiences to invent the technologies and advancements for the future. The unfortunate problem is that, at the time of this study, there continues to be a growing diversity gap within the so-called "STEM Pipeline" (STEM Pipeline, 2014). This gap is called the *gender gap*, the historical lack of gender-related diversity in the pathway leading to STEM careers.

"According to the Census Bureau's 2009 American Community Survey (ACS), females comprise 48 percent of the U.S. workforce but just 24 percent of STEM workers" (Beede et al., 2011, p. 2). These trends continue at the time of this study. To be precise, "females have seen no employment growth in STEM jobs since 2000" (female's Quick Facts, 2017, p. 207). Over 75% of American college students are female. Yet only 45% of graduate

with STEM degrees (female's Quick Facts, 2017). The data indicated that females are underrepresented to a lesser degree than in the past, with the number of science and engineering degrees doubling over the last twenty years. However, there are still disparities with increased policy and support geared towards promoting females and minorities in STEM (National Science Board, 2016). This gap in social, cultural, and intellectual diversity brings forth many questions: Why are females not equally present in the field of STEM, especially in engineering programs where females account for a small percentage of STEM professionals? What social and cultural barriers make it difficult for females to engage in STEM fields?

Whether or not a person advances to a STEM-related career, the skills gained through a STEM-rich education can carry them in all areas of their life:

> STEM education creates critical thinkers, increases science literacy, and enables the next generation of innovators. Innovation leads to new products and processes that sustain our economy. This innovation and science literacy depends on a solid knowledge base in the STEM areas. Most future jobs will require a basic understanding of math and science - 10-year employment projections by the U.S. Department of Labor show that of the 20 fastest-growing occupations projected for 2014, 15 require significant mathematics or science preparation (Eberle, 2010, p. 62).

Even the construction, transportation, and hospitality industries rely on STEM knowledge and skills. The benefits of a STEM-rich learning environment are essential to developing students capable of the technical and critical understanding of systems, whether mechanical or logistical, and problem-solving capacity to overcome obstacles in business. "Students must be prepared for any path they choose, whether directly into a STEM career or studying a

specialized STEM field in college" (Gerlach, 2012, p. 3). Thus, fewer females in STEM programs result in an intellectual and cultural loss for our economy and society.

Children, boys, young females, and trans, are born curious to explore the world. "Female students in the class of 2016 are significantly less likely than their male counterparts to report plans to pursue a college major or career in STEM (16% vs. 41% respectively)" (female's Quick Facts, 2017, p. 218). What happens from when they are children, excited, and ready to be scientists, engineers, and innovators to when they graduate and become disinterested in STEM? With an increase in programs in school and out-of-school designed to engage females in STEM, why are 18% of female computer science majors now compared to 37% in 1985 (female's Quick Facts, 2017), indicating a decrease?

No matter where the student resides, the school is a pivotal piece of the puzzle, and within schools lies the role of the teacher. Teachers have a tremendous capacity to inspire. "Good teachers possess a capacity for connectedness. They can weave a complex web of connections amongst themselves, their subjects, and their students so that students can learn to weave a world for themselves" (Palmer, 2007, p. 11). The worlds they weave can lead students towards paths they imagined yet seemed unattainable, or pathways never imagined. They can pollinate the imagination of inspiration, empowering students to achieve goals they previously thought impossible. During an online discussion board, a student shared:

> My mother went to college for two years. My father, I'm not sure. I never thought I would be able to go to college [because I was] poor and not able to keep my grades up last year. [No one in my family] pushed [me] any other years but, as of late, being pushed by great teachers; my hopes have gone up [regarding] going to college (personal communication, 12-9-2016)

She believes that her teacher is an inspiration and provider of support to help her work on raising her grades to go to college and pursue a STEM degree. A student's teacher is vital in helping students imagine themselves in STEM.

Statement of Problem

In spring 2017, I worked collaboratively with a diverse team of formal, informal, and higher education professionals in a professional development course. Throughout the academic year, close to 80 professionals met to discuss the state Science Academic Standards and how they could effectively provide rich STEM experiences through phenomenon-based lesson plan development. On the last day, we prepared for the annual STEM Ed Camp in which each teacher facilitated sessions about what they had learned alone or in a group. We explained the STEM Ed Camp format and asked for people to talk in groups about sessions they would facilitate. I looked around the room and watched nearly every educator turn their head away, physically adjust in their seat so as not to sit towards me or turn their head down to stare at the floor.

I sensed their discomfort with this activity. Sharing what the teachers had learned seemed so simple in planning. The teachers would have an opportunity to talk with colleagues about the projects they worked on for the last six months. Finally, one person said quietly, "Shouldn't a professional do that? Talk, I mean, shouldn't it be a professional that presents about the workshop?" (Personal communication, 3-25-2017). I paused; I was at a loss for words. Where do I start? Where do I go from here? The room was silent. Only a few hours prior, every person in the room was outside, engaged, laughing, discussing, discovering, conversing, sharing, and learning. Now, when asked to share their knowledge

over months of learning and working together, they ask, "... shouldn't it be a professional that presents about the workshop?"

I gathered myself and asked, "Okay, who in here can self-identify as a professional?" They stared at me, perplexed, like no one had ever asked them this question. Three people slowly raised their hands, not upright and straight, but only halfway and crooked, indicating they weren't sure if they should say yes. Three people. With nearly eighty people in the room, overwhelmingly female from pre-kindergarten – twelfth grade, only three raised their hands. Three of eighty teachers, one male and two females, from districts across the region, including rural, private, urban, and suburban schools composed of a majority of female teachers.

Three of eighty teachers spanning from two years to over thirty years in the profession of teaching. Three raised their hands, announcing they believed they were a professional. My heart sank, my mind enraged and swirling. How could this be? How could our society downcast the most critical profession to the degree to which they then degrade themselves? From the moment I asked the question to the moment, my heart broke into eight hundred pieces, probably only lasted less than a minute and a half, but the vision of those three hands in the air has never left my memory. My mind now turned to their students. If these educators could not self-identify as professionals, how did their students see them? Yes, the term professional has a complicated history with different meanings. Perhaps, a term better suited to capture this experience is pedagogical STEM content expert. This particular professional development was aimed at cultivating a rich STEM content knowledge and relevant pedagogical approaches to facilitate lessons through relevant experiences. So then, with a term more appropriate to this setting, how would this influence their teaching practice

if they do not self-identify as a pedagogical STEM content expert, especially with young females in their class?

Based on this experience, I quickly became interested in investigating science teachers' self-identity as pedagogical STEM content experts and its influence on their teaching practice when working with female middle school students. Enderle et al. (2014) point out the cyclical reaction of teacher beliefs and courses. Whether or not a teacher has a positive belief system associated with a particular content area influences their practice and the students' learning experience. So, what happens if the teacher does not identify as a professional or a pedagogical STEM content expert or identifies negatively in this area? For the purpose of this study, the term pedagogical STEM content expert refers to an educator who is confident and able to provide guidance and leadership for these young, impressionable female students (Akkerman, 2011). The literature lacks a clear definition of professional identity, and this concept becomes exponentially complex when applied to educators. The notions of content experts, teacher professionals, pedagogical experts, and pedagogical content experts are still unclear terms, and many people in the field of education are trying to clarify their definitions and applications to practice. Lasky (2005) points out that the construct of a teacher professional or expert evolves over their career and can be shaped by school, reform, and political contexts, which can impact classroom culture and, for the context of this study, young female students. However, female teachers' difficulty with claiming expertise, as my experience showed, is often associated with gender biases, and teachers' embracing of a pedagogical STEM content expert identity means that they have to navigate with multiple identities since female teachers' traditional identity and expert identity

tend to have conflicts. Teachers confident in their content and proficient in their pedagogy can be a role model showing female students how to push forward through gender biases.

National Center for Education Statistics (2016) claims female teachers comprise 76% of public-school teaching positions. Coupled with increased professional development opportunities in STEM-related content, including grants and scholarships to attend such training, one could argue that female teachers are more equipped than ever to encourage and equip young female students to continue STEM. Yet, over the last 25 years, there has been a dramatic shift in teacher expectations to be a content or pedagogical content expert in STEM (Ball, 2000; Driel & Berry, 2012). Since the early 2000s, literature has demonstrated that it was no longer expected or necessary for the teacher to be a pedagogical content expert. Instead, teachers are urged to bring in outside experts as mentors for students, especially in STEM courses (Arenas-Martija, Salinas-Silva, Margalef-Garcia & Otero-Auristondo, 2016; Roberts, 2013).

Due to the combined issues of teachers no longer being regarded as the experts plus middle school female students' continued disinterest in STEM when they reach high school, I think that research needs to focus on understanding teacher perspectives regarding self-identifying as a pedagogical content expert and how this identity influences their practice in the middle school classroom. Schools cannot focus primarily on outside mentors' roles to influence young females' pursuit of STEM. Within the limited research focused on teachers as role models, most studies focus on teacher preference between male and female students or focus on the level of undergraduate students (Tofel-Grehl & Callahan, 2017; Bottia et al., 2015; Lam et al., 2012; Hughes, Wu, Kwok, Villarreal, & Johnson, 2012; Cushman, 2010). At the time of this study, a few studies have started the complex work of examining teachers

as role models for K-12 female students, but the trend is to correlate by gender alone; for example, A study finds that female students are more likely to declare STEM majors if they come from a school with predominantly female math and science teachers (Stearns, Bottia, Davalos, Mickelson, Moller & Valentino, 2016).

In the current canon of literature and from discussions at national STEM Ecosystem conferences across the country, there is a gap in researching STEM teachers' identity and its influence on female students' pursuit of STEM learning. Qualitative studies are in high demand to unpack how the teacher identifies as a STEM expert and, more specifically in an educational setting, a pedagogical STEM content expert, and its influence on their interactions with female students. In other words, if young female students look to their teacher as someone confident and competent in STEM when they cannot see themselves as such, how a teacher identifies as a confident and competent expert becomes very relevant to those female students' learning.

Purpose of the Study

The purpose of this study is to understand how female middle school teachers in a mid-western American city self-identify as pedagogical content experts in STEM and how their perceived identities influence their practices in the classroom.

Research Question

The main question of this study is: How do female middle school teacher participants identify as pedagogical STEM content experts, and how do their multiple identities influence their teaching practice?

The sub-questions are:

1. How do female middle school science teachers navigate gendered norms to self-identify as pedagogical STEM content experts?
2. What are teachers' perceptions of how their identity as pedagogical STEM content experts influences their interactions with female middle school students?
3. How are these teachers' perspectives on negotiating multiple identities reflected in their teaching?

Theoretical Framework

This project studies how teacher participants define pedagogical STEM content experts, to what degree they identify with this concept, and how their sense of self-identity influences their teaching related to female middle school students. Research about females in STEM has shown teachers to be the second most influential role models for students (Walkerdine, 2005). Young female students who lack other positive female STEM influences may only have their teacher to look to as a role model in STEM.

Grounded in the poststructural feminist theoretical framework, this study aims to uncover how teachers consistently navigate and transcend the gendered cultural norms that impact how they identify as a pedagogical STEM expert and how their identity influences their teaching of female middle school students. It also means attending to the power relations in a broad social context in which STEM teachers construct their identities and in the school space in which they interact with their students.

Poststructural feminism was utilized to orient this study because it demonstrates the complexity of the subjectivities and lived experiences of both the researcher and participants to understand better the systems of gender-based disparities in participants' classrooms

(Freeman, 2019). This study challenges the essentialist notion that females constitute a single, static identity; instead, it adopts the notion of an emergent, multifaceted, and constructed identity within competing discourses (Butler, 1990). The theoretical underpinnings and assumptions most directly related to this study can be outlined by looking at three themes: identity, power relationships, and difference.

Identity: This study seeks to unpack how these female educators are simultaneously engaged in resisting and subjected to patriarchal power through sharing their perspectives regarding self-identifying as a pedagogical STEM content expert. To establish a baseline of how my teacher participants define this concept and how it influenced their teaching practices when working with female middle school students, I used an initial survey that showed that teachers have a complicated identity. Teacher's identity provides the structure and logic to "see through the ambiguities and confusions of *particular* discursive contexts where woman/female students are located as simultaneously powerful and powerless" (Baxter, 2002, p. 9). Female students have numerous opportunities to be powerful in the classroom through leadership roles, providing input, and using their voice. Yet, dominant, gendered discourses continually undermine their identity. The simultaneity of being powerful and powerless is also demonstrated in teachers' lived experience.

Researcher Valerie Walkerdine (2005) has studied female students in mathematics since the early 1990s, using the lens of poststructural feminism. Drawing upon Julia Kristeva's theory, Walkerdine argues that poststructural feminisms "allow us to take apart these [gendered] truths and their forming and informing of practices in which female students and women are taken to be poor at Mathematics" (p. 16). She calls for a realignment in thinking and researching differences between males and females, including looking at the

multiple identities within each, and in this particular case of my dissertation, the multiple identities that exist within females. In acknowledging the multiplicity of identity, females and other marginalized people can make visible the stereotypes and limitations placed upon them and take a more comprehensive perspective that includes both an individual's unique experience and social constraints to which they are subjected (Rosser, 2000).

Historically, young females were not seen as academics, and under the social pressure to choose between femininity and intellect. Female students are taught to be passive, quiet, and "perfect," and boys are expected to be loud, dominant, and brave, according to a TED Talk on risk and failure. Reshma Saujani, the founder of Girls Who Code, discussed the concept of raising female students to be perfect without failures and boys to be brave through failing and learning from their failures (https://www.ted.com/talks/reshma_saujani_teach_girls_bravery_not_perfection?language=en). Taking a poststructural stance, the teacher has a tremendous responsibility to deconstruct gendered dualism and understand the multiple identities shaping females, such as embracing an identity of being both academic and nurturer, both strong and feminine at the same time. In doing so, this breaks the social norms of what it means to be a girl, as one must constantly negotiate the expectations and limitations from society and school culture.

The term identity on its own is a massive area of research. This study uses the term identity to examine the constructs of gender and power within a school context. Particularly the notion of female identity as a "fiction of coherence" (Miller, 2005, p. 143) in which one is constantly pulled between resisting and being subjected to power and between being authentic and meeting gender-related societal expectations. Under such multiple pressures, female teachers and students' gendered identities cannot keep the coherence of the singular

identity and become fragmented or multiplied. Educators are often loaded with many demanding social, cultural, and educational tasks while having to navigate a historical patriarchal system that split a female teacher's identity into either nurturer and caregiver or authoritarian, academic, and masculine. The struggle of females to live out these "impossibly contradictory positions" (Walkerdine, 1990, p. 145) is relevant for understanding female teachers' gendered identity. The identity of a pedagogical STEM content expert was historically not female. Embodying expertise in content and pedagogy of STEM requires teachers to be complex, unique individuals of multiplicity who are capable of being nurturers, science experts, and leaders all at once. Post-structural feminism offers a framework for understanding identity and subjectivity as multiple, complex, contradictory, and ever-shifting.

Janet Miller's work (2005) concerning identity provides a lens to see the spaces in which females can go beyond either/or dualistic positions to affirm both-and positions: "I continue to explore how constructions of women's work and voices, as situated within a private, domestic sphere, devalue teachers who wish to be both nurturing and authoritative in our work" (p. 82). Moreover, the internalized biases can make a teacher unconsciously enact a hidden curriculum of the socially constructed role of females in society through patriarchal norms of power and authority. A poststructural gendered critique requires revealing dichotomies and creating a new space where a woman can construct her multiple identities. To further unpack this notion, multiple identities refer to a person not being constrained to a singular quality but allowing the freedom to embody multiple aspects of a person. An example can include a woman to identify and to be thought as feminine, nurturer, academic, strong, and so forth, rather than binaries often portrayed in media such as either an

intelligent woman or the pretty woman. Multiple identities provide the possibility to be both at the same time.

As a point of tension, Patti Lather (1991) considers the overt ideological goal of feminist research in human sciences to "correct both the invisibility and distortion of female experience" (p. 71). As a correction, Miller (2005) argues that juxtaposition can be used to make different perspectives visible without reducing them to sameness. Juxtaposition is not only about highlighting females' perspectives different from what is defined by the gendered system but also about highlighting the diversity among females in following different paths in pursuing resistance and change. This study worked to call attention to diversity in identity, both internally and externally, through using multiple applications of juxtaposition. In reflecting on the historical, societal, and patriarchal systems that influence how female educators self-identify as pedagogical STEM content experts, through a poststructural feminism lens, what new versions of oneself can be constructed when one thinks of oneself as both/and rather than either/or?

Power: When the brazil nut seed hatches, energy passes back and forth through the ecosystem and seed. The flow of energy from one organism to another is a foundational principle of life within an ecosystem. The energy is never destroyed but transferred from the sweet nectar on the orchid eaten by the euglossine bee to the decaying husk of the Brazil nutshell back into the soil where the new seed can grow, creating a constant pull and pull between energy and organism. Similar to the transfer of energy through the brazil nut lifecycle, power is a dynamic situation. There is "no binary and all-encompassing opposition between rulers and ruled as the root of power relations" (Foucault, 1978, p. 94), so power flows in various directions like a web. Foucault states that power is "unbalanced,

heterogeneous, unstable, and tense" (1978, p. 93), constantly circulating, in which one can negotiate and resist in multiple, specific ways. The post-structural understanding of power helped me explore how power relationships influenced teachers' construction of professional identity related to STEM and their teaching practices in the classroom. As educators navigate their subjectivities in daily interactions with students, how does power relations through which they construct their identity influence their teaching practice and curricular decisions? Examining the identities of female middle school teachers, this study provides insights into how these teachers negotiated and transcended the institutional and cultural norms through the circulation of power relations within the school.

The capillary practice of power within a classroom in which the teacher, students, parents, fellow educators, administrators, and culture are constantly in flux in their interactions, has contradictory and complicated effects that influence teachers' identity. The theory of poststructural feminism has provided a frame for rethinking power, resistance, and creative negotiations for females. It offered a way of understanding the world through a rich plurality of voices and perspectives, which may lead to greater recognition and connection between people of competing viewpoints and ultimately rapid social and educational transformation (Baxter, 2002, p. 5). This approach provided the depth needed to investigate the meanings held within the gendered discourse and teacher self-identity. As stated by Jones (1993), "poststructuralism provides a conceptual language which transcends agency/structure dualisms, as well as avoids the simplicities of theories which invoke a monolithic notion of patriarchal power in understanding female students' classroom experiences" (p. 157). The same holds true for teachers.

The issue of enacting gendered identity beyond the opposition between agency and the system becomes critical to create more room for teachers' struggles. When teachers can seek multiple and specific sites of resistance beyond the boundary of the power system, new possibilities of affirming female identities can be opened by attending to the constantly in flux, unstable power relations within the school through the complex negotiation of the educator herself. Poststructural feminism offered a lens to complicate our understanding of female teachers' STEM pedagogical expert identity and their work to transcend the dualism within the power structure in this study.

Difference: Difference is an important poststructural concept essential to feminist theory. "Oppositions rest on metaphors and cross-references, and often in patriarchal discourse, the sexual difference (the contrast masculine/feminine) serves to encode or establish meanings that are unrelated to gender or the body" (Scott, 1988, p. 37). Through a poststructural lens, the difference became the space *between* what was assumed through cultural, societal, or gendered assumptions and what *could be* such as a female disrupting assumptions to transcend gendered boundaries. The difference lies in what can be and what is assumed, creating hybrid spaces of being.

This framework provides the lens to better understand the complexity of female teachers' identity and their interactions with middle school students. The lens of difference provides a broader notion of subjectivity incorporating the gendered discourses, relationships, and structures that restrict pathways that promote a female educator's self-perception of pedagogical STEM content experts. It attempts to "challenge, deconstruct, and pry open the 'already known' of fixed and static identity categories and ways of knowing" (Miller, 2005, p. 4), in which new possibilities can form regarding what it means to be a

female STEM educator, to be a leader, an academic, a mentor and all other identities that create an inclusive space for females in STEM.

STEM, as broad a subject as it is, combining four disciplines is ever evolving with new developments and discoveries. The subject matter of STEM pedagogical experts is not stable and ever-changing, so the meaning of difference is not only related to gender but also related to the nature of the curriculum. The pedagogical content expertise needed to engage all students in conversations effectively is also in constant flux, reacting to social, cultural, and political forces that pose challenges to effective STEM curriculum and facilitation. Shifting the meaning of an individual from "I," as the sum of fixed, gendered experiences to "I," as an ongoing evolving process of constantly renegotiating new meanings (Francis, 1999), this study may contribute to creating the hybrid spaces for both teachers and students to form their unique STEM identities (Baxter, 2002).

Research Design

This project was framed as a case study to understand the gendered nature of female teachers self-identifying as pedagogical STEM content experts and the influence of such identities on teaching practices with female students. As with the methodology of a case study, there was a small number of participants-- four female educators who self-identified as pedagogical STEM context experts-- were chosen to participate. Each participant represented a case. Data collection and analysis provided an in-depth understanding of the research questions through interviews, a focus group, and teacher writings. A case study methodology aided in allowing proximity with the data and observing it in a real-world context rather than relying on secondary data. Additionally, this project investigated the phenomenon as it occurred; thus, it was bound by time and activity; two components common in case studies

(Creswell, 2003). I, as the researcher, gave consent forms to all participants and they returned them to me with signatures before the start of the study.

Data Collection and Analysis

Once all participants were selected, and participants signed all waivers, data collection began. The data sources included interviews, teacher writings, and a focus group. I will discuss the timeline of this study and data collection and analysis in more detail in Chapter 3. Throughout the study, there were three interviews with each participant, a focus group, and two writing prompts for participants to answer. I also used a researcher's journal to document my reflections during the study.

Regarding the interviews and the focus group, attempts were made to conduct them face to face, but with COVID-19 restrictions and safety protocol, interviews and the focus group moved to the virtual setting using closed ZOOM meetings. Once data collection and transcription of all interviews and the focus group were completed, I examined individual cases and analyzed them using coding methods. Upon completing all the cases, I conducted a cross-case analysis and coded across cases to understand commonalities and tensions between the cases, using poststructural feminist framework.

Significance of the Study

By conducting this study regarding teachers' self-identity as pedagogical STEM content experts, I hope this research contributes to the current body of literature regarding teacher identity and the link between the teacher and how to engage young female students in STEM during the middle school grades. As a qualitative case study, this project did not attempt to be generalizable. Through detailed descriptions of participants in contexts, this study may inform the practices of other schools with similar situations that are looking for

strategies in assisting teachers in engaging young female students in STEM. The female teacher's identity as a pedagogical STEM content expert also can provide insights in teachers' professional development.

The role of STEM education is to develop skills and abilities to think critically and a process for continued learning. There have been numerous approaches to this topic. This study took a poststructural feminist qualitative approach to teachers' perspectives and how their self-identity influenced their classroom practice when working with middle school female students. Although poststructural feminist theory has been influential, data-based studies using it as the framework, particularly in the area of STEM education, to analyze the data are very limited. This study designed multiple forms of juxtaposition for data analysis, which makes a contribution to the field of curriculum studies and qualitative research.

The classroom is a complex ecosystem with classroom culture, hidden curriculum, and varied discourses. Like the brazil nut, students need to be cultivated, nurtured, and allowed the necessary nutrients and resources to thrive. This study focuses on the teacher's role in the classroom's gendered system and how their self-perception as a pedagogical STEM content expert cultivates female student growth. The teacher is a most important support for student growth, and the findings of this study will be beneficial for improving teachers' understanding of how their identities influence their teaching of female students in order to adopt responsive pedagogical positions.

Definition of Terms

STEM - Science, Technology, Engineering & Mathematics. The interdisciplinary approach to learning where rigorous academic concepts are connected with real-world applications. Students learn to apply STEM in contexts "that make connections between school, community, work, and the global enterprise enabling the development of STEM literacy and with it the ability to compete in the new economy" (Gerlach, 2012, p. 3).

Poststructuralism - is a theoretical framework that aims to expose "structures of domination by diagnosing 'power/knowledge relations and their manifestations in our classifications, examinations, practices, and institutions" (Peters & Barbules, 2004, p. 5).

Feminism - is a theoretical framework that aims to uncover gendered discourses targeted against females focusing on "attention to meaning, subjectivity, and power" (Kohli & Barbules, 2014, p. 59).

Discourse - written or spoken communication

Pedagogical STEM Content Expert - how teachers relate their pedagogical knowledge to their content knowledge to make STEM relevant and understandable for their students.

CHAPTER II

REVIEW OF LITERATURE

As a person who works in STEM education, I am frequently reminded of general misconceptions about STEM and who counts as a STEM professional. Through multiple personal experiences, I have noticed a trend towards a broader public concept of what encompasses STEM. Thankfully, at the time of this study, it was becoming less frequent that people approached me, seeing STEM on my nametag and asking, "Do you do that STEM cell stuff?" Nowadays, people are more apt to converse about their child's school robotics or STEM lab. Still not quite the full breadth of STEM, but an improvement.

In this literature review, I start by discussing STEM as a mindset to clarify the definition. Secondly, I discuss females in STEM and education, including barriers and obstacles they encounter and the importance of gender diversity. Thirdly, I focus on the motivations for female students to pursue STEM. Fourthly, I discuss STEM preparation for teachers. Fifthly, I review time spent teaching STEM in the classroom. Sixthly, I

discuss how teachers self-identify as pedagogical STEM content experts. Lastly, I review the influence of pedagogical STEM content expertise on teaching practice.

STEM: Science, technology, engineering, and math as an educational mindset

Interestingly, the main misconception is that people identify with STEM's particular components, such as only engineering or only technology, rather than the diverse ecology that is STEM, science, technology, engineering, and mathematics and how all of these components are interwoven into a very complex way of thinking and processing the world. On a more formal note, Gerlach (2012) defines STEM as an

> interdisciplinary approach to learning where rigorous academic concepts are coupled with real-world lessons as students apply science, technology, engineering, and mathematics in contexts that make connections between school, community, work, and the global enterprise enabling the development of STEM literacy and with it the ability to compete in the new economy (p. 3).

STEM offers a path to a deeper understanding of the world. From understanding the very atoms that make up our biology to studying ecology between the capybara and brazil nut tree to designing the tool to process and manufacture the brazil nuts for human consumption efficiently. As well as encompassing all the logistical systems that ship the nuts to your local grocery store, STEM provides expertise for making all these happen.

Within the STEM community, there is a phenomenon called the STEM pipeline. This is the pathway from childhood to the STEM workforce in which many attempts have been made to find the benchmarks that indicate a young person is on the

"right track" to achieving a successful STEM career. Numerous claims have been made regarding the path, but most agree there is one problem. The pipeline is leaky (Ellis, Fosdick, & Rasmussen, 2016; Shapiro et al., 2015). This refers to the phenomenon where students who show a high STEM interest in their younger years tend to not follow through in pursuing a STEM career for numerous known and unknown reasons. Thus, never entering the STEM workforce. Research also shows that this leaky pipeline is even more prevalent for females (Kinskey, 2020; Veldman, 2021). The National Girls Collaborative Project (2018) reported that females make up half of the U.S. college-educated workforce but only 28% of the science and engineering workforce. Even with gains in numbers of females entering the STEM fields, these numbers do not align with the job growth nor balance out the gender proportions, especially in the fields of engineering, computer science, and mathematics.

Needing a robust STEM program in school is not a new argument for an ongoing problem. With the launch of Sputnik, No Child Left Behind Act, Common Core, and Next Generation Science Standards, STEM is a common topic of discussion in school policy. Without having relevant, engaging STEM experiences as an adolescent, a students' STEM interest decreases dramatically in the middle school years, especially a female students. There are many discussions about what relevant, engaging STEM experiences look like. However, Cohen et al. (2020) argue that experiences that give ample time for female students to explore and understand STEM concepts while connecting them to their interests are valuable in developing a female student's STEM capital. What is more relevant is the question: What does a good STEM curriculum look like? How is it effectively enacted in the classroom? Why do so many female students

choose not to engage after primary years? From the 1980s to the present day, STEM reform has taken many forms, and each time there seems to be a communication gap among the policymakers, universities, K-12 districts, general public, parents, and educators (Breiner, Harkness, Johnson, & Koehler, 2012; Ross et al., 2022). There are mounting arguments about what counts as STEM and how much time should be spent teaching STEM, but a huge point is still missing. STEM is more than the amount of time spent doing worksheets for science or robotics. STEM is also a *mindset*.

Most importantly, as a mindset, STEM is, first of all, a way of thinking. It merges science, technology, engineering, and math disciplines to create a critical, problem-solving mindset that can aid a person in every facet of life. To harness this power, a good STEM program starts in schools. Good STEM learning should involve "learning across disciplines, promote student inquiry, engage students in real-world problem solving, and expose students to STEM careers" (Froschauer, 2015, p. 1). Together, these attributes contribute to the formation of critical reasoning and innovative thinking with global awareness of their future possibilities.

It's similar to the food web of the rainforest. Each organism directly or indirectly affects another member of the ecosystem. STEM education creates critical thinkers, increases literacy, and enables innovation (Hofstra B et al., 2020). As Eberle (2010) discusses, "Innovation leads to new products and processes that sustain our economy. This innovation and science literacy depends on a solid knowledge base in the STEM areas" (p. 62). STEM experiences provide a catalyst for innovation and inspiration and awaken natural curiosity. Numerous researchers are now beginning to tie the benefits of STEM experiences to social-emotional health (Shaby et al., 2021; Staus et al., 2019). Dr.

Chan Helman (2016), a researcher of character strengths, specifically studying hope, has started investigating how STEM inspires HOPE for people to increase levels of confidence and self-efficacy by developing problem-solving skills and capacity for adaptation, helping them in many more areas than science, technology, engineering, and mathematics.

There's a common saying; *I'm not a math person*. Even people working in a STEM field will self-proclaim that they are not *math people*. There is a fundamental problem with this statement. It is a fixed mindset that does not allow the opportunity to grow and learn. STEM provides pathways to develop growth mindsets (Law, 2021; Wang, 2021). Instead of saying, *I'm not a math person,* through STEM engagement, students move towards the openness of *I can learn to be good at math* (Miller, 2015). Perhaps this idea has more merit than ever. A longitudinal study with nearly 1,500 high school students highlighted the importance of growth mindsets through STEM to foster a positive STEM identity, especially in females whose performance is similar to that of their male peers (Degol, Wang, Shang, & Allerton, 2018).

STEM is more than a workforce, a subject, or a buzzword; it can be a pathway to equity through developing perseverance, critical thinking similes, and growth mindsets (Law, 2021; Wang, 2021). In times of uneven playing fields, STEM can provide a pathway for equity for students who may not learn well through the mainstream verbal reading and listening mode. Learners who prefer visuals and hands-on experiences can find multiple ways of learning in STEM. Research has shown that STEM lessons provide openness for students with special needs and those students who may not consistently achieve the top scores compared to their peers. STEM provides an opportunity to

showcase students' skills in persistence, creative thinking, and facing the fear of failure. STEM also offers counter spaces that can become safe spaces for racially/ethnically underrepresented students, particularly females of color (Ong, Smith & Ko, 2018).

Females in STEM and education

With STEM as a pathway for equity, why are more females still not continuing their STEM pathways? What still stands in their way? Turns out many things. Not considering females fitting in STEM professions starts everywhere, from home to school to community, and it can come from many people, even friends. This is not a conversation about females unable to perform, because we know they can, but is a question about what barriers block them from continuing through the STEM pipeline. If we take a moment and revisit our Brazil nut tree metaphor, we know that not every Brazil nut seed that is produced grows into a tree. Many are consumed by animals, many may fall and perish in the wet season of the rainforest, and many may sprout but then be outcompeted by other plants and not grow into a full tree. The point is that there is opportunity. Each seed has a forest to grow, nutrients to provide necessities to sprout and a web of organisms to help it move along its lifecycle. Whether or not every female that proclaims they like STEM as a child goes on to be a STEM professional is not the point, but the issue is to provide ample opportunity for those who desire to and for all females to benefit from the cognitive benefits of problem-solving skills, critical and growth mindsets to be competent and productive citizens. We need to provide conditions for STEM to provide the nutrition for students' healthy cognitive development. Even aside from STEM, Rogers, Boyack, Cook, and Allen (2021) found that females who experience

gender discrimination not only reduces motivations in math but also report lower levels of school connectedness. Thinking more broadly than STEM, the rest of their educational experience is affected by gender discrimination or gender-science stereotypes.

Barriers and Obstacles. An important barrier is confining females within the boundary of what they are supposed to be. A female student who is good at mathematics is often perceived as not feminine enough, as Walkerdine (2005) points out, "Females must choose to be feminine or choose to be successful at mathematics" (p. 10). Much of the current research points to a dichotomy of gendered identity. She either "is" or she "isn't." When, in reality, each female has an identity of multiplicity (even though some identities are in contradiction with other identities).

These dichotomies of identity are reflected in societal attitudes that "portray science as masculine and female students as incapable of meeting its challenges to a lack of equity-minded curricula, pedagogical strategies, and professional development tools" (Barton, Tan & Rivet, 2008, p. 71). Understanding and addressing gender-based inequities in education, which create a culture that undermines both female students and teachers, is vital in providing an inclusive education for all students and an inclusive working environment for teachers. Kuchynka, Eaton, and Rivera (2022), in their study, investigated the ways in which schools, peers, teachers, and parents have a positive and negative impact on female students. Some key points of obstacles include the lack of time spent with female students to engage in STEM, bias against females pursuing STEM, and gender stereotypes that create expectations that males are more innately talented in STEM than females. They also propose multiple practice recommendations to improve

STEM education in K-12 education, including designing relational classrooms, fostering collaborative and cooperative classrooms, and promoting active learning and growth mindsets. These practices can address the barriers and obstacles and encourage female students to pursue STEM education.

During the early years of schooling, research has shown that teachers tend to interact more with male students than female students, especially during math and science classes (Bassi et al., 2019; Opdenakker, 2021). It is also of note that teachers in Walkerdine (2005)'s study tend to direct more negative comments toward males for their misbehavior, while most negative comments directed at female students were related to the quality of their work (Walkerdine, 2005). The reverse can also be seen as detrimental; other studies found the opposite true (Geary, Hoard & Nugentr, 2021; Kenway & Gough, 1998). In classroom studies, teachers were shown to be "too caring" with female students cultivating dependent scientific learning and more likely to encourage the boy's intellectual engagement with the STEM content allowing them to dominate the intellectual and linguistic spaces in the classroom.

These studies are related to Gee's work on identity issues. He discusses identity as a "social performance that varies according to space, place, and time" (Gee, cited in Morton & Parsons, 2018, p. 1366). It is logical to relate the space and time in which young females are more likely to be criticized for their academic performance rather than behavior when achieving at the same level could have longer-lasting ramifications on their STEM identity in the long term. "The barriers that female students face in engaging with and succeeding in school science range from school and societal attitudes that portray science as masculine and female students as incapable of meeting its challenges

to a lack of equity-minded curricula, pedagogical strategies, and professional development tools" (Barton, Tan & Rivet, 2008, p. 71). Barton, Tan & Rivet's research not only points out school and societal attitudes as the barriers but also points to directions of change for overcoming obstacles.

Importance of diversity. When particular groups are marginalized or shut out of STEM pathways, this creates a bottleneck of intellectual diversity, limiting further innovations. "It was argued that the male nature of the practice of science was oppressive for females, hence their 'science avoidance'" (Kenway & Gough, 1998, p. 1), but the very idea that a subject or area of knowledge can be gendered is problematic. This notion creates the very basis of the patriarchal oppression that leads to the bottleneck in the first place. More importantly, this bottleneck creates a narrowing of who can become a STEM literate citizen and who can all enter the global STEM conversation. As previously stated, the beauty of STEM is that it provides a pathway to diversity. If the very act of learning and growing in STEM perpetuates patriarchal discourse oppressing students based on gender, then the system is clearly broken. Diversity is not merely looking around and seeing variation, but it encourages the emergence of particular ways in which people belong together through interactions (Hershock, 2012). The beauty lies in diversity, as life cannot thrive as a monoculture. Diversity matters, and representation matters.

Within the microcosm of a classroom, whether or not students have a STEM identity is "contingent upon the individual's belief in their capabilities within and their conceptual and practical knowledge of their particular STEM discipline" (Moton & Parsons, 2018, p. 1365-1366). This is contingent not only on their belief but upon others'

beliefs. Not only is the environment important to be conducive to students' STEM learning and developing a positive STEM identity, but the resources available and perceptions of others within that environment are also equally important. Female students specifically frequently describe relationships with others as central to classroom engagement, in which experiences that provide pathways for inclusion rather than exclusion are more effective in developing STEM identities (Ball, Thames & Phelps, 2008).

What motivates female students to pursue STEM?

There are some students who are determined to be in the STEM field from early on and there is nothing that can deter them from this pathway. Others may have the interest and the intellect for pursuing STEM careers, but for some reason find themselves pushed out of the way. Bandura's (1997) social learning theory suggests that a person is neither driven solely by inner forces or their environment. Rather, it is a combination of influences and perceptions that forms identity, and students also form their own agency in their responses to external influences. These environmental influences can be both positive and negative. Research has shown numerous environmental influences can guide students towards a positive or negative STEM identity: parents, teachers, peers, mentors, of school time experiences are a few we will discuss (Cipollone, Stich, & Weis, 2021; Lynch, 2018).

Out of School Time. There is a space called out-of-school time, which suggests that learning can take place outside the formal school setting. Compared to the time spent learning inside a formal school setting, out-of-school learning comprises over 80% of our lifetime learning (Falk & Darling, 2015). This can include a trip to a museum,

summer camp, engaging with online learning, and many more things. As students are interested in a particular subject, cause, or content area, they are free to explore on their own, which benefits their in-school learning. Falk and Darling (2015) note that the role of out-of-school time, or as they refer to it, "informal education," actually comprises much of our lifetime learning. With only a set amount of time in a structured classroom, out-of-school learning accounts for most of the learning that stems from our natural curiosities which makes it a powerful tool to cultivate and provide the resources to explore in youth.

Not bound by the typical constraints of standardized testing, teacher evaluations, or district mandates, these informal learning spaces are more open to exploring and promoting student-centered and student-led learning. There have been many reports and studies cataloging the benefits of out-of-school time programs including reducing the summer lapse in content knowledge, providing safety and basic services including food to students as well as enrichment programs for those particularly interested in the content being taught. Stanbury, Stanbury, and Reeves (2020) documented similar results when they studied the effects of before-school clubs on young female interest in STEM. They found females who already had an interest in STEM were more likely to continue their pursuits in high school compared to those who did not attend a club. School STEM teachers can benefit from the studies on informal learning to incorporate some effective practices in the classroom and intentionally connect with out-of-school educational institutions for enriching students' learning.

When it comes to young females, out-of-school time provides additional benefits. Much of the structure of out-of-school time resonates with the self-identified

learning styles. According to Jacob, Kuriloff, Andrus & Cox's (2014) study, "Girls liked lessons that were clear, relevant to their lives, and provided opportunities for collaboration. They were engaged by activities that were hands-on and multimodal and included discussions and elements of creativity and the creative arts" (p. 69). Additionally, in a study looking at female students, Girls and Women in STEM (2014) documented, "small group and project-based work that is the hallmark of OST programs can help female students develop STEM identities by providing opportunities to showcase unique skills" (p. 142). It allows females, especially minority females, to create an identity of practice in science classes by combining knowledge from their in-school and out-of-school worlds (Calabrese Barton et. al., 2008). The ability to see oneself as a master practitioner is formed through a classroom community of practice created by teachers who provides space for students to bring knowledge from their social worlds to their study of science (Tan & Calabrese Barton, 2007).

Mentorship. Starting in the primary years, mentorship is a fundamental way to engage students in STEM learning, increase socio-emotional health and provide access to a potential STEM pathway. These types of mentoring relationships help young females develop confidence and a sense of community (Kim, Sinatra, Seyranian, 2018). One such program, Hidden Figures Math Mentors in a midwestern US City provides such a mentoring opportunity. This program works with seconders grade at a public school students to increase math proficiency while playing math games with STEM professionals before school. In these formative years, this program has been shown to increase student-to-student relationships, student-to-adult relationships, how students self-identify as STEM people, reduce chronic absenteeism, and increase math proficiency

as recorded during standard math proficiency tests. The environment makes math fun, in which students play games like UNO, addition and subtraction BINGO, and board games using rulers to measure distances or count money.

Partnering with a local oil and gas company, STEM professionals arrive at 7:15 am each Thursday morning for 30 minutes of math games with a group of 15 second-grade female students. All the students in this program are female and mentors are both male and female. The reasoning is that if both males and females are available for support and encouragement for these young females then access can open wider to showcase there is room for females in the profession. Males provide support to encourage and welcome female students while the females provide insight into their own STEM pathways as well as encouragement in the student's math interests. Through the combined evaluation tools of the STEM Alliance and Harvard PEAR (2018), results indicate this program aided in increasing student peer-to-peer relationships, peer-to-adult relationships, and overall growth in attitudes towards STEM from the start to the end of the program. It also resulted in (or aided) increased attendance on the days of the program (Hidden Figures Math Mentors, 2020; Harvard PEAR, 2018).

Peer Relationships. Walkerdine (2004) lists peer relationships as the top three influencers of young females' STEM identity. Within the unique social structures of schools and home life, peer relationships play an integral role in the formation or deformation of STEM identity. Especially during middle school years, peer interactions are important for students' identity development, including academic identity. When there is a culture among female students mutually supporting one another's academic

pursuit of STEM, it can make a difference (Park et al, 2021). The reversal is also true. Particularly central to female engagement in the classroom, young females describe

> collaborative lessons and bonding activities as being instrumental in helping them master a particular concept and providing them opportunities to get to know themselves and their classmates better. In turn, they demonstrated how these connections contributed to deeper learning experiences (Jacobs, Kuriloff, Andrus, & Cox. 2014, p. 71).

Collaborative activities are often mediated through peer relationships, sometimes without the teacher's guidance. Teaching and learning experiences involving peer interactions either formally or informally in and out of the classroom provide a certain orientation that may encourage or discourage female students' STEM orientation. Research shows that an all-female student arrangement tends to provide a positive environment for them to take risks and try new things (Laury, Lee, & Schnier, 2019; Sutter and Glatzle-Rutzler, 2015).

As young female students progress through their classes, other phenomena can occur, such as imposter syndrome (Pennie-Sims, 2020 This concept refers to a belief someone is unworthy of the place they are in. Often, this mindset is accompanied by self-doubt or occurs when a female enters a higher-level STEM class and is suddenly in the vast minority of her class. Trefts (2019) documented factors attributing to imposter syndrome include: a lack of sense of belonging, negative stereotypes toward females and external invalidation, and maladaptive coping methods and ineffective work habits leading to negative psychological well-being. As much as positive peer interactions can give students belonging and confidence, the alternative is also true, and with the

additional barriers of social, cultural, and patriarchal systems, healthy and productive peer relationships are tremendously valuable to building a positive STEM identity.

Parental Support. The importance of parental support in forming a positive STEM identity is not a surprise to know. Parents are the main influencer on a child's life (Walkerdine, 2005). Notably, the term parental support encompasses any adult who takes on the day-to-day responsibility for raising a child. Whether biological or not, the adult in the home who assumes the role of "parent" or guardian is instrumental in how a child grows and develops. Walkerdine (2005) goes on to point out the importance of a mother-daughter relationship in forming a STEM identity: "To make early experiences salient in later educational success, and to suggest that children acquire roles from agents of socialization, particularly parents, and that early feminine stereotyping will later produce stereotyped performance" (p. 42). Continued pressures on parents today, such as work, family, and school, can limit their time spent engaging in meaningful experiences to further a child's STEM identity. Archer, Dewitt, and Willis (2014) coin the term "science capital" to identify the advantage of a family engaging in STEM-related experiences together, in which families with a higher science orientation raise kids with an increased chance of success in STEM.

Even more importantly, Simunovic, Ercegovac & Burusic (2018) found a student's perception of their parent's value of STEM whether or not it aligned with the parent's own ability played the largest role in how the child self-identified with STEM. Regardless of how a parent feels about STEM, if parents have a positive outlook on STEM, their children are likely to have a positive outlook too. For parents, it is

important never to say, “I’m not a math person” to their children because they *are* listening.

Teachers. Documented in Walkerdine’s (2005) research as the second most influential aspect of a young female’s environment, teachers play a critical role in STEM identity development. This role of a teacher not only teaches content but also needs to know their students, provide examples of representation in STEM, introduce students to potential career pathways and provide the stability of an encouraging, welcoming atmosphere within the four walls of their classroom. Jacobs, Kuriloff, Andrus, and Cox (2014) studied how young females perfected the support they received from their teachers, suggesting that “these relationships took the form of academic support through individual conferences and help sessions and emotional support in ways that showed that teachers knew the female students beyond their academic selves” (p. 71). We can see that the role of the teacher is instrumental in allowing young female students to learn and grow in their STEM identity. Teachers also mentor students beyond academic concerns to help them develop pathways for their goals.

“Good science teachers capitalize on the ah-ha moments and work hard to help students not only understand science, but also foster a lifelong learning in science” (Eberle, 2010, p. 62). Parker Palmer (2007) wrote eloquently, “good teaching cannot be reduced to techniques. Good teaching comes from the identity and integrity of the teacher” (p. 10). Teaching is much more than conducting tests, lectures, and activities because it encompasses the delicate social intricacies of classroom sub-culture, including the existing power imbalances. The capacity of a teacher to inspire is immeasurable. Adversely, the opposite is also true. Beilock and her colleague (2010)

studied the teacher's role as a role model through a regression analysis study. They found that when teachers had anxiety about their subject areas, such as mathematics, their students were more likely to develop gender-based bias, and the female students' math achievement actually declined.

Historically, in terms of math classrooms, numerous researchers, including Walkerdine (1989, 1990), Mendick (2006), and Walshaw (2007), have documented classrooms mainly operating through a predominantly masculine rationale to which historically, females were excluded. New initiatives have been brought in to modernize pedagogy to be more inclusive of females (Adu-Boateng & Goodnough, 2022; Morina & Orozco, 2021). Some of these pedagogies include more modern gender inclusive pedagogies include lessons that are clear and relevant to student's lives (both male and female students), collaborative structure, class discussions, hands-on, minds-on engagement, multimodal, creative through innovation or pulling in the creative arts and out-of-class experiences (Jacobs, Kuriloff, Andrus, & Cox. 2014). Yet, there is still a discrepancy in how these pedagogies are enacted in the classroom:

> girls, like boys, elicit the pedagogy they need, though perhaps without (overtly) displaying resistance to the degree that boys do, and that both male and female teachers of girls are especially attuned to what girls need in terms of pedagogy and activities that maximize girls' engagement (Jacobs, Kuriloff, Andrus, & Cox. 2014, p. 71).

Teachers' support of students can be manifested in arranging classroom norms, uncovering hidden curricula, setting up classroom rules, and later encouraging the goals, aspirations, and resiliency of female students (Virat, 2022; Wentzel, 1998). The role of

teachers in developing positive personal relationships with students as well as providing encouraging environments for students to learn and develop is widely recognized as an important component of student motivation, intellectual development, and achievement (Aultman, Williams-Johnson, & Schutz, 2009; Zhang et al, 2020).

STEM preparation for teachers

"The quality of the teacher education directly affects the teaching process. Teacher content knowledge is one of the paramount elements for the improvement of teaching and learning" (Kaya & Elster, 2018, p. 15). Traditionally, content knowledge is developed through a teacher preparation program at an accredited university. However, multiple studies have shown there is a disconnect between STEM content knowledge and teacher preparation programs (Johnson, Byrd, & Allison, 2021; Norville & Soonhye, 2020). Teacher preparation programs focus a large amount of time on classroom management and lesson development. Yet, regardless of how well this is done, it is still possible for teachers to leave with a low level of confidence and competence in STEM (Teo & Ke, 2014Yildrim & Turk (2018) conducted a qualitative study interviewing teachers about their attitudes towards STEM teaching. The teachers in their study emphasized they did not feel sufficiently prepared to teach STEM content through their STEM education courses and believed an excellent STEM teacher should have comprehensive STEM content knowledge and pedagogy knowledge. With the vast amount of curriculum that needs to be covered to adequately prepare someone to become a teacher, it can be a challenge to also include not only how to effectively teach each subject individually but also how to integrate between subjects.

To be confident and competent to facilitate high-quality STEM experiences takes a high level of expertise to execute. Also, the integration of multiple subjects is not alone sufficient. Pedagogical expertise in student-centered practices incorporate hands-on activities and are grounded in real-world learning and problem solving (Dare, Ring-Whalen, & Roehrig, 2019). When teachers provide these rich learning experiences of student-centered problem solving and hands-on activities, students are more likely to become inspired, interested, motivated, and demonstrate higher achievement (Bybee, 2013).

Time spent teaching STEM in the classroom

If students spend more time studying a subject, it is more likely that they will learn more about it. For the most part, this is true in students' learning of relevant subjects in STEM, but unfortunately, very little time is regularly spent teaching STEM (Honey et al, 2014). Within the context of a classroom, STEM is often broken apart into its subcomponents, such as science, technology, engineering, and math. With the push for higher reading and math scores resulting from the No Child Left Behind Act, math was a focus, but not in a way that was most relevant to STEM. The intersection and blending of science, technology, engineering, and math are where the real magic happens and critical thinking skills develop. Having twenty minutes of robotics a week is insufficient (Campbell, Coral, and Christopher Speldewinde, 2022).

STEM, at its best, highlights the integration of STEM knowledge to meet real-world challenges. Devoting time to integrated lessons that draw from real phenomena and pose relevant problems in which students can use their voices provides students invaluable tools to think critically, develop plans and execute and analyze their work

(Bybee, 2014; Vasquez, Sneider & Comer, 2013*;* Sanders, 2009). Effective STEM lessons take time and more importantly it takes a dedicated teacher.

Similar to a parent, how students perceive a teacher's attitude towards STEM has a dramatic impact on their own attitude. Additionally, a teacher with a negative attitude towards STEM is less likely to teach it well. Whereas a teacher with a positive STEM attitude and one who positively identifies as a STEM person is more likely to successfully integrate STEM into other content areas, increasing time spent teaching STEM and thus increasing the science capital a student is exposed to in school (Sujarwanto, Madlasim & Ibrahim, 2019).

How teachers self-identify as pedagogical STEM content experts

In ecology, there is a term, keystone. This is the organism in an ecosystem that holds the system. If the keystone species goes extinct and another is unable to replace it, the system collapses. Teachers are the keystone of STEM education. Without teachers who are effective and confident, the entire STEM pipeline crashes. Sujarwanto, Madlasim, and Ibrahim (2019) describe teachers as the most central component in STEM education, who are able to design activities that allow students to understand the real-world connection of STEM while targeting standards, fulfilling district testing requirements, and developing student's knowledge and positive STEM attitude. They are teachers with a strong background in both STEM content and pedagogy.

Teachers who identify as pedagogical STEM content experts can relate their subject matter knowledge to their pedagogical knowledge and they understand how subject matter knowledge is part of the process of pedagogical reasoning (Abell, 2007; Cochran, DeRuiter & King, 1993; Kaya & Elser, 2018). *"*Pedagogical knowledge is used

to facilitate effective teaching practices in ways that aim to make learning more accessible to students" (Kaya & Elster, 2018, p. 15), and accessibility is important for STEM in which the content can be abstract.

It takes time to develop strong pedagogical STEM content knowledge and align this knowledge to standards. It takes constant practice, reflection, and knowledge of the subject matter, goals of instruction, understanding of students, curriculum organization, assessment, teaching, and resources (Saito & Atencio, 2016). Not only must teachers ensure the curriculum they teach is engaging to students it must also provide clear links to standards such as the Next Generation Science Standards (2022) that provide clear links to real world application and systems thinking to explain phenomena. Imagine the science classroom as an authentic scientific community in which the teacher served as the expert and guide, facilitating the learning and guiding students towards their own discoveries and learning. Seeley, Etkina & Vokos (2018) take us on such a journey, investigating physics teachers and how they create such a community through a strong sense of pedagogical STEM content knowledge. Combining analysis from teachers' subject content knowledge and pedagogical content knowledge as well as student achievement, they found both teaching and learning were effective in achieving their goals. The ability of a teacher to respond productively to students was contingent on their disciplinary and pedagogical knowledge that can be used for furthering student learning.

Influence pedagogical STEM content expertise has on teaching practices

Expertise in pedagogy and content is a key factor in "determining whether the integration of STEM can be done well" (Honey, Pearson & Schweingruber, 2014, p. 115). At the most basic level, an educator must combine content knowledge with an

understanding of the most effective teaching approaches to connect with the diverse learning styles of their students. A teacher with a high level of pedagogical STEM content expertise has the necessary knowledge to gauge students' development of concepts related to STEM with effective methods of instruction. Such a teacher also has the ability to intentionally shift instruction and pedagogy to make the content more relevant and impactful for students, and help students connect to the real world(Allen et al., 2016; Kaya & Elster, 2018). As in any other profession, "High self-efficacy promotes ambitious intrinsic goals and encourages analytical thinking, whereas low self-efficacy beliefs can lead to diminished quality of task performance" (Hamadeh, 2017, p. 46). A teacher's level of self-efficacy not only affects themselves and their coworkers but also their students. With teachers as one of the most influential people in a student's life, the degree to which a teacher can self-identify as a STEM expert has a tremendous influence on their students and the degree to which STEM is taught with fidelity.

Teacher competence and confidence have a dramatic impact on student self-confidence in STEM. The degree to which a teacher can have a level of self-confidence in teaching STEM has been shown to be directly proportional to the confidence of their female students (Vidic, Klasnic & Duranovic, 2022). STEM is not an area that can be taught without content expertise and fixing the leaky pipeline cannot be done with worksheets and YouTube videos. It comes from the integrity and efficacy of the teacher. The brazil nut does not transform into a giant tree on its own but depends on the organisms to break down each barrier to release its seed and nutrients from the soil and organic matter to provide the nutrients needed to sprout and grow. Students are similar. Without teachers to stand up and help them navigate the cultural, societal, and

gendered discourses that are implicated in patriarchy, students are easily lost to the path of least resistance (Johnson, 2005).

The teacher is a pivotal influence in a young female student's life, and her ability to form a teacher identity as a curriculum creator and pedagogical expert is important for positively influencing female students. This literature review ends with the importance of the teacher and their influence on female students to situate my study that explores female teachers' pedagogical STEM content expertise and its influence on their interactions with female students. There are very few qualitative studies using a poststructural feminist framework that directly relate to my topic, so this study will contribute to the literature.

CHAPTER III

METHODOLOGY

The purpose of this study is to understand how female middle school teachers in a midwestern American city self-identify as pedagogical STEM content experts and how their identities influence their teaching practices in the classroom with female middle school students. This study involves one main research question and three sub-questions. The main question of this study is: How do female middle school teacher participants identify as pedagogical STEM content experts, and how do their multiple identities influence their teaching practice?

The sub-questions are:

1. How do female middle school science teachers navigate gendered norms to self-identify as pedagogical STEM content experts?
2. What are teachers' perceptions of how their identity as pedagogical STEM content experts influences their interactions with female middle school students?

3. How are these teachers' perspectives on negotiating multiple identities reflected in their teaching?

This study uses a qualitative research methodology. Applying qualitative research in education to unweave the complex experiences provides an emergent rather than a tightly prefigured pathway (Creswell, 2003). Qualitative research was a good fit for this study as it allowed me, as the researcher, to follow and reflect on the data and understand what emerged from the process. Moreover, since all qualitative inquiry "is laden with values" (Creswell, 2003, p. 182), it allowed me to question the gendered biases, values, and interests. Using inductive and deductive reasoning, I circled back and forth between multiple data and analysis to conduct thematic analysis.

I chose a case study design for this study because it provided a lens into a participant's experiences anchored in real-world contexts and bound by time and activity (Yin, 2012; Creswell, 2003; Bromley, 1986), as I explained in Chapter 1. In this study, the case was the individual teacher, and I conducted an in-depth investigation of each case within the context of its unique environment, including its social dynamics each participant resided in. After focusing on each case, I used cross-case analysis to examine the tensions and juxtapositions between

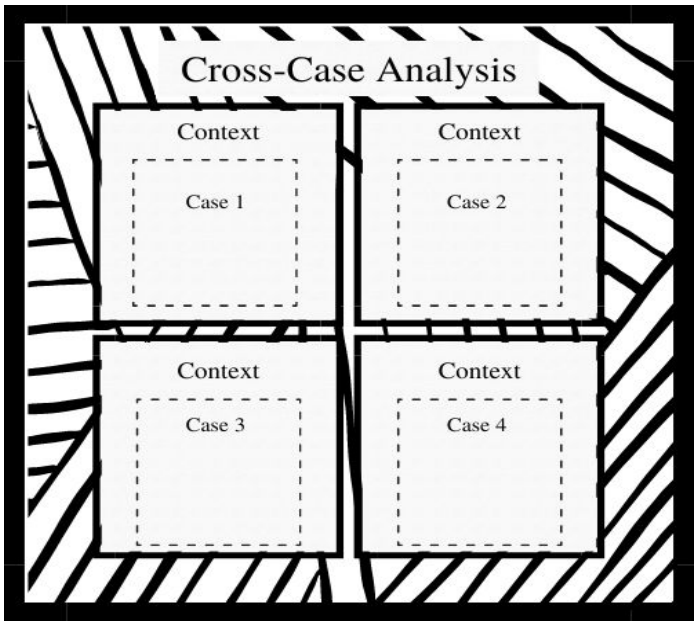


Figure 1: Cross case analysis diagram

cases and analyze all cases to reveal intersecting or different themes in broad contexts (Figure 1). In individual case analysis, I explored how each teacher's experiences were rooted in a context, such as the gendered discourses that might have influenced their perceptions or actions and how they negotiated their multiple selves. Then, I conducted a cross-case analysis to look across the four cases for points of tension, differences, and similarity.

Participants

Initially, this study planned to seek assistance from local district coordinators for inviting potential participants. With the onset of the COVID-19 pandemic in 2020-2022 and schools' rearrangements of classroom teaching, this strategy was no longer realistic. Therefore, with IRB approval, I adopted a new plan. After the approval from the Institutional Review Board regarding the change of plan from my university, participants were recruited through contacting educators within a Regional STEM Ecosystem in a Midwest state. I also obtained consent from the executive director of the Regional STEM Ecosystem. The Regional STEM Ecosystem was a non-profit education organization that provided STEM programs, events, camps, and professional development to meet its mission of STEM for ALL, including students, families, and educators. At the time of the study, the organization served over 150,000 students annually and provided professional development to over 1,000 educators.

Using the organization's network of educators that regularly attended STEM professional development, I asked the organization to send out emails, with the goal of choosing four to six female STEM middle school teachers from those responded to participate in the study. The Regional STEM Ecosystem Professional Development

Manager agreed to send out a solicitation email to all educators engaged in the Regional STEM Ecosystem for the past two years. Participants were purposefully selected using a survey to filter the candidates most ideal for this study as those who self-identify as pedagogical STEM content experts. The survey included basic demographic questions, seven identity questions, and two open-ended questions to understand if a potential participant self-identified as pedagogical STEM content experts. The survey results will be reported in Chapter 4 as the beginning of data analysis of each case. Participants signed consent forms before the start of data collection.

Initially, four participants were selected from the initial survey who indicated they self-identified as pedagogical STEM content experts, with two backup participants chosen in case a participant decided to drop out of the study or was no longer able to participate. Upon the start of data collection, one participant needed to leave the study due to health reasons and was replaced by one of two alternate participants. Each educator was a traditional, state-certified teacher. Each participant taught at different districts or private schools in settings ranging from urban to suburban to rural areas, and all within the state's northeastern region. For confidentiality, all names were changed, and I removed identifiers from transcripts. Due to COVID-19 pandemic, all interviews and the focus group were conducted over Zoom to ensure proper social distancing. With permission from all participants, all sessions were recorded and transcribed.

Case 1 Participant: Amy

Amy was a middle school STEM teacher at a private Christian school called midwest private city school (pseudonym) and taught from the elementary to middle school levels. For this study, all interviews, writing prompts, and the focus group focused

on her experience with her middle school classes, rather than elementary classes. At the time of the study, Amy had been teaching for over ten years. On the initial survey, she self-identified as a pedagogical STEM content expert, and 30% of her classes were identified as female students. Amy indicated the three strategies she believed were most effective when engaging young females in STEM: allowing for female groups to have activities together; rotating team roles between males and females to ensure all female students can participate in team leadership; and encouraging students to meet the challenges of STEM learning based on their personal interests, skills, and talents.

Case 2 Participant: Lynn

Lynn taught eighth grade STEM and Science at the suburban public middle school (pseudonym). Each middle school grade was divided into a separate center at her school, so she only saw eighth-grade students. Lynn had a strong science background, attended Pacific Northwest University, and graduated with a degree in Physical Education and Biology. She took ten years off from teaching to pursue other interests and to raise her children before returning to the teaching profession. She worked first at a suburban district and then a rural district, and she moved to her current one in 2016. Lynn was a robotics coach for multiple teams and believed fully in being a role model for the young females in her class, ensuring they were engaged in STEM.

Case 3 Participant: Danielle

As a twenty-four-year veteran in education at the time of this study, Danielle taught at the school she attended as a child, northeast public middle school (pseudonym). Situated within forty-five minutes of a large metropolitan area, Danielle's school had fewer than two hundred students in grades 6-8, with 46% female students. In only two

years, Danielle built the entire STEM program at her school, starting with a budget of $500.00. Through grants, professional development, and determination, she grew the program from a single STEM-1 class to three levels of STEM classes, filling her entire teaching schedule.

Case 4 Participant: Cynthia

Also, a veteran teacher of twenty-three years at the time of this study, Cynthia taught science, engineering, coding, and STEM at the rural public middle school (pseudonym). The most rural district in this study, Cynthia's district, had a little over one hundred students in their middle school, with 45% identified as female students. Cynthia developed the middle school STEM program, the robotics clubs, and mentored the elementary and high-school teachers on STEM integrated curriculum and robotics programs. Beginning her teaching career as a physical education teacher, Cynthia quickly discovered her passion for STEM by teaching computers after school. When it came to strategies to best empower female students in STEM, she believed that it was essential to acknowledge their contributions to the STEM activities and compliment them when they had a great idea.

Data Collection

Once all participants were selected and signed all waivers, data collection began in August 2021 and concluded in November 2021. The data sources included interviews, writings from two writing prompts, and a focus group with all participants. Interviews and a focus group were conducted on Zoom, and they were all recorded and transcribed. Writing prompts and answers were communicated through emails. I also kept a

researcher's journal for general observations and questions. The following outline describes the timeline and will be discussed in more detail.

Study Timeline

- Week One through Week Two –I administered participation surveys (Appendix 1) and selected participants. Surveys were sent out to prospective participants with a two-week deadline. Upon this deadline, I filtered responses based on my acceptance criteria: female middle school participants who self-identify as pedagogical STEM content experts. From this list, I sent formal confirmations regarding their participation in the study and including consent forms.
- Week Three – I gathered consent forms and began the study. I explained, in detail, the study, including interviews, writing prompts, and the focus group. I also scheduled and conducted the first interview (Appendix 2) with each participant using a closed Zoom platform.
- Week Four –Educators completed their first writing prompt (Appendix 5). The writing prompt was sent digitally via email and participants had two weeks to complete their responses and submit them.
- Week Five – The second interviews for each participant were completed (Appendix 3), and the focus group was scheduled and conducted (Appendix 6). During the second interview, I asked about participant preference on dates and times to schedule the focus group. The link to the focus group was a closed, password-protected Zoom link. All participants were present for the focus group.
- Week Six – Participants completed the final interview (Appendix 4) and the second writing prompt. The writing prompt was sent digitally via email and

participants had two weeks to complete their responses and submit them back. All participants responded to the writing prompt by the designated deadline.

The study included three interviews, two writing prompt responses, and one focus group with each participant. Since all interviews were conducted during the 2021 COVID pandemic, attempts were made to conduct face-to-face interviews but due to COVID-19 restrictions and safety protocol, interviews were conducted virtually, using a closed ZOOM meeting.

The following sections outlines the three points of data used for the study's triangulation: interviews, focus groups, and writing prompts. I also used a researcher's journal to keep notes related to inquiries based on interviews, observations, and general thoughts. I used all data points to serve all research questions during the analysis.

Interviews: The first set of data included three interviews with each participant conducted throughout the study. The goal of the first interview was to gather background information, and I asked them to define the term pedagogical STEM content expert and how their personal histories helped create this identity. All virtual interviews were semi-structured and lasted about 30-45 minutes and all the interview questions can be found in Appendix 2, 3, 4. The first interview reflected and probed deeper into their life histories and how they interpreted their self-knowledge regarding historical assumptions and limitations, most specifically within the context of education. The second interview, about 1.5 weeks after the first interview, focused on how participants self-identified as pedagogical STEM content experts and examples of life histories that demonstrated how this perception was enacted in their classroom, including what barriers and support they

had experienced regarding this identity. The final interview focused on summarizing their classroom experiences about any success or challenges teaching STEM, particularly with female students, and how their identities affected their pedagogy. While these three interviews focused on different aspects of research questions, participants' answers sometimes became intertwined in revealing their thoughts and discoveries.

The necessity for using Zoom to conduct all interviews had both advantages and disadvantages. This study was conducted during a global pandemic, so safety was a top priority. As many schools did not allow visitors and COVID cases were still spiking, Zoom was a safe option to ensure this study did not act as a spreader event for my participants. Additionally, there were added benefits of convenience and the ability to record the interviews, which provided some data related to behavior, voice inflections, and body language during a conversation. The disadvantages of using Zoom included the loss of personal interaction and face-to-face relationship building. Dialogue in Zoom is more restrictive as people take turns to talk, and the conversation can lose spontaneity.

Writing Prompt Responses: As a second set of data, between interview sessions, participants were given two weeks to respond to two writing prompts (Appendix 5). The writing prompts served to deepen or expand upon ideas and experiences discussed during the interviews, and participant answers ranged from about 600 words to 1200 words. The writing prompt questions included two series of questions. Writing Prompt 1: Have you experienced any conflict between being a woman and being a STEM expert in schools and in the classroom? In what ways? Did anything similar happen when you were a student? How did you deal with the conflicts and how do you do so now? Can you give an example? Writing Prompt 2: In what ways has your identity as a pedagogical STEM

content expert influenced your interactions with your female middle school students? Can you provide an example of positive and negative interactions that have occurred in your classroom? What would you have done differently?

The writing prompt responses served as a space for educators to self-reflect on their experiences in the classroom related to negotiating their understanding of gender as they navigate their multiple identities as teachers and pedagogical STEM content experts. Consistent with poststructural feminism, writing is central to the social construction of realities. It allows me, as the researcher, to look deeper into the unique realities in which my participants live. Each prompt focused on different aspects of how participants reflected on their multiple identities in their teaching. I removed all identifiers, so participants remained anonymous with pseudonyms.

Focus Group: As the third set of data, each participant was asked to participate in a focus group. The semi-structured focus group provided information about how each participant, as an individual and across the group, navigated socially constructed gendered norms to self-identify as a pedagogical STEM content expert. The focus group occurred virtually over the Zoom platform and provided a space for the study participants to be open and share experiences related to the research. Upon the completion of the focus group, the recording was downloaded and sent for transcription through GoTranscript. I sent all data securely through their platform and saved the downloaded transcripts to an external hard drive with password-protected file encryption.

Optimally, face-to-face interaction would be ideal as conversation can naturally flow easier for focus groups. Still, Zoom provided a more structured speaking space where people could not talk over each other and offered a chat option for participants to

agree and disagree or comment throughout the process. Given each participant was very busy with work and home, Zoom also provided a more accessible way to schedule the focus group, so participants did not need to find childcare and saved additional time needed for travel to and from the focus group location. The disadvantage of this convenience is the potential for distractions, as many participants took the calls from their homes, where family interactions could be a distraction.

From participants' responses, the individual interview and focus group supported each other, although there were also some differences, such as the flow of focus group interactions whereas some participants agreed on a particular aspect of identifying with students as part of the same team, others disagreed about cultivating a relationship that was so close. During the interviews, participants were able to go into more depth regarding their personal experiences and stories about a particular point, while during the focus groups they were more likely to share stories that were similar across their individual experiences but highlight the subtle differences. The participants responded to writing prompts in varying lengths from two paragraphs to one and a half pages, and with different degrees of enthusiasm. In response to the first writing response, Cynthia responded with a very short two-paragraph response but by the second prompt, she responded with over a page of writing diving deep into a story she discussed during her interview with far more more detail and personal reflection. Danielle was more likely to respond more fully and provide more details to the interview and focus group, but her writing prompt responses were both briefer with two paragraphs for both first one and second response. Together, these different data sources complement one another to provide a fuller picture than one specific data source.

Data Analysis and Juxtaposition

Each set of data, the three individual interviews, focus group, and two individual writing prompt responses were analyzed together and grouped by their corresponding cases. All participants completed all requirements of the study, including interviews, focus groups, and writing prompt responses. Responses to the writing prompts did vary depending on participants, and some needed additional prompting to ensure they delivered their responses on time.

I analyzed the data with a poststructural feminist lens. All sets of data were first analyzed individually and then cross-analyzed across the cases. I fully transcribed the interviews and the focus group with a transcription service, GoTranscripts, with secured storage and confidentiality. The interview and focus group transcriptions and writing prompt responses were coded with holistic, In Vivo, and versus coding methods. These methods allowed for the collection of phrases and words to come forward to prioritize and honor voices that are often silenced. I used both InVivo and Holistic coding methods to draw out phrases and words demonstrating the challenges, successes, and terms participants used to self-identify as a pedagogical STEM content experts, especially focusing on discourses related to gender and the influence of their identity on teaching female students (Creswell, 2003). Then I further coded key words and phrases and organized them into visual maps. I used these maps to navigate through a complicated data analysis process to identify major themes and converge them into overarching themes to present individual case and cross-case analyses, which will be presented in Chapter 4.

Careful attention was made to how the lens of identity, difference, and power in poststructural feminist theory informs the analysis. At the same time, I made efforts to remain cognizant not to allow these categories in the theory to restrict the initial open coding process. Each case was analyzed one at a time, ensuring a deep look into the experiences and reflections of each participant. Comparing the interpretive findings within each case across a multiple-case study allowed me to synthesize whether findings from multiple cases can reveal larger patterns across cases (Yin, 2012). I chose to discuss these patterns through emergent themes or contradictions in the form of juxtapositions to illuminate the difference without reduction. For qualitative case study, thematic analysis is essential.

Using the poststructural feminist framework to focus on the complexity and fluidity of a teacher's identity, I mainly use juxtaposition as a mode to demonstrate *and* hold tensions, reveal difference *and* work differences without reduction, and open up but not fixate new possibilities. Through juxtaposition, I can illuminate the "stories, analysis and thoughts about the historically and politically significant ways that bodies, subjectivities, pleasures, fears, histories and power relations overflow the protocols, norms, and forms that are intended to 'contain' them" (Miller, 2005, p. 113). As a form of "local and contingent 'emancipatory' work" (Miller, 2005, p. 144), juxtaposition can be used as a poststructural feminist technique to challenge the gendered norms, understand the complex constructions of teachers' identities, and seek multiple and fluid ways of resistance.

I used a few different modes of juxtaposition in articulating themes so that themes hold multiple, and sometimes conflicting, directions. I also used visuals composed of

teacher quotes, thoughts, and positionality (with my own thought in one instance) and placed them side-by-side within themes to complicate analysis and demonstrate cross-case parallels and tensions. For thematic analysis, for example, juxtaposition was used to illustrate the nuances and differences within and among participants identifying *with* and *from* their students. Identifying *with* and *from* students as a theme seemed to include opposite directions, but it was in this contradiction that participants' efforts–with both strength and limitations–to care for and support female students were demonstrated. In using this approach, each participant's voice is evident, but the commonalities and differences among one another are more obvious without reducing the complexity of these teachers' identities. Another example that will be demonstrated in Chapter 4 is a pictorial representation of teacher subjectivity in relation to their students in a cross-case analytic theme. Through this data visualization, the quotes of teachers are listed in a sequence to demonstrate the points of similarity and tension, again without reducing their voices to a simplified consensus.

The rigor of the study

To establish rigor in this study, I took the following steps to demonstrate its trustworthiness. As an essential measure of qualitative research, these steps allowed me to provide data demonstrating proper protocols were in place during data collection and analysis:

First, I maintained a researcher's journal to document observations, insights, general questions, and emergent thought through the data collection. I consulted the journal when doing analysis to revisit my initial reactions and observations. Second, I used triangulation through three data sources, multiple interviews, the focus group, and

multiple teacher writing prompts. Triangulation was a useful protocol as it allowed me to analyze the same information from different sources, such as similar questions during the interviews, writing prompts, and focus groups (Guba & Lincoln, 1982, p. 247). Triangulation is also reflected in selecting poststructural feminint theoretical framework, because poststructural feminism is the combination of two theories: poststructuralism and feminism.

Third, the prolonged engagement of more than three months and the use of multiple interviews as well as a focus group allowed me to develop trust with my participant and attend to biases and assumptions of both myself and my participants to have time to "identify salient characteristics of both the context and the problem" (Guba & Lincoln, 1982, p. 247). Fourth, I used member checks and sent transcriptions to my participants for accuracy check in order to ensure transcripts were correct and represented the participant's voices. Each step was carried out throughout the study, providing the evidence of trustworthiness and credibility.

As participants were selected based on purposeful criteria, the results of this study are also transferrable to similar cases outside this study area on a case-to-case basis. All participants were female, experienced with at least ten years of teaching at the time of the study and taught STEM classes, and initially self-identified as pedagogical STEM content experts. I have described both participants and their school and school districts, and this contextual information can be used by others who might share similar research interests and who share similar contexts. This study is transferable to other studies whose salient conditions overlap or match through the thick descriptions of cases (Guba & Lincoln, 1989).

Ethical Considerations

Before starting the data collection of this study, I gained full approval from my university's Institutional Review Board. I also obtained the permission of the local organization where teacher participants worked. All participation was voluntarily with no compensation. To protect participants' rights, each participant signed a consent form indicating they understood the time commitment, the purpose of the study, and what to expect. If a participant chose to withdraw from the study, they were allowed to do so at any time. As the researcher, I collaborated with the participants on a member check protocol in which they were allowed to review interview transcriptions so that participants correctly represented their voices.

Interview and survey questions were not intended to elicit private matters or difficult situations. If participants chose not to answer a question at any time, they were allowed to do so. The researcher's ethical relationship with participants is more than the IRB approval and following its protocols. I have been respectful of participants' choices and perspectives throughout the research process. When my interpretation of participants' stories might differ from theirs in data analysis, I indicate both perspectives.

Researcher Subjectivity

As a female biologist turned educator, I hold the position of a researcher who is personally vested in providing pathways for other young female students to work in STEM. During data collection and analysis, I assumed the multiple roles of researcher, STEM professional, and teacher advocate in this study. Throughout the study, I did my best to be aware of my identity and its role in the research process. With my professional

experience working with teachers through professional development and STEM programming, I have expertise in questioning and conducting this research for various purposes. My role as a Vice President for a STEM organization has provided me with experience developing a STEM curriculum and recognizing pedagogical and content expertise related to STEM teaching. Through this study, I utilized my professional talents, as described, to provide detailed accounts of classroom observations and interviews. At the same time, I did my best to hold my own biases or assumptions related to female teachers' identities as pedagogical STEM content experts. Some teachers may not identify as pedagogical STEM content experts but are skilled in their STEM content and pedagogical skills.

CHAPTER IV

ANALYSIS

This analysis focused on my participants' varied perspectives regarding self-identifying as a pedagogical STEM content expert. Some aspects I will address in this analysis include navigating gendered norms associated with this identity, how they interacted with female students, and how this was reflected in their teaching. Each case was composed of three individual interviews, two participant writings, and one focus group (Table 1). Each interview was transcribed and then treated as a unique data source, and each participant's writing was treated as unique data source. Once data collection was complete, I worked with one case at a time, and read the data sources multiple times to understand the overall context and dialogue. Individual case analysis was conducted with all data sources, and then cross-case analysis was conducted based upon individual case analyses.

Table 1. Data Set Collected from Cases

	Initial Survey	**Interviews**	**Writing Prompt Responses**	**Focus Group**
Case 1	Completed	3 interviews	2 writing prompts	1 focus group
Case 2	Completed	3 interviews	2 writing prompts	1 focus group
Case 3	Completed	3 interviews	2 writing prompts	1 focus group
Case 4	Completed	3 interviews	2 writing prompts	1 focus group

Starting with one transcript at a time, the coding process began with research questions in mind. First, phrases were highlighted to indicate relevant thought patterns throughout the transcript. Next, I added keywords or phrases in the margins to start the thematic analysis process. These were re-worked as needed with each reading, and in total, there were at least 3-4 readings for each transcript or writing. Once a reading was complete without any other reworkings or edits to the keywords or phrases in the margins, I started to draw the thematic map.

I used a thematic map to represent the main themes across a text or multiple texts (Vaismoradi, Turunen & Bondas, 2013). To build the map, once I finalized each keyword or phrase in the margins of the text, these keywords or phrases were visually organized in a closed program called SimpleMind (SimpleMind, 2021). In this program, I moved themes around and created groupings based on thematic associations. The program SimpleMind is programmed to organize themes into topics, and their associations are referred to as *central, child,* or *sibling* topics. Central topics are central themes that other themes are associated with but narrower in focus, and child topics are more specific.

Sibling topics are themes tangentially related laterally rather than a more narrow or broader focus theme. Moving through the text again, I shifted themes and statements within the map, ensuring each central theme represented the child themes/topics and each sibling theme/topic represented the relationship accurately and logically.

Figure 2: Thematic Map, Expert vs. Facilitator

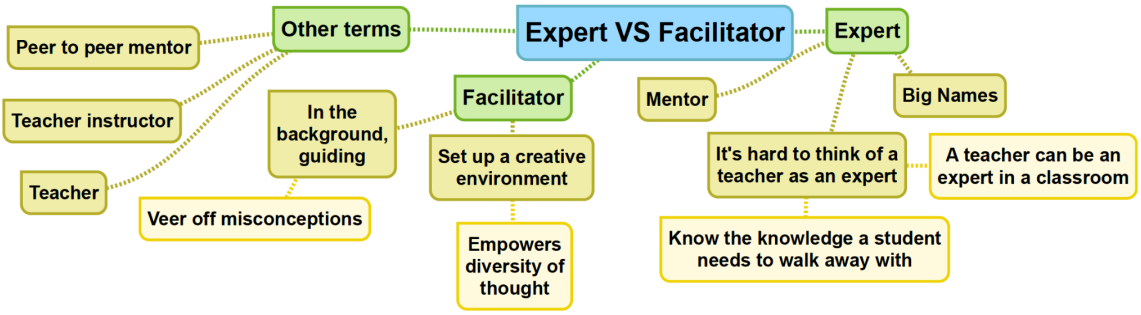


Figure 2 is a thematic map of the central theme, "Expert vs. Facilitator," showing the child themes/topics and sibling themes/topics. Some themes/topics were specific keywords used by the participant or keywords developed by the researcher representing the patterns visible in the text. Within this thematic map, all three interviews and both participant writings were represented in the themes. In the following sections, I will outline more explanation, evidence, and logic for each theme.

I first analyzed each participant's case, and after finishing all the cases, I conducted a cross-case analysis between cases. All names and identifiers regarding the school or district were changed to protect the identity of the participants. Each unique case and the cross-case analysis incorporated a poststructural feminist lens to analyze the participant's self-reflection, and my analysis highlights tension and the role of juxtaposition in the context of identity, power, and difference. The individual and cross-case thematic analysis is presented in the following sections.

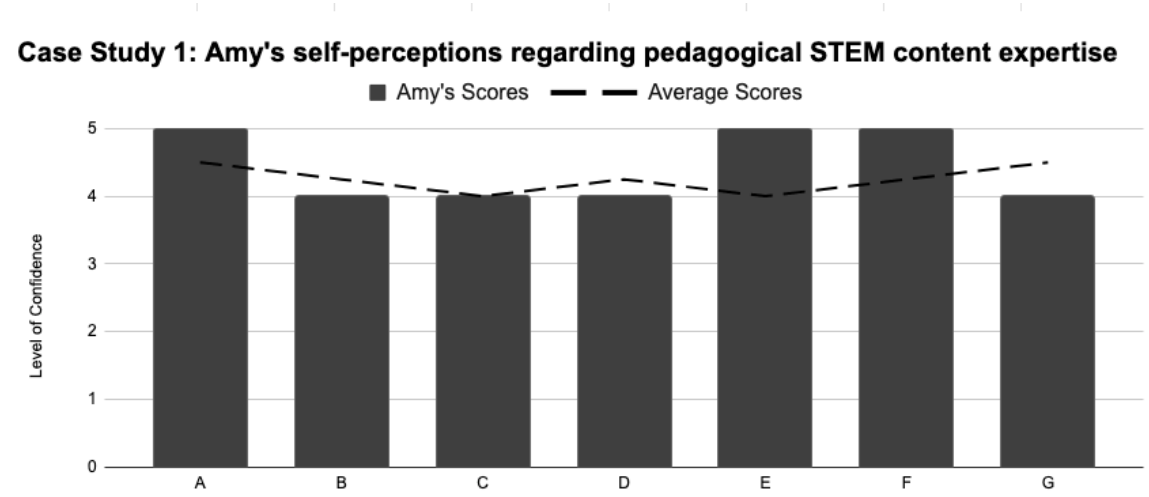
Case 1: Developing a STEM Team at a Private Midwest School

Amy was the lead Science, Technology, Engineering, Arts, and Mathematics (STEAM) teacher at a private school in a metropolitan city in a Midwest state, which will be known as midwest private city school for the purpose of this study. Midwest private city school served students from kindergarten through eighth grade with a total student body of 450 from K-12th grade. With substantial financial support through tuition, grants, and donations, students were allowed to participate in numerous academic and athletic activities while the school offered tuition assistance for families and free before- and after-school tutoring. Midwest private city school publicly declared they had dedicated efforts towards the STEM curriculum consisting of a structured elementary program, intermediate elective program, and integration of innovation into their high school curriculum.

The initial participant survey indicated that Amy self-identified as a pedagogical STEM content expert. She has taught for 13 years with a bachelor's in education and a teaching certificate in STEM. At the time of this study, she was teaching K-8th grade STEAM, 4-5th grade enrichment, and 2-4th grade computers. For the purpose of this study, all interviews focused on her experiences and perceptions of teaching 6-8th grade STEAM. 45% of her students were female in these classes, and many had been with her since early elementary. She indicated in the survey that she identified as at least confident or very confident in successfully facilitating STEM experiences, able to explain STEM concepts, and had sufficient knowledge of STEM subjects to answer her middle school student's questions. At the time of the survey, she also indicated that she was confident in employing a variety of STEM principles to deepen her student's understanding of STEM,

very confident in her pedagogical skills to teach STEM content and was able to effectively monitor students' progress in STEM learning (Figure 3).

Figure 3. Amy's Self-perceptions regarding pedagogical STEM content expertise



A. The degree of confidence to facilitate STEM experiences with students
B. The degree of confidence to explain STEM concepts to students
C. The degree of confidence in having sufficient STEM knowledge
D. The degree of confidence in employing a variety of STEM principles
E. The degree of confidence in teaching STEM content
F. The degree of confidence in effectively monitoring student progress in STEM learning
G. The degree of confidence in engaging both male and female students in STEM learning

Throughout the interviews, Amy's descriptions of her teaching to me demonstrated relentless dedication to her student's success and pursuit of STEM through the time she spent preparing her lessons to work with students after school on extra STEM projects. When asked how she defined STEM, she talked about STEM as a way of thinking critically and looking beyond how things are but how things could be better:

> It's more than just putting together four subjects; science, technology, engineering, and math. It's a way of thinking critically, being able to look at almost anything and not only think about how it works but is it what you need? Is that what you like? Is there a way to make it better? (Interview, 9-30-2021)

Crediting her students' influence on the origin of her definition, she believed that her students' curiosity enabled her openness to believe, "If you don't like something, you can change it" (Interview, 9-21-2021). Teaching in a building that embraced more traditional, lecture-style teaching, Amy continually shifted her pedagogy and curriculum to "teach a different way" (Interview, 9-21-2021). During the interview, she described going against the expectation of formal, lecture-style teaching and embracing an experience-based and project-based teaching style.

When asked, "Thinking back over your time teaching STEM, what are some of your favorite STEM lessons that you believe they the largest impact on your female students?" Amy responded by describing mentoring students to send a science project to the International Space Station called Dream Up. In this project, Amy mentored multiple groups of students to create a science project that progressed through numerous levels of judging and moved through numerous safety checks with NASA regarding their project design, materials, and how the astronauts interacted with the project. The entire project lasted fifteen months and was implemented as a partial after-school program and partial science lesson unit.

Developing the framework, time, and capacity for such an intensive student experience sets Amy's teaching style far from traditional, lecture-based design. This act showed her silent resistance against gender biases (Munro, 2006), in which she brought innovations in teaching practice. Amy's resistance against the patriarchal hierarchical system was embedded in her challenge of the traditional lecture-based educational approach. Historically, as a means for social control, the female educators were considered maternal, submissive, and passive, but Amy's actions disrupted prescribed

ways of thinking rooted in gendered norms, without direct confrontation with the system (Munro Hendry, 2011). Amy sought to inspire students' active learning through inquiry, engagement, and adventure, transcending traditional, lecture-based instruction. I term her act of resistance as "silent" rebellion, because her teaching served to transform female students' self-image through adopting newly accepted approach of project-based learning. Without making too much noise, she set the course of opening more diverse possibilities for her female students to go beyond the gendered expectations society placed upon them.

Amy's subversion or disruption of the STEM curriculum was not a forceful opposition. Still, it was aligned to shifting the traditional ideologies of STEM learning within midwest private city school to experiential learning that benefited female students (Munro, 1998). Amy gently shifted the narrative to a new way of learning, making STEM more than a set of projects in sequence hitting benchmarks or aligning to a pacing calendar. She confessed she found whatever she could online to use as curriculum when she started teaching, but, over time, she had grown her teaching strategies, and adapted to designing projects that intentionally demonstrated an understanding of STEM. Now, Amy carefully created her curriculum to allow for open-ended creativity, "In having such an open-ended creativity, that allows the girls to shine" (Interview, 9-30-2021). Open-ended creativity here referred to female students who were encouraged to explore, take risks, and create new things. She created experiences with a high volume of student choices to give them opportunities to make decisions that affected the project's outcome. With no absolute, singular pathway for success, students could be creative in their

solutions and understand that the process was sometimes more important than the product.

"Girls seem to enjoy that more than the boys do at times. The boys are like, 'what do you want me to make? What do you want me to use?' Whereas the girls are like, 'okay'" (Interview, 9-30-2021). Amy described a time when many tornadoes were occurring, and students expressed frustration. They spent all their evenings in the closets or bathrooms, taking shelter. She asked, "Okay, how are we going to fix it? What can we do?" The students came up with many ideas, from building new storm shelters to finding a way to stop tornadoes from space. Amy created the openness for students to think that what may not be possible now may be possible in the future, "Just crazy ideas that could become something someday" (Interview, 9-30-2021). Through this experience, Amy empowered students to create knowledge based on their experiences and research under her guidance. She did not prescribe how and what they should create and learn but encouraged their learning and provided resources to allow them choice and autonomy in their discoveries. This open approach showed Amy's confidence to let things emerge as a knower and her ability to work with students as an expert. Her actions claimed expertise in a non-traditional way.

Honing her Expertise as a Facilitator

Cultivating such a rich curriculum takes substantial expertise in multiple content areas to support students on their unique journeys through the project. Even though Amy indicated she self-identified as a pedagogical STEM content expert on her initial survey, she declined to call herself an expert during any of the interviews. Instead, she commented that experts consisted of "big names" in a particular field of study. She stated

that that it was difficult to think of a teacher in the classroom as an expert. Contradictory to her answer to the screening survey, Amy was unable to think of a teacher as an expert, suggesting that teachers are "less than" those working in the field doing research or working in designated STEM professions. This claim is not surprising. Munro Hendry (2011) argued that the dichotomy between female teachers and male experts came from disempowerment of teacher: "the isolation of teachers resulting from centralization and bureaucratization functioned to disempower teachers (female), by removing their decision-making power over curriculum and school policy and placing it into the hands of supposed 'experts' (male)" (p. 22). Female teachers have a long-standing history of being subjected to gendered ideologies.

Females are positioned to be skilled as teachers but not knowers or creators. The continued gendered control of education works to explain the deskilling of female teachers as active agents in decision-making regarding curriculum and education policy (Hendry, 2011). Historically, the role of the "facilitator" was for disseminating knowledge, not for creating knowledge. In this view, the teacher's role was passive by helping a child release their inner self. Valerie Walkerdine (1990) reflects on this concept:

> In some ways, it [facilitation] kept females firmly entrenched as caregivers. Female teachers because caught, trapped inside a concept of nurturance which held them responsible for the freeing of each little individual, and therefore for the management of an idealist dream, and impossible fiction" (p. 19).

Over time, however, the idea of facilitation has changed, mainly when applied to STEM. A STEM facilitator can be considered having deep knowledge about multiple areas of

STEM and can facilitate profound learning experiences guiding the learner to the desired educational goals (Allen, 2016). This level of understanding constitutes a high level of pedagogical STEM content expert and seems to embody the qualities of both feminine nurturer and masculine expert. The contradictions in this concept of the facilitator are many, with a lot to unpack.

Operating under the definition of a pedagogical STEM content expert as a teacher who is confident and able to facilitate a high-quality STEM curriculum, Amy demonstrated these qualities through her stories but hesitated to self-identify as such. She described self-identifying as a facilitator, a direct contradiction to how she self-identified in her screening survey. She considered herself in the background while teaching, setting up creative, project-based experiences, guiding the learning, and veering students away from misconceptions. Historically, the role of expert was a masculine notion referring to the male as the creator of knowledge. At the same time, the female was situated as the facilitator, not the constructor of knowledge but the one who delivers knowledge (Munro Hendry, 2011). Over time, after the turn of the last century, the reliance on teachers as the factory hand broadened with the social reconstructionist model where teachers were no longer denied any role in decision making but allowed agency in preparing for students for the future of the democratic society (Munro Hendry, 2011; Pinar, Reynolds, Slattery & Taubman, 1995; Kliebard, 1986; Tyack, 1974).

Schempp and Johnson (2006) describe teacher experts as those who can "observe a learning environment and discern critical cues that provide insight for informed and intuitive decisions" (p. 29). In this description, a facilitator and an expert are no longer opposed to each other. Juxtaposing the role of facilitator with expert opens the possibility

that one can be both, allowing a "multiplicity of voices that emerge from a self that is continually changing and under construction" (Smith, 2022, p. 121). Providing a space where a female educator can be both facilitator and expert allows them to be leaders as other academic authorities, as they enable students to learn. Female teachers have the capacity to grow and when they are allowed to explore their multiple voices and integrate fragmentation, they can confront their internalized oppression to take action for opening new possibilities of their evolved self. That action "could include theorizing females as teachers, researchers, curriculum creators in ways that challenged patriarchal constructions not only of 'female teacher professor' but also of the field of curriculum" (Miller, 2004, p. 70). Although not resolving contradictions, Amy participated in challenging patriarchal constructs through her pedagogical actions.

The historical practice of teachers as not asserting authority was to ensure a "pedagogy of patriarchy" (Munro Hendry, 2004, p. 17). In today's STEM world, such a historical practice is reflected in the current trend of inviting experts into the classroom to replace the teacher's authority in the classroom. In this context, it is not difficult to understand the disconnection between what Amy can verbally identify as and what she does in the classroom.

Lachner, Jarodzka & Knuckles' (2016) study described three aspects of an expert teacher: first, content knowledge in which a teacher has a deep understanding of the content she is teaching; second, general pedagogical knowledge of understanding the best practices to engage students in content knowledge; and third, pedagogical content knowledge, more specifically how to disband potential student misconceptions about the content. Amy's practice matched such a description: she developed an open, project-

based learning environment, using her STEM content and pedagogical knowledge to help students to understand the content and discover knowledge from their projects. She also guided their learning towards a more profound understanding while dispelling misconceptions.

As an example of developing and facilitating projects to guide students toward a deeper understanding, Amy described a STEM lesson in which she mentored a group of her female students to develop a scientific experiment and compete in a series of presentations in order to send it to the International Space Station. The students chose their project, she mentored their progress to design a solid experiment abiding by the rules and regulations of NASA. When their project was chosen to be launched into the orbit, she organized a trip to the Kennedy Space Center so that students could watch the launch and learn about STEM and space exploration firsthand through an immersed experience with the company of their families. Throughout this year-long project, she mentored students to do projects ranging from topics in the areas of materials engineering, chemistry, and biology. She guided the group of students in the DREAM UP project through tough competitions, NASA paperwork, and safety checks while teaching other students in her STEM classes. This experience demonstrated Amy's fantastic expertise and pedagogical creativity.

Building The STEM Team Intentions

Working at a private school, Amy believed she had more freedom to implement creative interventions to promote student progress. She did so regularly by spending a lot of time mentoring groups in the classroom to ensure each student could share their ideas. Amy described walking around the room and not calling out the female students in the

groups but asking each student in the group, "What is your idea?" She supported them in their thinking, asking probing questions and drawing conclusions to help them think deeper. Another intervention she employed was to group her female students into all-female groups from the start of the year. In a discussion about best practices in teaching STEM, Amy described empowering her female students through first grouping them into all-female groups to cultivate their own voices and after a couple of months, carefully starting to disperse them around the classroom to work with males. Amy observed that from time to time female students "shrink back and lose their voice in coed groups" and decided to allow the female students to find support in one another. Ample research suggests the benefits of promoting female groupings in STEM classes to cultivate STEM identity and leadership skills (Wieselmann et al., 2019; Hughes et al., 2013; Binchini, 1997). The suggestion is that coed grouping tends to result in males taking on more leadership roles and talk more often than the females in their groups, so this intervention makes sense. Many of middle school students had been with Amy since early elementary, and the trust and sense of community that had developed over time from elementary through middle school was a unique situation. Typically, teachers do not have more than two to three years to build community with students. In Amy's case, she had the opportunity to build community with her female students from early elementary, cultivating their sense of belonging and voice, so the intervention of female grouping worked well for her classes.

Throughout all conversations with Amy, she continually referred to the female students in her STEM class as a "team." This term went beyond the traditional notion of the team as a pedagogical approach to learning for developing cooperation and group

thinking. Amy mentioned the word “team” 26 times through her three interviews to indicating the female students in her STEM classes. The root meaning for the word "team," based on Old English, comes from the tight grouping such as family, more specifically childbearing, offspring, or brood (https://www.etymonline.com/word/team). Interestingly, the gendered root meaning of this word represents how Amy spoke of herself and her female students. When describing a recent time when her female students were split between her STEM class and the STEM class of another male teacher, she states, "We never thought we would be separated. We're just one team. Teaching them to do everything they have shown that they can do because they're amazing but do it with somebody else. We're all struggling with that."

When a student in the team decided to drop out of the STEM program because she was not in Amy's class and struggling with another teacher, Amy's response was enveloped in devastation. Amy commented on all the attempts to encourage this girl to stay in the STEM program, including offered her the chance that she would be back in Amy’s class next year. However, before the end of the first semester, this female student decided to drop. Amy received the call from her parents the same day as our last interview. Fighting back her tears during the interview, she expressed her feelings of loss for a team member to drop out. She described how she saw boys leave a STEM class for another class such as art and then return, but she said that the female students might not return. Her confidence in female students to explore alternate options and return to STEM was significantly less than her confidence in male students’ return.

Previously, I discussed a gendered paradox as a historical construct that creates an assumed dichotomy between the masculine role of STEM content expert and nurturing

female educator. Related to this, another tension can be identified through Amy's being both powerful as the lead STEAM teacher and powerless to persuade her student to stay in the STEM class. In addition, her duality of identifying as part of her student team and as the teacher of her students was caught in the tension between grieving for the loss of someone on her team and her own identity as a female STEM teacher. Identifying as a teacher who guided students in their own choices and identifying with female students as if they were her are not the same. Amy felt a heavy and even excessive sense of loss when one of her female students dropped the STEM class, which indicated the tension between identifying as a teacher and seeing herself in her students.

Teachers navigate a very fluid boundary between identifying with students and being authoritative. As a female teacher, that paradox tends to deepen, which becomes multiple fluid identities that require "working difference" (Miller, 2004, p. 181). A part of Amy identified with her student, and when a student was successful, she also felt successful, but when a student failed, she also felt a heavy sense of failure. Such a burden can be onerous for the morale of a teacher.

Quiet Resistance through Professional Development

My analysis revealed that the actions Amy took demonstrated she cared deeply about her students and had the level of expertise needed to provide them with high-quality STEM education. She was able to embody a pedagogical STEM content expert through these actions. All her efforts worked relentlessly to cultivate engaging STEM experiences, and diving into content based on her student's interests could be exhausting. So, what was driving her? Throughout our interviews, Amy repeatedly talked about her experience as a student and how she had to overcome her self-perceived shortcomings in

her higher education or work. Amy described herself as a new STEM teacher who had no idea what she was doing. She started with finding projects online and came up with a simple, prescribed curriculum for every student and did not give students any choices in what they must do for assignments. Quickly, she realized that she must make a change and teach in a new way. When asked to what degree she believed she contributed to her female student's success, she said:

> I know in our school environment, that's [Amy's pedagogical approach] not something they get inside the classroom. You don't have those opportunities not to have them - I'm trying to think how to say that. It's not as structured [referring to her STEM class]. Inside their classrooms and from music to most of their classes, there's so much structure for a student, besides recess, to be able to go to a class that's not structured so that they can think out of the box. I feel like I've contributed to that.

Loosening up the structure of teaching and learning, Amy resisted gendered scripts of conformity to provide something richer for her students.

Recently, there were faculty changes in her department, going from an all-female STEAM department, in which they traveled to professional development together and collaborated on curriculum and after-school program development as well as summer camps, to a coed department. With this change, the opportunities to travel for professional development lessened as it was more "economical and acceptable" in the eyes of her administrators. She stated now that there was no longer the same dedication to planning and alignment once shared by her coworkers, and she firmly believed that this change was disadvantageous to her school and students. As another act of quiet

resistance, Amy actively pursued other professional development opportunities. Without school support, Amy secured outside grant funds to attend courses for her own enrichment and wrote grants for additional supplies to enact curriculum change according to what she learned from these courses.

As a pivotal component of cultivating pedagogical STEM content expertise, Amy sought out professional development and opportunity for continuous learning, and her efforts demonstrated an act of quiet resistance against the patriarchal power systems through asserting her intellectual and pedagogical authority. Although the administration made changes to professional development that no longer allowed an all-female team, Amy found ways to overcome the blockade Amy. Through her persistence in attending professional development on her own and applying for grants or attending virtual sessions, she kept enhancing her expertise and persisted in developing a STEM-rich curriculum. Ensuring her students could thrive as they had before, but without the previous facility support, would Amy be allowed the same privileges to thrive as she once did? How long would she be able to quietly resist and open possibilities within the system (Munro, 1996; 2011)?

Case 2 Analysis: Suburban STEM Leader and Learner

Growing up in a small logging town in the west, the daughter of a medical professional, Lynn found passion in science with an interest in possibly becoming a nurse when she grew up. Part of a graduating class of 150, Lynn had found herself often one of a few females in her STEM classes, and she had very fond memories of those times. She said she knew everyone and built great relationships with other students in her physics, biology, and chemistry classes. Lynn continued her studies after high school graduation,

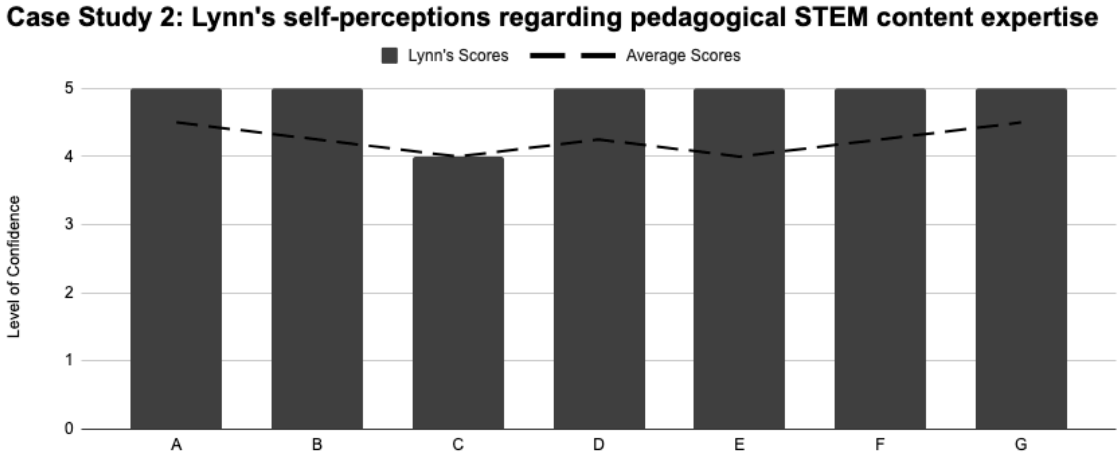
earning a degree in middle school education and multiple STEM education credentials from professional development experiences. These studies and education equipped her with curriculum and skills to enact STEM teaching in her classroom.

Drawing from her experience as a learner and educator, Lynn had a unique perspective on being female in the classroom. Continuing her graduate studies in education, she developed a positive outlook on being a female in STEM education, but she wondered: what if? What if she had been introduced to other STEM fields such as engineering? What would her life be like today? Would she be a teacher or engineer? Attending professional development courses throughout the years, she had found a passion and intellectual home in engineering. Understanding the processes and application of the math and science she loved, Lynn could easily see herself pursuing a career in STEM rather than STEM education. Perhaps, the hidden curriculum, the implicit discourse, and subconscious actions in her educational experiences played a role in not offering the possibility she could have seen for herself to become a STEM expert? Valerie Walkerdine (2004) explicitly focused on mathematics to uncover sexist bias in the context of STEM. She explains that hidden curriculum refers to the subconscious discourses in which "students are subjected to information or processes that would be extrapolated and taken to produce norms of feminine and masculine behavior, roles and stereotypes" (p. 103). Unaware at the time, female students may adopt these behaviors and roles by unconsciously aligning to predetermined gendered roles and possibly limiting their ideas of what is possible for their future.

Perhaps the regret of not continuing down the traditional STEM pipeline fueled her passion for exposing the females in her class to as many different STEM pathways as

she could fit into the school year. Even a snowstorm during a global pandemic did not stop Lynn from bringing awareness of STEM careers to her students. Schools were closed in the 2020 snowstorm during the COVID pandemic, but the STEM program was still in full operation. Lynn figured out how to bring 40 female students together at the school to participate in a STEM virtual field trip, and students participated in hands-on STEM activities and watching a virtual STEM panel composed of female experts. Similar to Amy's story about the NASA project, Lynn's exceptional work ensuring her female students' participation in the STEM program exemplified her exceptional pedagogical creativity.

Figure 4. Lynn's Self-perceptions regarding pedagogical STEM content expertise



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G. The degree of confidence in engaging both male and female students in STEM learning

The screening survey initially measured Lynn's confidence in teaching STEM (Figure 4). With her passion for STEM at the forefront, Lynn believed that every class should be taught in STEM ways. Through problem-solving strategies, STEM provided a

self-described "better way" for students to think, process, and learn. While thinking of herself as a facilitator rather than an expert, Lynn believed that STEM was a mindset that allowed for hands-on exploration and problem solving through self-discovery. As a STEM teacher, Lynn had grown in confidence in fixing equipment in her classroom, such as 3D printers, something she never thought she would be able to do, or think of trying to do, before teaching STEM. Through learning to teach STEM, she improved her problem-solving skills: "I've been learning to approach problems that way whether it's fixing something or just in life, meeting these life challenges." This role as both an educator and learner allowed her to expand her "professional knowledge landscape" (Connelly & Clandinin, 1995), becoming more aware of her role as a model for students' learning process from unknowing to understanding. Increasing resilience had been a positive effect of her STEM journey and she hopes to pass it on to her students, especially her female students.

Knowing and Teaching: Embodying a Facilitator

When asked how to define an expert, Lynn stated an expert was "somebody who went to school and studies and has done the research and been part of teams that have researched and collaborated and come up with data, solid data that can be backed up by whatever their studies are." Throughout Lynn's descriptions, she focused on the action of creating knowledge by "doing research" which a teacher is perhaps not required to do. This notion did not reflect the concept of pedagogical content knowledge or expertise but only the practical applications of constructing knowledge through the scientific process. When asked how she would define a facilitator, she responded, "someone who has a background but also uses their best knowledge to push something forward and guide in a

direction." Taking a moment to compare these two definitions, we can see that both described a person with enough background and context to push work forward, whether through devising solutions or guiding work. Lynn had a science background, taking many science courses in high school and undergraduate studies. She also participated in numerous professional development opportunities deepening her STEM content and pedagogical knowledge, and she was currently pursuing a master's degree in STEM education. During her master's studies, Lynn conducted a study on the effects of movement and learning based on her observations in her STEM class and the increases in students' engagement and achievement, compared to "sit and learn" teaching styles in more traditional core classes such as science, math, and English-language arts. Her interests in STEM and in teaching converged to develop her content and pedagogical expertise.

I already discussed the notion of expert was viewed as exclusively masculine as a historical construct. This ideology defined the role of an expert as objective and rational, in contrast to the gendered role of the facilitator, in which the subject/object relationship was more holistic regarding the relation of the self to others (Munro Hendry, 2011). Through this relationship, "the social self that becomes lost is the female self" (Munro Hendry, 2011, p. 182). Female educators refer to themselves in the third person making themselves invisible by erasing their gender, complying with the "assumed gendered neutrality that was embedded in the discourse" (Munro Hendry, 2011, p. 182). Echoing this historical account of expert versus facilitator, Lynn had the notion of an expert as objective and rational, and of the teacher as a facilitator to establish holistic relationships with students. My question is: Does it need to be a choice between facilitator and expert?

Is it possible for both expert and facilitator to be true at various times during teaching? Does the concept of facilitator and expert need to be binary? I think that the fluid meaning of facilitator can encompass both expertise in content and pedagogy. A teacher can be a facilitator while demonstrating excellence in content knowledge. Lynn demonstrated her willingness to engage in labs she was unfamiliar with and persisted in learning to teach students with a level of expertise while facilitating her students' learning process effectively. She did not lecture but thoughtfully curated experiences to guide students' self-discovery.

Like Amy's self-perception regarding her level of expertise, Lynn also lessened the value of her numerous learning experiences and considered how much time she spent "figuring things out" as not having excellent expertise. She generally underappreciated the role of informal education when describing expertise unless it was termed "self-taught." With the rise of computer science and computational thinking in the industry, many self-declared or known experts describe themselves as "self-taught." This term seems a bit of a misnomer as the act of purely discovering knowledge by oneself would be a very daunting endeavor. Typically, self-taught individuals seek out knowledge through informal education avenues such as the internet, literature, or other forms of media rather than attending formal classes. This learning pathway should not be underestimated. Even the gendered role of a female as a mother is self-taught. The very basic roles of parenthood are learned through discovery.

Informal education researcher John Falk (2018) claims that 95% of our learning comes from informal education. Every time someone becomes curious about a topic and takes the initiative to research on their own time, informal learning happens; this

encompasses everything that happens outside a formal classroom. As adults, the basic premise of our continued education is through self-education. Seeking YouTube videos about how to fix a leaky sink or researching expectations and available treatment options for a loved one who was just diagnosed with cancer is informal education. Learning how to code through code.org or understanding how to fix a 3D printer, as Amy or Lynn did, accumulated their expertise after continuous research, practice, and reflection. The point is if self-taught programmers such as Bill Gates, Margaret Hamilton, or Steve Wozniak are considered experts. Therefore, can't someone in education learning and developing a curriculum that demonstrates consistent high academic rigor to promote student achievement be considered an expert?

Until recently, there have not been preservice education pathways for STEM education. Even recently, most education degrees have a limited focus on STEM content mastery. If STEM educator desires to be impactful, they must pursue a level of self-education. More so, self-identifying as a facilitator where Lynn could guide students in the desired direction took on a lot more than content expertise, as her work required the pedagogy and agency delivering information in a relevant and impactful way for student growth and development. How Lynn worked to build her knowledge through informal self-education to teach her students questions the notion that experts are educated formally for creating knowledge. The continued narrative of the female teacher as facilitator and curriculum deliverer rather than knowledge and curriculum creator appeared in Lynn's story telling. However, I think it is a false dichotomy between knowledge creator and knowledge deliverer, further echoing the gendered notion of expert versus facilitator. Lynn demonstrated a hunger for knowledge and actively sought

out a level of expertise to effectively facilitate students' learning experience. Lynn also silently resisted the patriarchal script by pursuing opportunities to gain knowledge and skills in STEM content and pedagogy for creating deeper learning experiences for her students, especially her female students.

Digging Deeper: Gender Blindness & Internal Ambiguity

During one interview, I asked Lynn if she worked with female students differently than male ones. She pondered for a moment and replied that she tried not to see students in terms of race or gender, and that she saw students as students. While embracing the uniqueness of the individual regardless of race or gender has merit, one cannot discount the role and orientation that race and gender have on our identity. We are all subjected to the positive and negative effects of socially determined assumptions about race and gender. Operating within gender blindness could have unintended negative consequences by not acknowledging unconscious bias.

When we blind ourselves to our differences, we can become complacent in not noticing our unconscious bias and allowing it to be demonstrated in our actions, leading to the opposite effect to we intended. Patricia Lewis (2006) approaches this issue by claiming, "while appearing to be progressive, [gender blindness] conceals female's continued disadvantage, neutralizing gendered experiences which privilege the masculine" (p. 453). Her research also shows that gender-blindness tends to ignore the issues that those from the privileged gender group do not take notice, often related to their gendered privilege in daily life. Gender-blindness is a variant of liberal individualism that protects the privileged from blame for current inequalities while blaming the disadvantaged, implicitly or explicitly, for their current condition (Lewis,

2004). In post-structural feminist theory, the gendered difference must be recognized, although gender itself is a fluid concept.

In direct contradiction, Lynn also described a need to "protect" her female students, to the point it became evident to her that the boys in her classroom noticed that girls receiving preferential treatment. She described allowing female students to have the first choice at projects or first turns at resources. She narrated a time when one of her male students asked why the female students received special treatment. She responded, "Look around. I have to treat these female students special because there are two of them. They deserve to have some extra--" (Interview, 9-25-2021). Lynn's intentions are likely good, but potentially unintentionally singling out a specific difference as a reason for preferential treatment can lead to animosity and tension, further causing divisions between student groups in the classroom. In her actions, Lynn was not gender-blind and intended to support female students to combat the internalized gendered image. On the other hand, if the groupings were essentialized, they risked positioning female school students as unable to compete well in STEM. Constantly negotiating "a paradoxical zone in which the teacher's positioning can hardly be geared toward any neutral ground" (Wang, 2004, p. 164), Lynn's exercise of compassion and responsiveness could be both a support that provided her female students opportunities to move forward in their learning and a hindrance for female students to develop self-affirmation.

Singling out female students can lead to "othering" effect, in which female students are perceived as other than the standard and thus less than being adequate. When someone is singled out as different, special, or out of the ordinary, this can have an effect that contradicts what was intended. Suppose it becomes the main way in which a student

is seen and begins to see themselves, then it may lead to female students' increased insecurity and unwillingness to take any risk for new learning. Females are historically positioned as non-risk takers, whereas boys are encouraged to take risks and learn from failure (Saujani, 2016), as Amy's anxiety over her female student's dropping out of the STEM class showed.

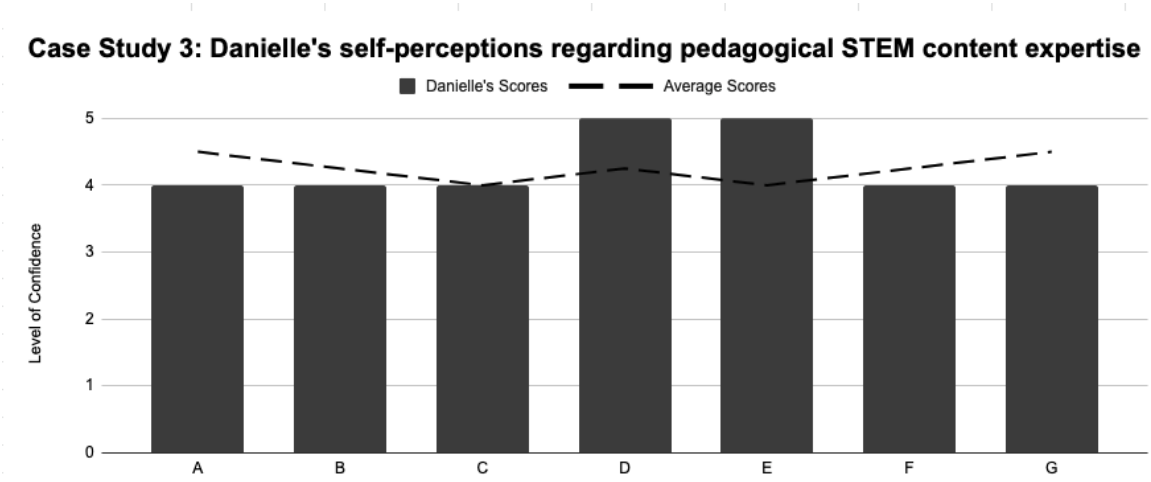
Case Analysis 3: Small Schools and Big STEM Ideas

Danielle was from a small rural school located less than thirty miles from a large metropolitan midwestern city. Surrounded by farmlands, her school had less than 1,000 students in the entire district. The entire K-12 was located on a single campus surrounded by fields. Down the narrow hallway, Danielle's class was full of interactive STEM materials, and long tables set up in rows mimicking a large picnic table. Each inch of the classroom was filled with materials, STEM kits, robotics, lab spaces, and work benches. Upon seeing how full the classroom was, I was surprised to learn the entire STEM program was non-existent only three years ago. Building from the ground up with no to limited experience teaching STEM, Danielle had created an incredible learning atmosphere and STEM program for her small school.

Danielle taught many subjects for many grades, but STEM was never one of them until three years before the start of this study. She started out teaching elementary for many years, moved to middle school teaching geography, reading, and one hour of science, and then her new principal observed her teaching science one day. The next year, he asked her to help start a STEM program. It began with one STEM class, and within the first year, there was a waitlist of students wanting to take it. The next year they added another STEM-1 class, and she filled the rest of her day teaching geography and math.

Her passion and persistence in cultivating STEM experiences for her students can be seen in the initial questionnaire survey (Figure 5).

Figure 5. Danielle's Self-perceptions regarding pedagogical STEM content expertise



A. The degree of confidence to facilitate STEM experiences with students
B. The degree of confidence to explain STEM concepts to students
C. The degree of confidence in having sufficient STEM knowledge
D. The degree of confidence in employing a variety of STEM principles
E. The degree of confidence in teaching STEM content
F. The degree of confidence in effectively monitoring student progress in STEM learning
G. The degree of confidence in engaging both male and female students in STEM learning

By the third year, she was teaching STEM courses at all levels: STEM-1, STEM-2, and STEM-3. Using grants, borrowed materials from a regional STEM alliance, and personal ingenuity, Danielle single-handedly transformed an empty classroom into a full STEM lab in three years, earning her the title of STEM Innovator for the state in 2021.

The Learning Pro…not the expert

Through the story above, it is easy to visualize how Danielle saw herself as a "learning pro." She believed she was an active student in the learning process, not as an expert, but someone who continued to adapt and gain new skills. This idea of the "Learning Pro" provides an interesting perspective, in which the teacher acts as an expert in searching for more knowledge to solve problems or questions. In this notion, the very

act of an expert is not to start with a high level of knowledge on a subject but to consciously seek out new knowledge to the level of expertise, in which the expert can successfully enacts skills or applies knowledge gained to solve problems or investigate questions.

When Danielle started using a piece of STEM technology called a Raspberry Pi, she had no idea what it was or how to use it. She knew the basics of building simple computers and games and ways to teach coding, but she had to learn how to teach others to use it. As a facilitator, she saw her teaching approach as one that looked for the resources and built the connections between them and her students. In the example of the Raspberry Pi, she confessed that she Googled what it was and learned some basic lessons related to it. In this case, the resource was her students, as she found two students familiar with the equipment and proclaimed them the class experts to help troubleshoot and teach others how to use it.

When asked how to define the term pedagogical STEM content expert, Danielle described someone with more knowledge, whereas a facilitator was someone who guided and assisted students. She also described how she had inspired other educators to collaborate on subjects such as social studies and English language arts. Other teachers worked with her to develop a curriculum that blended writing assignments, historical people in STEM achievements, and activities through hands-on labs. This level of facilitation demonstrated a deep knowledge of content which she was able to use to educate other faculty and help guide their curriculum development toward cohesive, immersive STEM experiences.

Sexism and Grouping

Early in Danielle's teaching experience, things were not quite conducive to collaboration, and there were concerns over females teaching science. When I asked about her early years teaching STEM, she recalled a time early in her career when she applied and interviewed for a middle school science teaching position. The principal told her they would not be hiring a female teacher for this position because they believed a female could not handle this class. Later, Danielle learned that there were allegations involving student harassment of a previous female teacher. The administration believed they would protect a future female teacher from such an experience, but this was a form of sexism she experienced. Knowing how she would go on to create the first STEM program in the entire district earning thousands of dollars in grant money and achievement awards, I think this school missed out on a great opportunity.

Years later, at the time of this study, there were still threads of sexism and gender stereotyping in her STEM class, but this time, biases entered into Danielle's pedagogy. In narrating her experiences, she used the language of assigning specific activities as a "guy thing" or a "girl thing." as Danielle reflected on a time she built rockets with her STEM class and how it was difficult to engage her female students, describing rocket building as a "guy thing." Whether or not Danielle was labeling the rockets as a "guy thing" or "girl thing" was not something I could fully discern from the interviews, but describing certain activities as a “guy thing” had the potential for gendered hidden curriculum to be embeded in the classroom. Danielle continued to recall that once they moved past the initial build and launch, the females in her class seemed to become more engaged and active in putting forth ideas on improving the rocket.

It is interesting to contrast this tendency of gendering different activities with the notion of boys learning to be risk-takers while female students are less inclined to take risks of failure. While female students in Danielle's class had the initial hesitation due to not knowing the risk, once they realized that failure in terms of the rocket not launching or landing correctly was low, they became more invested in the process. Their hesitation was associated to internalized gender biases. Research regarding gender disparities in STEM indicates that females may encounter negative reactions when they violate hierarchies in which males tend to hold positions of power (Glick & Fisk, 1996; Rudman et al., 2012). For example, a study shows that females encounter backlash when they threaten the status quo by demonstrating high levels of agency in STEM education or achievement (Robinette, 2016). This issue raises a nature versus nurture question: Are females inherently non-risk-takers? Gendered environmental influences position female students to do badly in STEM classes because they grow up not to play "guy things" and are not encouraged to play with Legos or construction toys when they were children. Instead, they were encouraged to construct houses and play with dolls cultivating their nurturing tendencies (Walkerdine, 2004). Research shows that it is more likely that female students will leave STEM fields by middle school but does not show any significant difference between male and female students regarding risk-taking or achievement before middle school years. They are more likely to be subjected to gendered stereotyping through hidden curricula and patriarchal systems as they grow up to reach adolescence, and tend to become more vulnerable to social pressures towards acquiring the qualities of traditional femininity and are less likely to choose a STEM area such as mathematics (Walkerdine, 2004; Shapiro & Williams, 2011).

Although slipping into gender labeling occasionally, Danielle understood female students' hesitation and had pursued strategies to keep her female students engaged in STEM. Understanding the importance that her female students see other females engaging in STEM, Danielle herself makes it a point to demonstrate doing the projects she had assigned to her students. Active as a facilitator, she did not intend to show the only right way to do something but to show the process of working on it. She learned that when her female students saw her try, sometimes fail, but persist through to the end, they were more likely to have a growth mindset and be more resilient when they struggled on projects. Through modeling, she encouraged female students to become more comfortable to take risks for learning new things.

Broadening the Idea of Team

A benefit of a small school where K-12 was located on the same campus was that Danielle regularly saw her students after they attended her class. Even when they could no longer take her classes due to an advanced math class scheduled in conflict with STEM-3, she could still interact with them regularly on campus. Danielle recalled one student who was very disheartened that she could not take the STEM-3 class, but she still stopped by nearly every day to see what other students were learning in the class. Danielle had tremendous hope and a positive outlook for students who, for one reason or another, could not continue her STEM classes to resume STEM learning when they moved into high school. When asked how she knew they would continue STEM in high school, Danielle referred to students' home life in which they still demonstrated interests in STEM related activities. She mentioned of one student: "she'll [the student's mom] send me little videos of her doing stuff at home or her mom will take pictures and tag me

in it" (personal communication, 11-22-2022). Moreover, from her statements it was obvious that Danielle was very connected to the parents of her students, and this connection is important for helping female students. The role of both teachers and parents in a student's life, especially related to STEM identity, are the top two most important relationships in a student's life (Walkerdine, 2004). The role of parents in STEM education was a vital piece to the puzzle for Danielle, and her notion of a team included parents in the community.

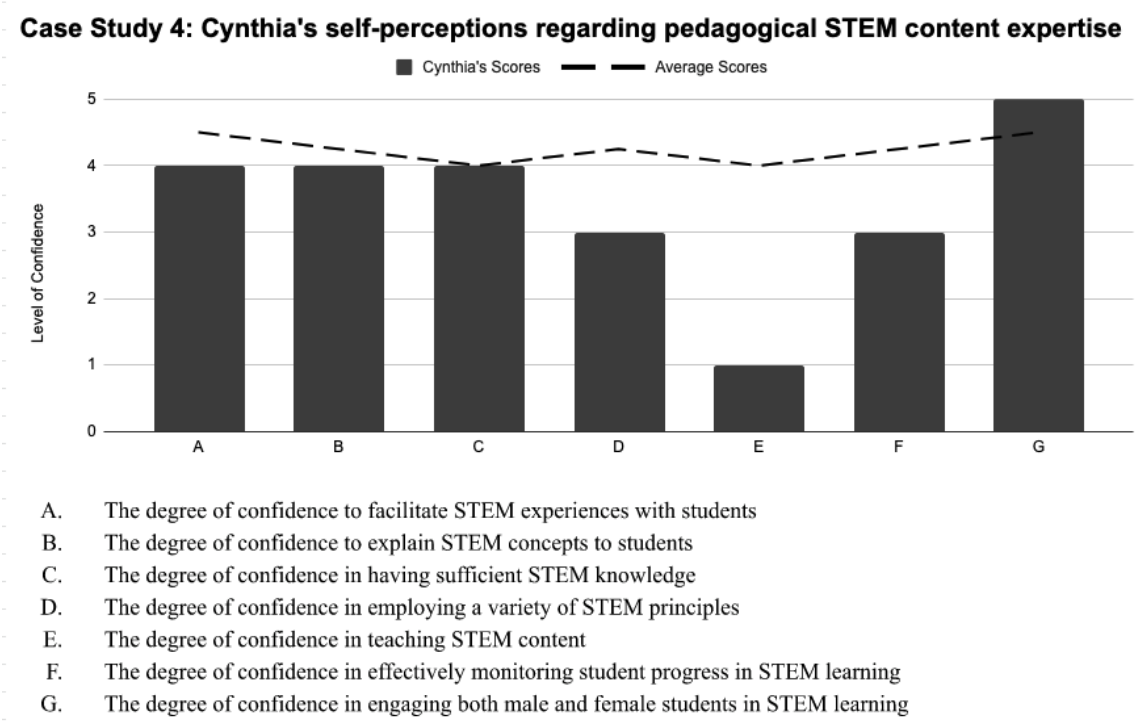
Case Analysis 4: Teaching and Self-Discovery in Rural Midwestern City

As a self-proclaimed "country girl," Cynthia described her home in a small rural school in a rural midwestern city. She began with a physical education degree, and STEM was not on her "to-do" list, but became the destination of a journey marked by passion, heartbreak, and self-discovery. She recalled that she was always interested in computers and working with them when she was young, but never took a computer class, and did not know STEM was an option. In junior high school, Cynthia taught herself to type to publish a book of poetry written by a family friend she knew. From then on, she found a way to incorporate computers into everything she pursued.

Early in her teaching career, she taught physical education, and she was asked to help teach students PowerPoint and other programs in a lab. Cynthia happily helped. After moving around to a few districts, including one of the largest metropolitan districts in a midwestern region, Cynthia decided that she preferred to teach in rural schools. With over twenty years into her teaching career at the time of this study and four years at her current school, Cynthia created a STEM program, a truly remarkable program, for the students she saw daily and throughout the entire district. With no formal STEM education

training, Cynthia was self-taught and gained skills and knowledge through professional development. In the screening survey, Cynthia responded to the questionnaire that she did not have high self-confidence in her skills and pedagogy in teaching STEM curriculum, but She indicated that she self-identified as a pedagogical STEM content expert and responded with higher scores in the other pedagogical areas (Figure 6).

Figure 6. Cynthia's Self-perceptions regarding pedagogical STEM content expertise



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F. The degree of confidence in effectively monitoring student progress in STEM learning
G. The degree of confidence in engaging both male and female students in STEM learning

At the time of this study, Cynthia's current district was a small, K-12 rural public district with about 255 students PreK-12 and the majority of them qualifying for free and reduced lunches. As a small district, Cynthia's impact had not only reached middle school, but she also provided training and mentorship for elementary and high school educators in STEM and computer science. Coaching the robotics teams for middle and high school, Cynthia had built the entire STEM program for the district and transformed teaching and curriculum across the grades.

Cynthia's belief that STEM was a mindset and a way of thinking critically about the world enabled her to develop the capacity and ability to equip and empower other educators in her district to integrate STEM into any content area. Taking the concept of STEM and applying it as "being able to look at almost anything and not only think about how it works but also" what is needed (Writing Prompt, 10-18-2021), she built an important bridge to use STEM as a pathway that can transform school curriculum as a whole rather than specific subject area.

Tension, Gap, and Ambiguity

Cynthia found herself constantly battling predisposed stereotypes in allowing students to grow in their interests. In her descriptions, I detected that she believed there was a stigma for female students in her classrooms, who were supposed to perform certain tasks like marketing or designing the presentation, whether or not they were explicitly told so. To combat this type of bias, Cynthia assigned tasks gradually to female students who seemed hesitant to engage in STEM learning, such as starting with ironing on bumper stickers on the robots and then moving into coding and building. Step by step, she worked to build students' confidence and combat the stereotypes through students' gradual process of taking risks in new learning.

When asked about the struggles she negotiated within herself to better relate to her female students, Cynthia reflected on her personal experience. She recalled the hard work she had to do to emerge from her divorce. A mother of two female students in seventh and fourth grade, she remarked that the divorce crushed her sense of the self. Married for many years, raising their daughters together with her husband, Cynthia found her own identity tied to him. Without him, she no longer knew who she was. As a wife,

she melded her identity with his, and once that was fractured, it took a long time for her to reclaim herself and affirm her own worth. Her identity had been wrapped up as a support for her husband and his career. She was "his wife," not herself. Embarking on her journey of self-discovery, untethering herself from the identity of wife to an independent woman, she finally claimed the freedom to be a mother, woman, academic, and educator. In doing so, she unlearned the historical gendered identity that was confining to her but she had been living with for so long. The act of shifting self-erasure in which she positioned herself in a supportive role for her husband for so many years to self-empowerment in which she became the author of her future was a long and difficult journey.

Through this journey, Cynthia believed that what she had learned about understanding a female's place in relation to a male helped her see that many of her female students' self-confidence was hindered by being seen as less than a male. In the classroom, she saw the boys step up to the task without fear of failure. On the other hand, the female students hesitated to ensure that each first step was correct so as not to subject themselves to potential humiliation or wrongdoing. Cynthia had won educator awards and grants, and her colleagues applaud how incredible she was as an educator, but the little voice that said she was not good enough still echoed in her ear. Only recently did she begin to see herself as a contributor to the world. Instead of always looking at others such as astronauts, engineers, scientists, or the "really cool people" (Interview, 10-25-2021) as those who contribute to society, she finally started to realize the influences she had on the world around her. Through this confidence, she was empowered to encourage

her female STEM students to go beyond what they thought as possible, push the limits of their self-expectation and take on new tasks that they were hesitate to take.

Embracing Multiplicity

Throughout the interviews, Cynthia discussed the need to empower females in her class to advocate for themselves and build their confidence. Working in multiple districts over the years, she discovered one constant issue: females, in general, were more apprehensive about starting projects they did not have a lot of experience in, such as robotics or engineering, compared to the boys in her classes. When asked why she believed this to be true, she discussed the role of media portraying females as characters with qualities such as pretty, smart, or dumb but rarely multiple qualities such as smart and pretty or smart and strong. When young females see such images, they develop the idea that a female can only have one singular quality. They can be pretty, strong, or smart but not a combination of any of those qualities. Janet Miller (2005) explores the constructions of female identity by reshaping the rigid boundaries:

> between public and private spaces to allow multiplicity to co-exist, which also include notions of communities and collaborations without hierarchies and mandated consensus. Instead of promoting unity and sameness, Miller advocates that female teachers should struggle together to create versions of the curriculum, teaching, and learning that do not posit particular voices, bodies, and experiences as representative of all. (p. 82)

Embracing multiplicity stood out in Cynthia's STEM teaching. Cynthia intentionally worked to resist the gendered roles portrayed in media but exposed her students, especially female students, to diverse experiences much beyond those portrayed in media.

She encouraged her students to code, develop apps, builds robots, and cultivate their voices.

Describing how her perspective was enacted in her classroom, Cynthia recalled times when the female students were apprehensive about starting a project when the males would jump in with an Allen wrench in hand whether or not they had ever held one before. The females would pause before picking up any tools and ask, "What do I do?" while the boys in their group jumped in and started working on the project, even when they did not have a clear plan in mind. Recalling other similar experiences, Cynthia continued to explain that some of her female students internalized a gendered labor division and often commented, "that's boy's stuff; where's something I can do?" In such situations, Cynthia worked to encourage her female students to take the next step and told them: "You just need to learn how to do it."

Empowering her young females was a priority for Cynthia in this small STEM class in a rural midwestern city. She declared, "I love to empower my students, and so being able to provide them with the STEM environment and empower them to think bigger, I love being able to do that. For selfish reasons, I love to see them be able to do that" (Interview, 10-20-2021). Anchored in her experience of self-erasure, Cynthia considered her passion for female students to overcome obstacles as “selfish,” but her work was to encourage the female students in her class to develop their own identity, independent of patriarchal systems.

Allowing her female students the opportunity to see themselves as more than singular qualities but as multi-dimensional, complex, strong, empowered female leaders in her classroom was a central mission in her work. It seemed, for this reason, she pushed

her students to develop their selfhood, consistent to Foucault's notion that the self is "an unending process of creation and recreation" (Wang, 2004, p. 43), continually in flux. She challenged them to think of themselves as "in-the-making" and thinking of identity as a reiterative process of coming into being and simultaneously failing to adhere to the "fixed" and gendered notions placed upon them (Miller, 2004). Challenging students to think outside of what they were normally comfortable with and to try something new, even if they might fail during the process, are crucial to growing and becoming resilient in STEM learning and life, because learning from failures is an important skill to develop. She also encouraged her students to know there was always something to learn and grow even if class projects were not aligned with their personal interests. She taught them that whether the learning involved negotiating with their team, or understanding a concept that could be applied to other projects of greater interest, learning could grow into something fruitful for the student.

During one of her robotics seasons, like in other years, only a few female students were on the team. Most avoided the coding aspect and took on other important tasks such as developing the presentation or marketing. The male students on the team continued designing and coding the LEGO robot while the female students worked on other tasks, even though Crystal encouraged them to mix up the team responsibilities beyond gender divisions. Then, suddenly a few weeks before the competition, all the male students working on the design, engineering, and coding quitted. Their reasons are unknown, and from the received information from Crystal's inquiries to their parents, she believed that the reasons were potentially unrelated to the robotics team. Still, the robotics team suddenly had no coder, engineer, or designer. That was when the female students stepped

in. One of the female students, Rachel (pseudonym), had no coding experience but stepped up and taught herself how to code. She came in on lunches and during advisory periods to work on her code and was ultimately able to make the robot operational. The team was able to compete in the regional competition. Crystal reflected on this experience and commented that female students were simply more reliable: "Somebody is going to have to step up, and nobody's doing it. It must be me" (Interview, 9-15-2021). Cynthia and Rachel continued to work on the robot together. When Rachel was frustrated when the code did not work properly, Cynthia drew parallels between the real world and the unpredictability and often unfairness that we all had to face from time to time. Through this process, Rachel's mindset shifted toward seeing unpredictability and failure as challenges to empower herself and grow her confidence in solving problems.

Rising to the occasion is a valuable and empowering skill for female students to have, but Rachel's story highlights a deeper issue: Why must one *wait* to rise to the occasion? Cynthia described multiple times her female students tended to be quiet and stay back at the beginning while male students just jumped in. She even recalled her own life experience when her dad jumped in to fix problems, regardless of his knowledge or comfort level, but "eventually he just let the mom take over because it's easier just to let her do it" (Interview, 9-15-2021). In her experiences, Cynthia also adopted the mindset, "if nobody else is going to do it, then she must do it," regardless of what the challenge was, but the gendered nature of waiting for others to lead needs unpacking. Rosser's (2000) research regarding the stereotypes and limitations placed upon females to prevent them from embodying a full version of themselves is relevant here. Identifying in her own and students' lived experience the females' tendency to hold back until there is no

one left to take a task before they stepped into taking on the task, Cynthia became aware of the need to encourage female students to take initiatives.

Meador (2018) examined the phenomenon of stereotype threat in education that adversely affects the retention and recruitment of minorities in STEM programs. Stereotype threat is identified as one or more self-perceived concepts that create apprehension to engage in certain behaviors that may confirm negative attributes commonly associated with their minority group membership. Cynthia's comments about her female students being hesitant to jump in could be an example of this phenomenon, which inadvertently confirmed that male students were better at STEM than female students. Females can become more hesitant to take on difficult classes when such a stereotype is present in their minds. Such stereotypes can cause apprehension and a deficit in performance (Beasley & Fischer, 2012). In Cynthia's class, it was a stereotype that females were not expected to be the ones who did coding, designing, or engineering the robot, which made female students hesitant to step forward in the beginning.

Cynthia's ability to pull in her own experiences to encourage her female students to engage in her STEM classes was an important step in combatting gendered stereotype threats. Alongside her students, Cynthia was also heavily involved in mentoring other educators in the district so that teachers could work together to provide STEM opportunities for students in all the K-12 levels. Perhaps a benefit of working in such a small, one-campus district, she could quickly mobilize other educators to adopt project-based lessons and establish robotics and coding clubs, teaching alongside them to model best practices in teaching and working with diverse students. Cynthia's journey was not straightforward and full of unexpected heartbreak, but she persisted. Her expertise in

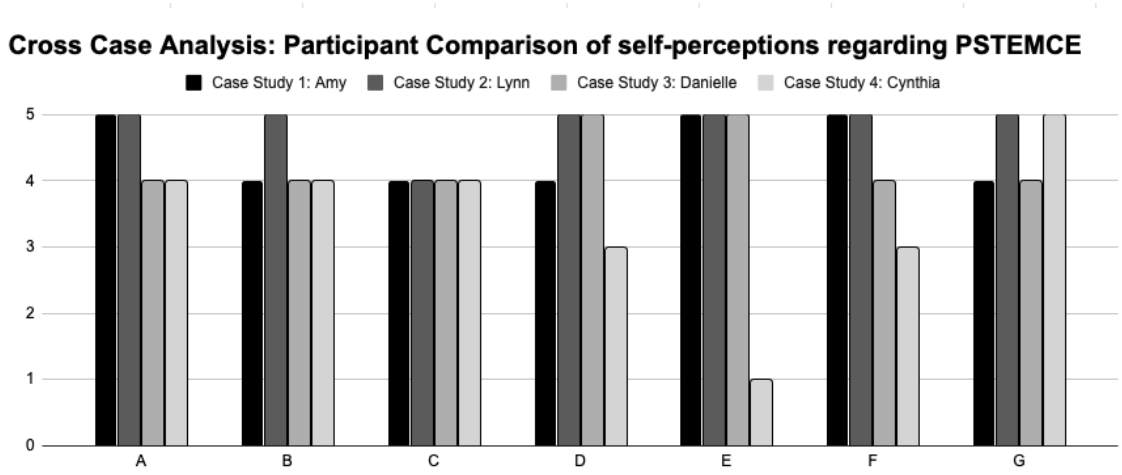
STEM and pedagogy would continue to impact female students many years into the future.

Cross-Case Analysis: Merging the Storylines

Independently, each participant demonstrated their pedagogical STEM content expertise through excellence in providing engaging experiences and student mentorship in STEM education. A characteristic of pedagogical STEM content expertise is the ability of a teacher to organize their knowledge in such a way that can result in more coherent and elaborate curriculum scripts. Curriculum scripts are "higher-order structures which integrate subject-matter knowledge to be conveyed together with pedagogical content knowledge" (Lachner et al., 2016, 9. 198). During the focus group interview, the intersections between each case became more apparent, and participants' desire to provide exceptional STEM experiences for their students was seen clearly. Moreover, the results from their initial surveys indicated some interesting trends across four cases (Figure 7).

Throughout the initial surveys, all participants responded relatively highly confident regarding STEM facilitation and pedagogical skills. I need to point out that the question not shown on this graph is the question in which all participants responded that they self-identified as a pedagogical STEM content expert. This question was a simple yes or no question with no option for further explanation, and each participant chose "yes." The responses were mixed when it came to how they self-identified regarding their skills in implementing STEM and monitoring students' progress. Coupled with the responses from interviews, writing prompts, and a focus group, it became clearer that the

Figure 7: Participant comparison of self-perceptions regarding pedagogical STEM content expertise



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participants believed that they had a high degree of ability to implement STEM and provide educational experiences leading to student success. Still, they were also hesitant to identify with being an expert in their interviews or focus group

Each independently rose to the challenge of establishing a STEM program at their school and navigated the challenges and assumptions they encountered, and all four teachers established locally recognized STEM programs with recognitions of numerous grants and awards for their efforts. It is clear to me through my analysis that each participant was an exemplary example of middle school STEM leadership. Through their shared perspectives, they described how their identities and unique positions interacted with their curriculum and pedagogy and influenced their interactions with female

students. In this cross-case analysis, I discuss points of commonality and tensions through a poststructuralist feminist lens of identity, power, and difference.

The complex interplay between being a nurturer, expert, and facilitator

One commonality that rose to the top was the facilitator concept throughout the interviews and the focus group. Regardless of their initial survey where they identified as a pedagogical STEM content expert, all four participants pushed back on the term of expert and used the term of facilitator during discussions. Each, in their own ways, defined facilitator as something less than expert, but from my analysis, I have come to believe their shared experiences demonstrated skills and knowledge far greater than content expertise, coupled with a high degree of pedagogical expertise, to empower their students to learn in STEM courses.

Reflecting on the difference between facilitator and expert, the participants self-identified as an educator who was responsive to their students and focused on creating something "truly amazing" (Focus group, Lynn, 10-21-2021) in terms of STEM education. Going against the mainstream way of teaching in each of their schools, they broke barriers to teach through project-based and student-centered design rather than traditional lecture-based approaches. Choosing projects that challenged not only their student's understanding but their skills and content knowledge, they learned and grew with their students, purposefully developing their skills on an ongoing basis to improve their teaching practice. Their role as facilitators involved being astute in group dynamics, using processes such as conflict resolution, strategic planning, and team building, as well as being active listeners and engaging leaders, which went beyond the expectation of

being confident and competent in their content knowledge (Reeve, 2006). The following descriptors are related to the notion of expert and facilitator, which I juxtapose in Table 2. Their notion of expert and facilitator brought forth almost a dichotomy in which the expert held a higher level of knowledge, and the facilitator was the composer of applications.

Table 2. Key Descriptors related to expert and facilitator

	Key Descriptors of Expert	Key Descriptors of a Facilitator
Amy	• Formally trained professional in their specific field of study. • Someone well known in their field. • An expert knows what knowledge someone needs to walk away with.	• Empower students to think differently • Real world application • Someone who sets up an experience where there are multiple solutions to a problem • Helps students apply previous knowledge
Lynn	• Someone who went to school and studied and conducted research in their field of study. • Perhaps in education, the term for expert would be “master teacher”	• Developing the recipe for learning but allowing students to create their own unique solutions. • Flexible • Relevant • Someone that can use their knowledge to push something forward
Danielle	• Someone with more knowledge base than a facilitator. • Someone who can definitely answer any questions pertaining to their field of study.	• Inclusive to multiple learning styles • Cultivates student voice and student agency

Cynthia	• An instructor at a higher education institution • Someone who is intimately directing the learning • Someone with a high level of knowledge about a particular field of study.	• Open-ended in which you don't always know where the lesson will lead. • Flexibility • Student autonomy to where they are almost able to fully control their learning experiences

The juxtaposition of the participant's views regarding expert versus facilitator visualized in Table 2 highlights the overarching theme where they collectively described an expert as someone with more knowledge and positioned at a higher place of power and authority than what they described themselves as facilitators reside. Hendry (2011) describes a similar analysis, "the isolation of teachers resulting from centralization and bureaucratization functioned to disempower teachers (female), by removing their decision-making power over curriculum and school policy and placing it into the hands of supposed 'experts' (male)" (p. 22). Hendry's account of a larger-scale study seemed similar to the discourses and ideologies present in the data for this study. It indicates that there is still much work to do to resist the systems of power that continue to perpetuate disempowerment of teachers. However, this dichotomy is not absolute. As Lynn described, a "master teacher" was the indicator of an expert, as Table 2 shows, and her perspective blurred the lines between the expert as the authority and the teacher as the facilitator.

Between this space of expert and facilitator lies the role of the teacher. Not explicitly mentioned in these statements, but through the interviews and writings, each participant individually and collectively discussed their role as a teacher to provide a nurturing and encouraging environment for their students, especially their female

students. Some actively protected their female students by making it known to all students that they were special and deserved special treatment. Others coached and mentored them through acknowledgment and championing their success. This space of may reinforce the gendered narrative of the teacher as female and the role of the facilitator in education.

Between these two concepts also lies the role of nurturer. Although the term nurturer was not directly mentioned in the data, the descriptors for the facilitator suggest the image of the female teacher as the nurturer. The term nurturer has traditional roots in femininity and motherhood and is linked to traditions of female teachers. Trousdale (1994) examined how female teachers are portrayed in children's storybooks. Many books present an image of the teacher "as an extension of the mother, as a nurturing, protective and caring person who is indeed able to provide a secure environment" (Trousdale, 1994, p. 202). Females continued to be socialized to be kind, considerate, and caring, embodying the *good girl image* (Miller, 2005). Why must females, especially female teachers, be limited to only one identity? Walkerdine (1990), in one of her earlier works, warns about the risk of labeling pathological nurturance as essential to female teachers. Such a teacher can become fixed on being nurturant and nice or even being seen as the babysitter or older sister, rather than a compassionate educator who is also an expert in her content and pedagogy.

During the focus group, Danielle remarked how she treated the students in her STEM class: "I treat them just like I would to my very own kids, so when they walk in the classroom and I tell them so" (Focus Group, 10-21-2021). Echoed around the rest of the focus group, each member described their love for their students and the overlap of

rules between their household and classroom. Amy chuckles while she admitted, "We don't talk about *Fortnite* because I don't allow it in my house, so I don't allow it in my classroom either. That's just the rule" (Interview, 9-16-2021). It is important to note that Grumet's (1988) work points out that when teachers identify students as their children, students' parents' roles disappear in teachers' ownership. Through the continued discussions during the interviews, all participants who made such claims also discussed how they involved the parents in their classrooms and kept in close contact with them. When describing their role with female students in their class, they were more welcoming to the idea of nurturer in contrast to the idea of being an expert. The relationship between these two roles could be re-thought. Nel Noddings' (1984) work argue that "a more nuanced awareness of the complexity and interconnectedness of authority, responsibility and nurturing might be essential to a well-anchored sense of professional identity that integrates personal as well as social aspirations" (p. 311).

In direct comparison, the term expert is defined as "(noun) a person who has a comprehensive and authoritative knowledge of a skill in a particular area" (Expert, 2022). The expert teacher is one with the experience to read a classroom effectively and differentiate student experiences as needed for creating the best learning conditions, and such a teacher have a large amount of knowledge regarding pedagogy and content (Lachner et al., 2016). In a study uncovering the best practices of educators in the US and China, researchers narrowed it to four main components: personal characteristics, planning and assessment, instructional practice and classroom organization, management, and discipline (Grant et al., 2014). These components are compatible with Lachner's

(2016) work in describing the expert more as an academic, authoritative presence than a nurturer.

These gendered concepts of nurturer and expert lend themselves to the double conformity described in Walkerdine's work as the "dilemma of a situation where there are two mutually conflicting sets of standards or expectations to which persons have to conform" (Walkerdine, 2005, p. 10). If the standard of expert is understood to be stereotypical as male and academic and nurturer is understood to be stereotypical as female and non-academic, then teachers' conforming to the standard of expert conflicts with the standards of femininity.

Embracing multiplicity was implied in the participants' work and my experience. My early training as a wildlife biologist allowed me to develop expertise in an area of study that I could then take into the classroom, teaching at zoos. The pedagogical skills I developed while teaching and through my graduate work in education and curriculum studies allowed me to be both an expert and facilitator. Webber and Mitchell (1996) think that nurturing and authoritative images are not mutually exclusive. They argue that the tendency to misconceive or artificially polarize them reflects the teaching profession's preoccupation with the appearance of authority rather than an open-minded dwelling on the deeper meanings of having both authority and caring qualities. I think that limiting female teachers to one role limits the experience of education itself. Can we imagine a new notion of what a pedagogical STEM content expert can emerge embodying multiple identities of nurturer, facilitator, and expert?

The participants hinted at a gendered dichotomy: "I just see teachers, I don't see men or woman, but I do notice coaches and teachers" (Interview, Cynthia, 10-20-2021).

The dichotomy between coaches and teachers as Cynthia mentioned alluded to a gendered binary between the coach, situated as the stereotypical masculine, and a teacher, situated as the feminine. She continued to describe coaches as the ones focused on the game and a specific target in a tournament, while teachers focused on curriculum. The stereotypical roles of coaches and teachers need to be questioned since female educators are individuals of multiple identities.

The multiplicity of both masculine and feminine could suggest room for moving fluidly between nurturer, expert, and facilitator identities as an effective way to bridge the duality of teacher expert and teacher nurturer. Green Run Collegiate, located in Virginia Beach, VA, no longer uses the title of the teacher and embraces the concept of teacher-facilitator. According to their job description for a teacher-facilitator, they describe this position as someone who provides:

> an educational atmosphere where students have the opportunity to fulfill their potential for intellectual, emotional, physical, and psychological growth; evaluates the needs and abilities of students, and determines methods and techniques to best present and provide instruction to students within assigned subject areas; ensures students show continuous improvement in learning basics and essential skills; embrace technology and looks for purposeful ways to engage students; welcomes the challenge of creating and engaging and rigorous curriculum that makes a connection to important concepts and ideas within and across disciplines (Teacher-Facilitator, 2013).

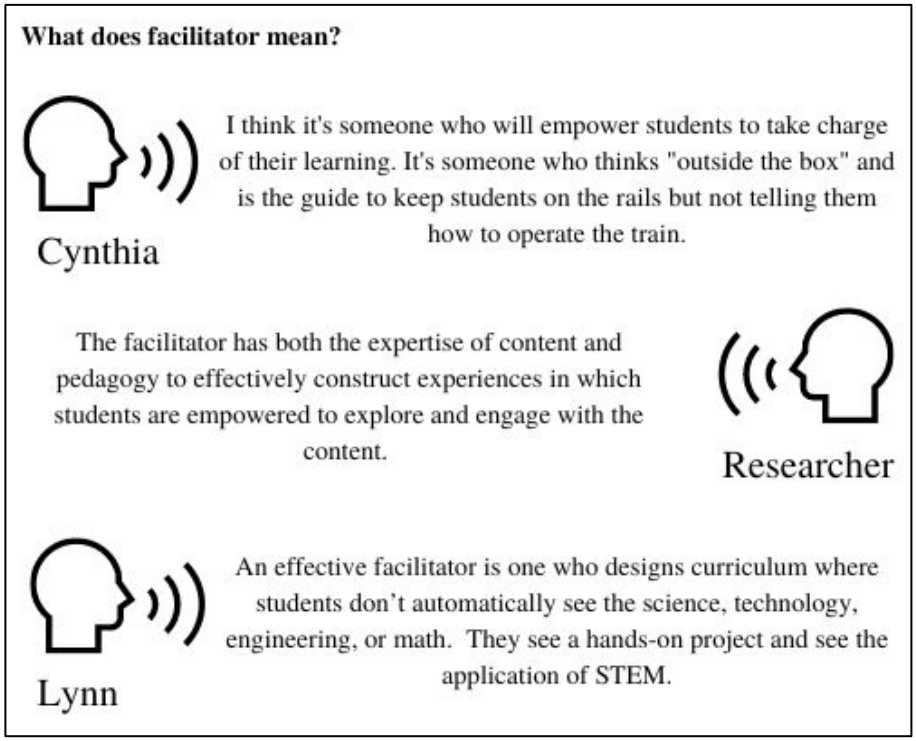
In this description, the term expert or any reference to the qualities of an expert is completely absent. Further ingraining the concept of the teacher solely as facilitator, this

description emphasizes the role of the teacher as the one disseminating prescribed knowledge but not the one creating knowledge, reinforcing gendered biases. The term facilitator was repeated throughout individual interviews and collectively during the focus group in my study, but I argue that the collective responses of my participants regarding how they used the term facilitator and pedagogical STEM content expert suggest the possibility of embodying both feminine and masculine elements in their gendered identity. This redefinition comes from my analysis, but I am also aware that there is no final word for the complexity of a female teacher's identity, and the facilitator is not free from gendered implications. To hold open the complicated interplay of three roles, I use a juxtaposition in Figure 8—reconstructed from interviews--to show this tensioned space of intersections and differences.

Through the conversations in Figure 8, the term facilitator takes on multiple meanings among the participants and the researcher. Cynthia saw the idea of a facilitator as a part of how someone teaches, Lynn described it more as how a teacher designs curriculum, and I claimed both content and pedagogical expertise. The nuances of teachers' difference created space for the multiple sub-identities of a facilitator, but both allowed for the teacher's ownership as a knower and creator of content through designing and engaging curriculum. It goes beyond the application of content and curriculum but flows through the relationships within the classroom. Cynthia focused on empowering students and thinking outside the box, while Lynn focused on curriculum design and using facilitation as a way of using her knowledge to transform content for students to make connections. In my experience of developing curriculum, teaching professional development, and leading students, I tended to stand in the in-between space of Cynthia

and Lynn's description but also directly claimed expertise. In presenting my own perspective in this way, I visually show my intersections and differences with teachers. Through my experience of trying to cultivate a deep understanding of developing and delivering an engaging curriculum for students in a way that they can grasp, question, and interact with, I find a need for deep knowledge and a high degree of pedagogy to translate that knowledge and deliver it to students. I find the merger of a content expert and a pedagogy expert is essential in effective facilitation. It is simply not enough, from my experience, to casually deliver knowledge. A teacher must enter a teaching space with a high level of confidence to interact with the content in order to engage students in learning to the degree they can think critically about it, question it and develop their understanding.

Figure 8. female teachers as facilitators versus pedagogical STEM content experts?



Throughout conversations with participants, additional keywords regarding the role of a facilitator emerged, such as empowerment, creativity, content expertise, effectiveness, and engagement. All these terms are key in delivering high-quality STEM experiences (PEAR, 2021). PEAR (2021) states that these dimensions evaluate in-school and out-of-school STEM experiences. Studies have shown that incorporating high-quality STEM attributes, including declaring specific STEM content goals, inquiry, relevance, and engagement with STEM, allows for a higher degree of student success, peer-to-peer relationships, peer-to-adult relationships, and an increased chance of students' developing a strong STEM identity. It is interesting that the participant's choice in using the term, facilitator, rather than nurturer, which can be seen as a more feminine term, seems to indicate their ambiguity in navigating gendered implications of these terms. While my redefining of facilitator as having expertise has tensions with participants' focus on teaching and students rather than on their expertise, our differences are not without intersections where they intuitively act as knowers. However, the gendered connotations of facilitators do not disappear but are unsettled.

Each participant discussed the opportunity of student voice and choice in facilitation, in which the teacher positioned themselves as the guide, allowing students to make choices regarding their learning. In my interview with Danielle, I asked her how her female students interacted with the STEM lessons she taught. She responded:

> I think whenever the kids are the ones that are helping guide what's going to be taking place in the classroom. Then they're finding their voice because there are many kids out there who are just sitting back. They're the nice quiet kid that you never hear anything about, but once they're in a STEM classroom. You have all

> different types of kids in the classroom. In those creative activities, they can then help groups out with, 'Hey, let's try it this way.' I tell my kids every single time we start something, 'You need to listen to everyone in your group because this kid over here, he may have a good idea, this kid have a good idea' (Interview, Danielle, 10-20-2021).

The role of the facilitator's identity is not to be taken lightly here for Danielle. It embodied a large level of confidence and competence in content knowledge while the teacher's intuition, flexibility, and creativity to differentiate learning and provide productive learning experiences for diverse students. In discussions with my participants, the term facilitator was also seen as *less* than the expert was. Each participant vocally declined the title of expert but chose to claim facilitator for themselves. The gendered connotations of the term facilitator suggests it brings in lesser quality than an expert does, because the teacher only delivers the curriculum rather than creating knowledge. In Joe Cosette's (2014) poem, *The Persona of a Teacher,* he describes the complexity and multiplicity educators must embody to provide effective STEM learning experiences. It is noteworthy to mention that the concept of persona is different from the notion of identity, but Cosette's juxtaposition of the different roles illuminates the teacher's multiple, fluid, and often contradictory roles.

The Persona of a Teacher

As a scientist and teacher, I like to make things clear:
If a system receives inputs, certain outputs should appear;
When I put a plant in sunlight, and give it water, it should grow;
When I drop a ball and let it fall, I know which way that it should go.

On the whole, we find connections relating everything;
In isolation, we can see outcomes our actions bring.
We don't need to know the details of what makes our world respond,

As long as it repeats, we know right where it belongs.

Teaching, I'm afraid, is much messier than science.
It is built on hopes, and fears, independence, and reliance,
The way things are presented, and the way that they're received,
The things that bring us struggle, and the things that we've achieved.

Science would predict that, if a lesson finds success,
The instruction should repeat and produce the same process,
But the variables have changed with different students, different classes.
That A-plus bit of teaching is now viewed through different glasses.

I think that the profession wants to test and quantify,
To think of things as actions to check off and verify,
But the rubric doesn't score what the rubric cannot see:
A hidden, special something makes the evals disagree.

I have always been aware of the existence of a feeling
That makes some teachers magical, inspiring, and appealing.
This "it" factor of sorts cannot be learned from a book;
Sometimes it's wit and humor, or a reassuring look,

Sometimes it's being flexible when no one else will budge,
Sometimes it's holding ground when students need a steady judge,
And sometimes it is age, gender, background, race, or creed
That helps establish bonds that a certain student needs.

So, what is the persona that I've crafted and presented?
Is this really me, or a character I've invented?
If I'm always intentional, does it make me less authentic?
Is a teacher's persona something more, or is it propped up by aesthetic?

When my students face struggles, I try to be understanding.
I push all my students, but I'm not too demanding.
I show them I care through dedication and through prep,
But if the plan takes a turn, I'm not afraid to sidestep.

I'm quick to respond with a line or a joke.
I try hard to be "with it" or (as the kids say) "woke."
When I teach, I perform to make our lessons exciting,
But does that improve their learning or just give it nicer lighting?

The person that we are is how our students find their space.
They see the way we act, and they analyze our face,
This also shapes instruction and the style we present.
There's more to our curriculum than worksheets and content.

In a world and a school where content is king,
I think we should reflect on the persona we bring.
How do we make visible these aspects from within?
How can we define ourselves from the moment we begin?

And how do we respect that there are other ways as well
That are as (or more) effective to help students to excel?
And probably most essential, how can we quantify the hidden
So the evals are wholistic and the rubrics are rewritten?

There may not be an answer, but I think that it's all right.
My goal here is reflection and perhaps to cast a light:
We all provide our "something" and we all deserve our feature
Because we live our lives in the persona of a teacher.

Navigating between identifying with versus identifying away from female students

Within the multiple identities that teachers navigate, the role of the teacher in the teacher-student relationship was a theme that emerged across four cases. The concept of teacher identity is broad and complicated, and for this study, the term identity narrowly focused on the relationship between the teacher and their female students from the teacher's perspective. Akerman and Mejer (2011) discuss a similar concept of identity related to teacher-student relationships as "evolving 'sub-identities' [referring to multiplicity], as being an ongoing process of construction and as relating to various social contexts and relationships" (p. 310). Within the extensive issue of teacher identity and sub-identity, the issue of how the participants saw their relationship with their female students stood out from my analysis.

Two potential sub-identities emerged from the process of analysis: identifying with versus identifying away from female students. For the purpose of this study, the notion of identifying with students refers to the phenomena in which the participants had a strong sense of connectedness with students. The identification was so strong to the

point that they saw themselves as part of the female team with a high level of emotional attachment to the success of their female students and potentially saw themselves as a vital part of their life (Lankveld et al., 2016). The other perspective, self-identifying away from students, describes participants' relationship with female students as from a distance, in which they do not have intense emotional investments in their female students' success. Although the teacher works to see their students succeed, they tend not to see it as a personal failure if students leave the program.

The four participants had mixed roles in this contradictory relational orientation. Some self-identified as a part of the female team or family, seeing their students as teammates or their children. In contrast, others saw themselves as the captain of a ship in which they must teach their female students to navigate the turbulent waters ahead. Figure 9 provides a juxtaposition of quotes from the focus group to highlight these different perspectives.

It is clear from Figure 9 that Amy had conflicting positions. She explicitly claimed both identifying with and away from her students, while others seemed to have a more prevalent orientation in identifying one way or another. Perhaps hidden from what the juxtaposition shows, the inner contradictions may still exist in other participants. This highlights the importance of situations contributing to teachers' navigating of their relational orientations. I recall my years teaching in many different classrooms while working for a zoo. I can relate to this notion of inner contradictions in navigating my relational orientations with students. Most of my interactions with students were brief, either 3-6 days spreading across an entire school year or a weeklong camp as an informal educator at the zoo, except for working with our Zoo Teen program.

Figure 9. Identifying *from* and *with* female students.

Identifying *from* Female Students	**Identifying *with* Female Students**
	
"I just told them, "Just hold on, when you can get with the older girls, they'll empower you," and they have. They have to have each other when they're isolated from the other ones. It's almost like they get overrun" (Focus Group, Amy, 10-21-2021).	"We never thought we would be separated. We're just one team. Teaching to do everything they have shown that they can do, because they're amazing but do it with somebody else. We're all struggling with that." (Focus Group, Amy, October 21, 2021)
"I do know that I make a conscious effort trying to find things outside the room that are more focused on girls, where I don't do that with boys, shame on me. It should be the same for both, [00:45:30] but I know I make a conscious effort to try to find things for girls in STEM areas that aren't just in the classroom" (Focus Group, Danielle, 10-21-2021).	"It's powerful to bring that mother part of you into the classroom, and because you do, you got to love these kids, just like they are your own" (Focus Group, Danielle, 10-21-2021).

This was a program for teens to attend classes at the zoo throughout the year and gain experience working with exotic species and learning about zoo education. Through this program, I developed close relationships with my students, especially the female students, who often reminded me a lot of my younger self. Thinking back to this period and the team we had developed over time, I can see that I tended to play the outsider role.

I recall that I was very aware of the dangers of working at a zoo where certain choices could result in bodily injury. For this reason, I tended to try my best to be fun, caring, and motivating, but also strict and kept a distance, because my students needed to know that when I gave orders, they must take them very seriously and follow my instruction. I also believed it essential for the teens at the zoo to build community with each other to move forward in their educational journey, as they might feel isolated and should bond with each other to form a sustainable support group.

Perhaps this belief was rooted in my personal history from feeling isolated in my passions for wildlife biology and intimately understanding the potential danger that may come from not following directions when working with large, dangerous animals. This belief oriented my teacher-student relationship in a particular direction. It is not uncommon to see a categorical approach like mine, based on teachers' beliefs, perspectives, learning styles, and teaching styles as subject-matter focused or student-focused. The work of Akerman & Mejer (2011) suggests that such a categorical boundary could be problematic because it suggests unity. In contrast, several empirical works have demonstrated that teachers have multiple, possibly "conflicting I-positions" (p. 316), and their identities are not unitary. Still, teachers may shift between and renegotiate their identities, such as shifting from an identity of subject-matter-focused to student-focused, depending on the situation and what is encountered.

I can see my participants' positions changed according to the context. Much of teachers' identity cannot be reduced to a singular quality, sub-identity, or only one "I-position." As teachers, we constantly negotiate how to present ourselves to our students based on the circumstances and power relations we are currently negotiating. From my

own experience, I never limited myself to one “I-position,” and my position as a Zoo educator was only one of my positions. There were times when I was more formal and identified away from my students. In other circumstances, I was very different and became a nurturer with my "zoo babies" classes, in which I was more like Danielle, identifying with my students as extensions of my family to provide a very family-centered experience. I offered sensory-oriented classes to toddlers or work with students with special needs, and since the potential physical dangers were minimal in these programs and classes, I did not adopt the more authoritative approach.

Teacher as part of the team

When it comes to a teacher's role in working with students, “empirical [research] supports the theoretical idea that a positive affective relationship with a teacher might promote learning and positive adaptation within the school context, and the affective quality of the student-teacher relationship is an important predictor of children's development and wellbeing” (Glofre, Lucangeli & Cassibba, 2020, p. 4). A positive, nurturing student-teacher relationship is beneficial for students’ learning and wellbeing, which inspired their passion for learning and providing an opportunity for joy in the classroom. Ruzek (2016) believes that in "emotionally-supportive interactions with students, teachers create experiences that lead students to perceive that their peers are supportive, positive, and respectful" (p. 101). Numerous studies, including our data from my place of work, indicate that effective facilitation can lead to greater gains in peer-to-peer relationships and peer-to-adult relationships (PEAR, 2021). Central to teacher-student relationship is "teacher provision of pedagogical caring or involvement which focuses on a constellation of teacher behaviors, including warmth, affection, fostering a

student's sense of belonging and enjoyment that marks a close and caring teacher-student relationship" (Vollet, Kindermann & Skinner, 2017, p. 636).

When Amy described her need to champion the success of her students by describing her STEM team, including herself, I think she intended to foster a deep sense of belonging for her students to ensure they had an adult cheering them on towards success. But what if someone from the team did not succeed? Earlier, I described Amy's reaction when one of her students dropped out of STEM class. She was devastated. In her interviews and writing prompts, she related this loss to losing one of her teammates. This was a personal loss for her. Even though more of her students were moving forward than leaving the program, the loss of even one student meant for her the destruction of the team, at least for that time being. Amy's grief from losing one of her female students in the STEM program seemed to be excessive, potentially challenging her professional identity as a guide for students. Erik & Reed (2001) discuss professional images regarding teachers and teacher identity: “They bring a professional image of their ideal self as a teacher created from past experiences as a student. These images, originating in lived experience, are founded on personal beliefs, values, and fantasized view of *self* as a teacher” (p. 402).

Buchannan (2015) continues this discussion by citing Lortie's (1975) earlier findings regarding teachers' construction of *self* as a result of their "apprenticeship of observation" (Buchannan, 2015, p. 702), in which their twelve-plus years of observing teachers during their own K-12 experience acted as an apprenticeship of sorts to influence their teacher identity. Many participants described their perceived ideal STEM teacher as one who is an effective facilitator is confident and competent in their subject

area, able to engage students to meet and move beyond their known potential and bring a new, innovative curriculum to the classroom. This means that a teacher may identify with or away from their students, depending on situations and power dynamics. Foucault (1980) discusses the idea of power as relationships, suggesting that power is not possessed but exercised, so teachers must constantly make decisions based on the power relationships encountered daily, including in the classroom. Drawing from my own experiences of negotiating multiple I-positions based on the safety of my students, I do not think that teachers must choose one position, but they can hold tensions among multiple positions. Still, I argue that teachers should constantly renegotiate their positionality with their students as a pedagogical choice and response.

Teacher as parent and protector

Along with a fluid notion that teachers may identify with and identifying away from students, teachers may also identify as the parent and protector, as if students were teachers' own children. Amy and Lynn described experiences in their K-12 education, in which they believed they could have become but did not get encouragement to become what they perceived as STEM professionals, working researchers in STEM, or hold STEM-specific degrees such as Chemistry or Biology. Throughout the conversations and during the focus group, both teachers identified as "protector" to offer the female students in their classrooms all the opportunities they lacked during their K-12 experiences. Lynn saw her female students, as she stated, "on a pedestal" and "deserve special treatment because there are so few of them."

This particular treatment demonstrated Lynn's desire to act as a protector ensuring female students had access to all the same opportunities as others in her class. Both Amy

and Lynn also described their tendencies to think of their students, especially the female students, as their own children. Lynn described bringing the mother part of herself into the classroom: “You got to love these kids, just like they're your own kids" (focus group, October 21, 2021). She went on to say that at the end of the school year, when her students left to move on to high school, she was sad, knowing she may never see most of them again.

Considering this concept of a classroom mother, I think that it is important to question the significance of a teacher who deeply cared for her student as having a motherly quality. Earlier, we discussed that good motherhood had a learned quality, and all types of mothers and parents exist, including not good enough mothers. The notions of the mother as a nurturer and the traditional gendered role of a teacher as motherly bring back the question of gendered ideas of what a teacher should be and how they should interact with their students. A teacher providing a place of nurture, care, and knowledge exploration is more likely to encourage female students to develop a stronger STEM identity and establish healthy peer-to-peer and peer-to-adult relationships. However, must this quality be associated with being the mother? Can this not be simply a good pedagogy?

Teacher as guide

As an alternative view, Danielle and Cynthia described their desire to help their female students have a strong STEM identity, but they followed a different pathway. Through individual interviews, writing prompts, and the focus group conversation, they painted a picture in which the educator should be removed from identifying with students but act as a guide empowering the student to advocate for themselves. Also, interestingly,

both participants were teaching in more rural districts. Perhaps because of fewer opportunities available in their more rural districts and communities, they developed a similar view that their female students must be independent and able to advocate for themselves in society. As a female STEM professional who grew up in a rural midwestern town, I can understand this viewpoint from my experiences. Although I had the support of a few teachers, there were simply few opportunities to continue pursuing my passions. It was vital that I advocated for myself and had the confidence to act independently from my circle of friends. When I drove around the county roads for hours and hours collecting stream samples to help the Soil and Water Conservation District build a case against a poultry farmer polluting the waterways, my friends thought W I was "weird." However, I knew my work was important regardless of how unpopular it was with my friends and classmates, especially when I returned to the school smelling like fish.

Cynthia told a similar story about one of her female students who decided she wanted to learn coding. Cynthia worked with her independently after school to nurture her intellectual independence. When asked about a great success story working with her female students, Cynthia said:

> I would say my greatest success story lately has been with my robotics team. We didn't get to go to state, but we got first place in innovation because my kids, they came up-- well, this girl came up with an idea of making an app for truck drivers that would be like a social app. It would show who's in the area, and they could set up dates to go to dinner at this time, or who wants to go bowling at this time or whatever, when they're on long hollers, basically, because they've gone for a long

> period of time away from their families and that there's a lot of emotional-- they're depressed a lot….She, by herself, figured out how to code and had multiple things she had. She had a homepage and a login page. She had a chat site. She had a place where we went to Maps. You could see who was around you and then had another page where you could click and link in with waze.com so that you could go to Waze and see the traffic. It was just really impressive (Interview, 11-22-2021).

Cynthia empowered her student to be independent in her passions and assisted her when she needed it but otherwise, she let her learn on her own. Drawing a parallel from her personal story of learning to do things on her own, she consciously or unconsciously identifies away from her students to keep a professional distance in order to push them to be independent and develop the mindset to take on challenges and solve them on their own.

Regardless of whether these participants identified with or away from their female students, the interesting commonality across all cases was that two identities existed in different combinations in different participants. Perhaps this co-existence is part of the larger question: Must teachers always choose one side of identifying with or away from female students? Can we not stand with one foot in the team and one foot outside? Negotiating the situations in which the nurturer sub-identity is more needed and other situations in which a more authoritative sub-identity is necessary, I do not think teachers have to choose one way and stay with it all the time. So much of our time is spent in different situations and experiences in which we must make quick decisions to respond in the most effective way to ensure our students are safe, able to learn, and grow. Why must

teacher identity be limited to choosing one path when the classroom is constantly in flux, responding to the varied political pressures and societal challenges we face in our daily lives?

Resistance and risk-taking in diverse forms

The act of resistance in teachers' effort to embody both the masculine and feminine qualities can take diverse forms. Abandoning the traditional lecture-style classroom can be risky for a teacher as she resists the hierarchical system by seeking out resources, developing a curriculum, and teaching in completely new ways. Administrators, faculty, parents, and students can all resist in multiple modes.

> Engaging dominant ideologies while simultaneously disrupting them, females 'narrate a displacement as they relentlessly shuttle between the center (patriarchal norms) and the margins (their understandings).' Thus, resistance is not limited only to nonhegemonic discourses, for hegemonic discourses can also be reconfigured and deployed to subvert each other (Munro, 1998, p. 31).

The act of resistance to power often implies force but does not have to be so, as it can include multiple forms. Silent resistance is one form of stepping away from the position of being subjected to the patriarchal gaze. As Munro (1998) points out, "the poststructuralist freeing of the 'subject' in which subjectivity is seen as nonunitary, multiple and constantly in flux is central to deconstructing the universal male subject of liberal, humanist as well as neo-Marxist discourse" (p. 30). Female teachers can resist in specific and fluid ways to shape and recreate power relations in new ways. The classical meaning of resistance is defined as "the refusal to accept or comply with something; the attempt to prevent something by action or argument. The inherent ability of an organism

to resist harmful influences (such as disease, toxic agents, or infection); or the ability not to be affected by something, especially adversely" (Merriam-Webster, 2022). In this definition, the notion of resistance seems like an action of negation. Is resistance always negative? Patti Lather (1991) discusses the idea of resistance as applied to the classroom, and during one of her lectures, a student proposed a new definition:

> A word for the fear, dislike, and hesitance most people have about turning their lives upside down and watching everything they have ever learned disintegrate into lies. 'Empowerment' may be liberating, but it is also a lot of hard work and new responsibility to sort through one's life and rebuild according to one's values and choices (Lather, 1991, p. 76)

The actions of resistance with a level of self-awareness and awakening to the necessity for challenging patriarchy bring forth a more internal approach, in which female teachers can rebuild themselves based on their values and choices either aside or in direct opposition to the power systems oppressing them. This approach of resistance is not necessarily negative but is built on the newly constructed identity, aligned with the poststructural feminist perspectives. For teachers, their resistance can come in the form of quietly, or perhaps, strategically, opposing the traditional ways of teaching, disrupting the patriarchal stereotypes by encouraging female students' autonomy and voices, and forging new paths forward through the position of a pedagogical STEM content expert.

This form of resistance allows females to discover new potentiality within themselves. Janet Miller (2005) describes her imagining a new possibility within the university to situate females as knowers, "to envision such a possibility within the university structure becomes an aspect of resistance. To write of those visions as well as

to reveal individual and collective struggles inherent in the envisioning become aspects of resistance" (p. 76). Resistance does not have to be categorized as dramatic action in direct confrontations, but can appear as small, intentional, or unintentional changes. Drawing from Munro (1998) and her "understanding of resistance based on positionality and acknowledging the subject as nonunitary and continually in flux" (p. 32), I argue that resistance does not need to be an intentional action, and the effects of my participants' pedagogical action could be long-term beyond their expectations. Sometimes resistance developed over time, while sometimes, it could be done through risk-taking. I read my participants' risk-taking action as resistance, although they might or might not intend to challenge patriarchy.

Amy, Danielle, Cynthia, and Lynn all sought knowledge, curriculum, and pedagogical approaches outside the traditional resources of their schools. They efforts were sometimes met with apprehension and challenges, and other times they were encouraged to develop their interests in teaching STEM. Their act of stepping outside the prescribed pedagogy of textbook-oriented teaching was a risk-taking resistance. They took risks to bring new techniques into the classroom and spent money and time investing in learning a new pedagogy and content, which subtly questioned the status quo of teaching. Each one of these female teachers built the STEM program at their school. They did not follow the path of least resistance, which Johnson (2014) defines as the phenomenon in which "we make choices unconsciously without realizing what we're doing. It is what seems most comfortable to us, most familiar and safe" (p. 31). Starting with close to nothing, they refused to choose the comfortable path of least resistance, but

forged a new way to teach through projects and integrated lessons, and they changed what was being taught and how it was taught.

Their own K-12 experiences impacted them to make such changes over time. In interviews and during the focus group conversation, participants commented how they felt when they were sitting in their science and math classes and wanted to have something more from their own teachers' teaching. Responding to the focus group prompt, "Describe some of the ways socializing agents such as family, peers, media, religion, or school has shaped your identity as a woman and woman teacher who teaches STEM." Cynthia talked about her school experiences. She commented, "I was at [rural midwestern city school district], and that's when I first learned the STEM word, and I just loved it because you just have all those kids who can't sit still, and I was one of those" (Focus Group, 10-21-2021). As a school student, she already began to strengthen her resistance against the notion of STEM as a boy's arena. Each participant also shared their happy memories that inspired them to pursue teaching STEM, even though STEM did not emerge as a field yet. Cynthia recalled her science teacher' effort: "we had a lab rat that we build a maze, and he went through the maze, and we did some testing with that in junior high" (Focus Group, 10-21-2021). Drawing from their positive and negative experiences in science and math as students, all the participants discussed the need to develop something new for their STEM programs. Through the encouragement of their administration, Danielle and Lynn could seek out these professional development opportunities and grants and bring in a new way of teaching. Amy and Cynthia had to propose the idea of the STEM program over time, demonstrating there was a demand and

need for a full STEM program. The efforts they put into building STEM programs demonstrated various forms of resistance in both negative and positive ways.

Yet, over time, regardless of the initial level of encouragement and support, they had all faced barriers in sustaining and growing their STEM programs. Amy, with staff changes, no longer had the full support to attend professional development courses and had to look outside of her school for financial support to build her curriculum and bring in new project-based resources for her STEM classes. Danielle began to see a trend of scheduling issues preventing students from continuing with her upper-level STEM classes, as the required upper-level math classes were scheduled simultaneously. To deal with this issue, Danielle offered other opportunities for her students to "drop by" or continue their engagement with STEM through robotics teams or afterschool STEM programs. Each participant, continually evolving their pedagogy to counteract the barriers they and their students face, was a prime example of risk-taking to overcome barriers. These quiet and sometimes not-so-quiet acts of resistance went beyond the expected norms prescribed at their schools to offer something different, something they believed to be better, and demonstrated the dedication these four females had to their students and the future of STEM teaching profession.

When responding to the focus group prompt, "How have social expectations affected how you self-identify as a pedagogical STEM content expert?" participants discussed the transformation of their teaching practices. During the discussion, Cynthia asked, "How did we acquire this confidence that even if there is an obstacle, we don't even hardly notice it, and how do we empower our students to have the same power?" (Focus Group, October 20, 2021). Amy discussed the very act of enacting risk-taking

resistance and not even noticing the step that was being taken: "Sometimes you don't notice it. Sometimes you're just – I know that I just get involved in what I'm doing, and not to say things don't bother you, but you have a mission and you're going on your mission, and I think Cynthia made a good point is that when you stop and think about it, you're like, 'maybe I didn't notice'" (Focus Group, October 20, 2021). They were so involved in the resistance and focused on overcoming each obstacle as it came in a fluid way that they did not even notice the systemic pressures placed upon them. In so doing, they bypass the systemic obstacles through a bottom-up approach.

Between gendered norms and a new vision

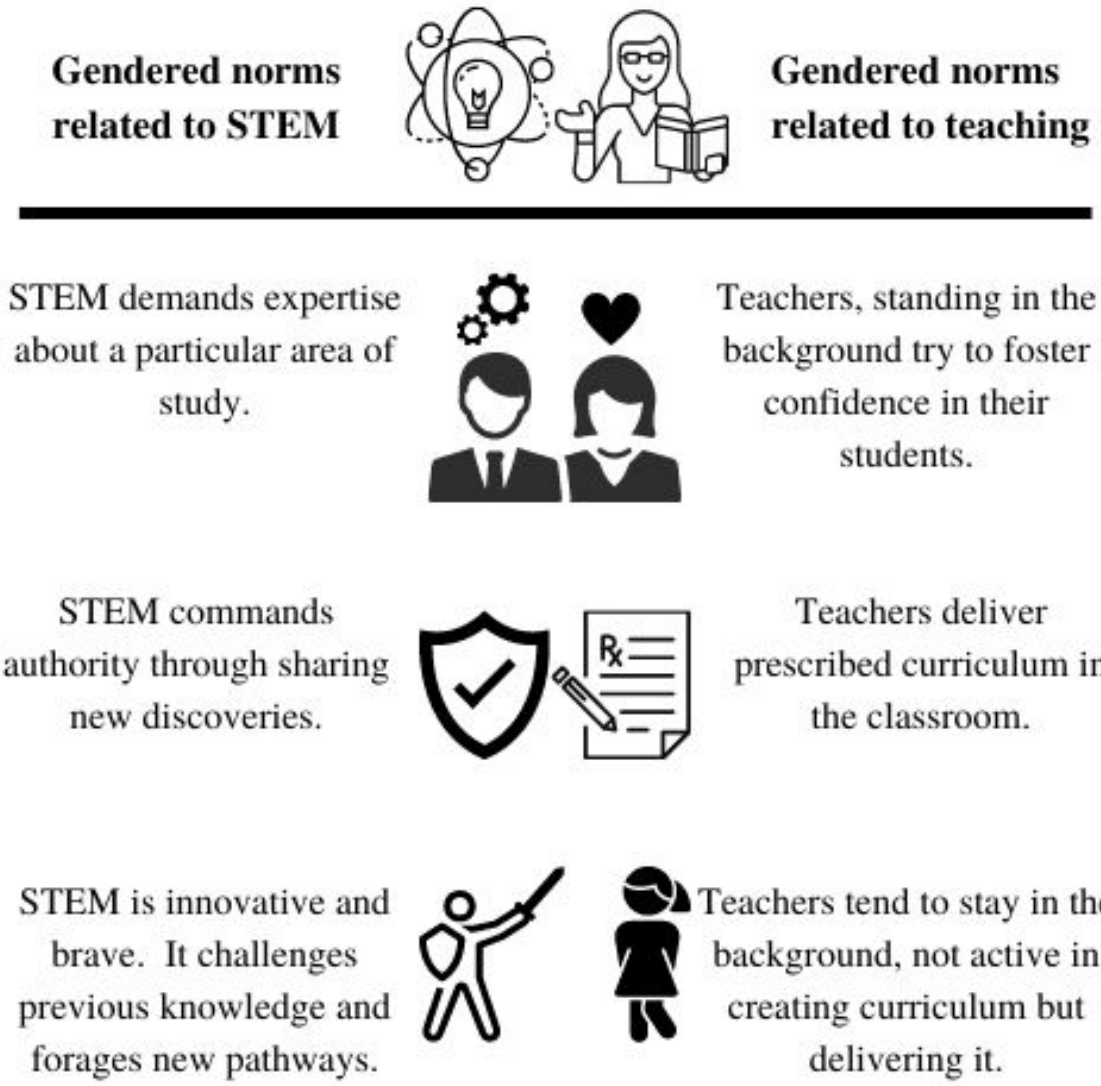
As one of the most influential people in a student's life, teachers must negotiate their multiple identities and position their subjectivity somewhere in-between the socially constructed meanings of STEM teacher. The gendered norms regarding both STEM and teaching are reconstructed from interviews, writing prompts, and the focus group and visually presented in Figure 10 (see below).

Through discussions, gendered norms related to what it means to be someone in STEM and what it means to be a teacher emerged. Upon looking deeper into their conversations, I am clear that each one, and collectively, were pursuing to go beyond what they already knew. Assuming their roles as STEM teachers, they sought out new knowledge and content expertise while ensuring their students, especially the female students, had the support to develop confidence in STEM learning.

Gendered norms and struggles for openings

As described in Figure 10, gendered norms create boundaries to prevent people from moving outside those socially established gendered roles as a system of subjugation

Figure 10. Gendered norms related to STEM and teaching



and a way to exercise power over people. Our system, from the start, is set up to establish boundaries between what one is expected to know and do and what one is limited in being able to know and do. The role of the teacher under gendered expectations is related to caring, whereas STEM education is described through excellence and expertise, as Weissmann (2015) argues. At the same time as this study, I observed a professional development session, in which an interesting conversation between a Ph.D. professor and middle school teacher attendees happened. The professor led attendees through a

discussion about imposter syndrome. Each teacher, one by one, admitted their insecurities, discussing their lack of confidence in fully knowing their content. The professor led the teachers through activities to understand the aspects of impostor syndrome. Even though teachers felt like outsiders throughout the day, he observed the times when they demonstrated their competency in content and pedagogy. My participants were similar to these teachers as each one of them described the expectations for STEM education and the teacher in opposing ways. They did not claim to be experts in the interviews and writing prompts, but they demonstrated STEM and pedagogical expertise competencies through their stories.

Demonstrating clear competencies as pedagogical STEM content experts, all four female teachers built their STEM programs and sought out new and innovative ways of teaching new curricula, either by writing new curricula or searching out vetted curricula. Cynthia and Danielle demonstrated their authority in helping other teachers in their districts implement STEM programs. Danielle collaborated with other teachers in her school to develop STEM and Social Studies integrated projects. Cynthia mentored and trained elementary and high school teachers in her district on how to teach both integrated and stand-alone STEM classes and coach robotics teams. The fact that they did not claim experts suggests the influence of gendered norms related to STEM as a discipline and the female teacher's position in society.

Traversing the in-between space from expert to STEM professional to pedagogical STEM content expert to a teacher, each participant demonstrated through their stories and beliefs the negotiations they made daily to be an effective STEM educator. The negotiation between student needs and female's responsibilities, as

described by Valerie Walkerdine (2004), presents a similar in-between space: "the 'truth' of female's sexuality is constantly reproduced in the formation of our identities: as schoolgirl, mother, teacher, psychologist, secretary. The regulation of – and our identities within – those practices make us guardians of fiction of autonomy and possibility" (p. 70). With each participant describing a constant flux between the different aspects of their identities, dealing the gendered norms of being a female, a teacher, and a STEM educator, teachers face tensions or conflicts in their daily teaching practices.

As females, we are so entrenched in the constant variation of misogyny that we have come to a point where we do not even notice the issues as we battle each day. We, as teachers, have become so focused on caring for our students and cultivating our expertise in curriculum and pedagogy that we do not even notice the systemic, gendered norms that we must actively resist to claim our multiple identities, as some of my participants noticed. During the focus group discussion, Amy mentioned not noticing the barriers she had to overcome each day, "I know that I just get involved in what I'm doing, and not to say that things don't bother you, but you have a mission, and you're going on your mission, and I think [Cynthia] made a good point is when you stop and think about it, you're like, 'Maybe I didn't even notice' (Focus Group, 10-21-2021). We need to unpack more the idea of not noticing. What are the ramifications of allowing ourselves to be so immersed in a system where we become desensitized to the misogyny or oppression surrounding us? Johnson's (2014) account of disrupting the patriarchal system can be helpful here:

> Given that systems shape people's behavior, this change can be powerful. When a man objects to a sexist joke, for example, it can shake other men's perception of

> what is socially acceptable and what is not so that the next time they are in this kind of situation, their perception of the social environment itself—not just of other people as individuals, whom they may or may not know personally—may shift in a new direction that makes old paths (such as telling sexist jokes) more difficult to choose because of the increased risk of social resistance (p. 31).

Disrupting the system by the poststructural theory does not mean abolishing it but means opening up the system to allow new possibilities. In allowing ourselves to be immune to the barriers we continually must overcome, rather than intentionally questioning the system, we run the risk of becoming part of the system that oppresses us. In challenging our thinking, assumptions, and internalized norms, I believe we can open ourselves to creatively negotiate the inner conflict and contradictions to allow for more new, multiple, and fluid identities for ourselves as female educators and the female students we teach. Struggles to challenge external gendered norms, we also need to engage in internal struggles to notice the gaps in different modes of engagement.

Miller (2005) discusses conflicting, multiple, and fluid identities and the potential for working differences in education. These areas of contradiction in identity are kneaded together, like the action of kneading bread. This action allows for the "transformation of separate elements into something that gives those elements new meanings and uses" (Miller, 2005, p. 180). Traversing their multiple identities, each participant described their acts of risk-taking and resistance, and their struggles gave way to the creation of new visions for the female STEM educator. While gendered norms still influence how they perceive themselves, they began to envision new meanings of a pedagogical STEM

content expert, in which a female teacher can be both the teacher and the academic, both the creator and the facilitator.

Imagining a new vision through "what if"

Driven, in part, by their desire to create something better for the female students in their classes, each female teacher described something I call "what if." Rooted in each of their stories, they all described experiences they believed they dreamed of being something else, for example, a programmer, a pharmacist, or a biologist, somebody they described as a STEM expert. Throughout their conversations, they reminisced about what if they had the opportunities they were now providing for their female students: How would their own lives be different? I also ponder if they had a sense of regret that created their drive to ensure their students had more options than they once had.

Throughout the interviews and writing prompts, none of them said that they regretted their choice to become a teacher, but time after time, they discussed the pride they felt seeing their students succeed and follow their dreams. When we mentioned the students who dropped out of their STEM classes, they believed they provided them with access to an opportunity that would otherwise not have been available:

> They're at the end of their high school, and how do you know what you want to do, and then having the confidence to go after it once you think you might know what you want to do, but then you see those girls that do too. I just don't know what the magic formula is. I know that as an 8th-grade teacher, I'm just always trying to just foster confidence in them (focus group, Lynn, 10-21-2021).

Lynn described a sense of possibility she proclaimed to inspire. Whether or not students enter a STEM profession is beside the point because teaching is about inspiring

the possibility of what could be and instilling the confidence in students to go after it. Danielle and Cynthia believed they were limited in their professional choices when they were young females. They believed that due to social pressures, they did not see most STEM-related jobs as suitable at that time. The social construction of professions for females then geared them away from the STEM profession, and they wanted to open such pathways as possibilities for female students now. Danielle, describing a recent discussion with a female student, stated,

> When they first walked into STEM, they would tell me, 'My mom said I wasn't smart enough to be in STEM. I don't know why I'm in here." I'm like, "Do you like to build things? Do you like to try to create things?" I said, "That's what we're doing in here." I said, "Don't worry about the math and stuff." I said, "We all work through the math together. Since they've been in my room, I've got kids now that they've said, "You know next year I'm thinking I need to be in STEM II instead of STEM I because I saw that you guys were doing this," and it's just them having the confidence to know that they're able to build and think outside of the box (focus group, Danielle, 10-21-2021).

For this reason, they continue developing themselves as STEM educators to ensure other female students know they can have a place to pursue development in STEM. The "what if" descriptions of each participant centered around the imagination of what if they could have done something else, specifically careers related to STEM. These thoughts and questions were related to open up the possibility of multiple futures for their female students. Their "what if" imagination also served as a form of silent resistance, as their visions became a catalyst for their efforts to learn new skills and knowledge to

broaden their content and pedagogy expertise and claim their teaching authority. Through imaging a new way of teaching, they each underwent a process of self-learning and self-teaching. Rather than seeing the "what if" as a missed opportunity, each participant described examples of learning new knowledge and skills for build their STEM programs, such as coding and building robots and learning new teaching strategies including the flipped classroom and inquiry-based teaching. In the action of self-teaching, each participant broadened their subjectivity to include multiple, new aspects of what a STEM educator could be while consciously or unconsciously resisting the prescribed notions of what a female teacher should be.

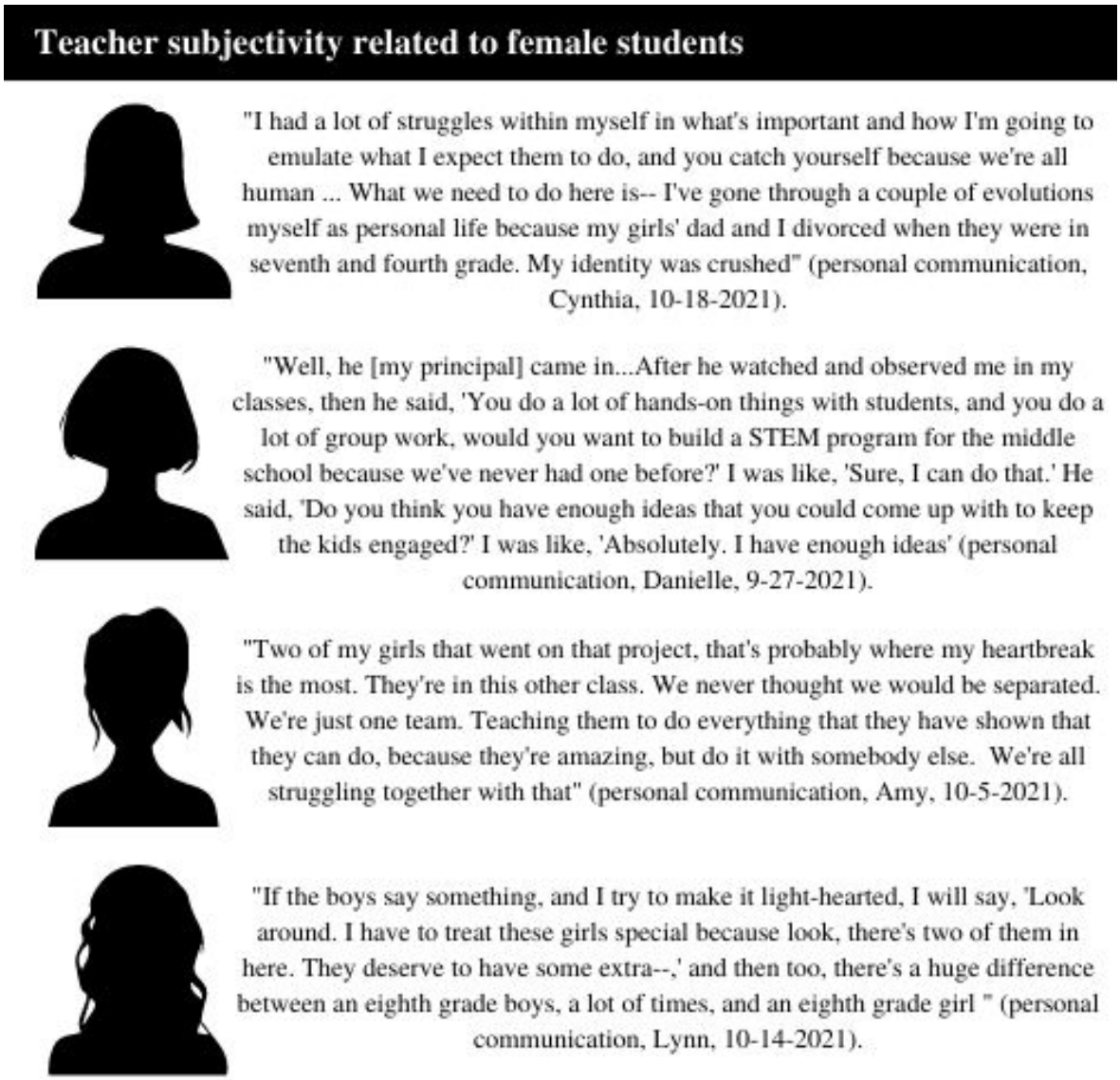
The idea of a broader subjectivity relates to each participant's multiple identities they constantly navigate, which are anchored in their personal histories. Avraamidou (2014) describes teacher identity as rooted in poststructural feminist views that "emphasize[s] the role of positioning and the various social markers that shape teacher identity development" (p. 151). Each participant described markers in their lives and teaching profession that shaped their emerging broader subjectivity (See Figure 11).

Each participant's reflections span the ideas of protection, collaboration, adventure, and redemption rooted in their personal experiences by taking risks to step into the unfamiliar and supporting students to ensure the inclusion of females in STEM learning. As we can see from Figure 11, they echoing each other's perspectives while also presenting an identity of multiplicity.

Danielle, Cynthia, Amy, and Lynn individually and collectively pushed against the gendered notion of what a STEM female teacher should be and opened a space for a

new vision of a STEM teacher. Whether intentional or not, they described experiences in resistance, taking risks, and renegotiating what it meant for a female educator to teach

Figure 11. Teacher subjectivity related to female students



STEM. By resisting the universalist or normalized concept of a female teacher, they opened a new space in which multiple new visions could be imagined. Even when they were not supported in their pursuits, they saw the possibility and benefit of STEM education for their students, especially their female students, and they kept pursuing it.

However, their achievement did not mean they were free from gender norms, as their inner contradictions in self-claiming as experts or their lack of attention to the systematic aspects of patriarchy showed certain reinforced gender biases. Their internal struggles often reflected how the social construction of gender permeated through their daily educational work.

The feminist poststructuralist theory posits that "identity is not a fixed 'thing,' it is negotiated, open, shifting, ambiguous – the result of culturally available meanings and the open-ended, power-laden enactments of those meanings" (Kondo, 1990, p. 24). The task of constructing oneself is an arduous task of taking up certain subjectivities when contextual demands are placed upon you (Jackson, 2001). The demands of the school, community, family, student, and all other aspects of their lives placed upon them pressures and assumptions that Danielle, Cynthia, Lynn, and Amy continually navigated: they resisted at times, internalized other times, and opened up space to create a new vision of a female STEM educator with multiple subjectivities. She is no longer limited to a short list of similar attributes; she can be a combination of qualities to pave the way to new modes of identity. She can be an expert, a teacher, a nurturer, a learner, a guide, a protector, an academic, and claims many more sub-identities all at once. Between gendered norms and new visions, these female teachers' struggles to negotiate among the multiple in an ongoing process have important lessons for us to learn.

CHAPTER V

CONCLUSIONS

The social landscape leading up to and during this study included global pandemics, teacher walkouts, political turmoil, racial tensions, and central to the topic of this study, gender issues in a broader context of the "me too" movement and abortion and LGBTQ rights. Many opportunities and experiences educators once had were taken away. Multiple educational partners throughout the community in which this study was located have commented on the lower participation of educators in their professional development and outreach programs compared to a few years in the past. In discussions with educators within my personal and professional life, many commented that they were experiencing burnout and could not implement or attend another thing due to feeling "underwater" (Personal Communication, 2021) with pressures of student performance, job security, fair pay, administrative changes, social pressures, and curriculum changes. At the same time many educators make tremendous efforts in instilling a sense of hope

and resilience in students amidst all the pressures and constraints continually placed upon them.

Continually navigating through the complex issues and pressures placed upon and surrounding educators, it is not surprising that the attrition and turnover rates for STEM educators has increased (Fuller & Pendola, 2019; Hutchinson, 2012; Ingersoll, 2006). For those who do stay in the classroom, they must confront all the challenging issues. A respected STEM education advocate stated, "in many schools, STEM is considered an extra or extravagant and optional topic for some students" but not for all students to take on (personal communication, 5/30/2022). Over the years, I have had conversations with people working in STEM, such as teachers, administrators, coordinators, and industry partners. Through these conversations, I have observed, time and time again, the inequity not only involving an educator traversing administrative restrictions and policies related to teaching STEM but also relating to the trickle-down effect of these power systems on the female students. The very programs aimed at sometimes preparing students for STEM learning, when hindered by stereotypes and power/knowledge arrangements (Walkerdine, 2004), may also cause students to become disengaged. "Students who had support at school (teachers and courses), encouragement from family, and exposure to STEM role models tended to persist" in taking the challenges of STEM learning (Hughes, Nzekwe & Molynaeux, 2013, p. 1985). The role of the teacher in this equation is irrefutable.

Dario (2017) conducted a quantitative study regarding the impact of teacher gender on male and female students in a STEM class. The study found that "student interest and self-efficacy were substantially affected by a teacher's ability to make their subject interesting and to create a positive learning environment, this was true for both

male and female students" (p. 17). Concerning specific ways to create a positive learning environment and engaging subject matter, Dario elaborated on how female student success was more "contingent on the time and skills that instructors put in preparing for their lectures and supporting students" (p. 17). The skills and pedagogical capacity required to create this type of learning environment need teachers with a high level of pedagogical STEM content expertise. A recent conversation with a local STEM leader and former State Department of Education staff member revealed the idea of a pedagogical STEM content expert as someone who "consistently hones their instructional methods based upon the development of their pedagogical content knowledge. They skillfully connect learning experience to their students' cultures and communities and seek new opportunities to reach their students" (personal communication, 5-30-2022). Considering the factor of gender, female teachers identifying as pedagogical STEM content experts are beneficial for promoting female students' learning in STEM.

Findings

The purpose of this study was to understand how female middle school teachers in a mid-western American city self-identify as pedagogical content experts in STEM and how their identities influence their practices in the classroom. Drawing from the experiences of my participants, I discuss the gendered pressures placed upon them while they were navigating their identities of a pedagogical STEM content expert and unfolding the new vision of what a female teacher could be. In summarizing my findings as relating to the research questions, I address the sub-questions first and then answer the main research question.

Sub Question 1: How do female middle school STEM teachers navigate gendered norms to self-identify as PSTEMCE?

Although demonstrating their expertise in pedagogy and content through their stories and writings, each participant discussed their role in gendered terms such as caretaker or facilitator. Refusing the term expert, except for the initial survey, each participant discussed navigating gendered pathways to start their STEM programs and to encourage female students to enroll and succeed. Based on Foucault's (1985) ideas of power as a relation and operates on both the macro and most micro levels of society, I discuss how participants continually adjust their approach with faculty, students, parents, and administrators as they try to move outside the fixed boundaries of what it means in society to be a female and educator.

Perhaps, their act of pushing back on the term expert reinforces the gendered norms placed upon them at the time of this study. Instead, they embraced a historically gendered term, facilitator. In participants' explanations of the definition of a facilitator, its attributes, skills, and qualifications closely resemble those described in the numerous and slightly varied descriptions of a pedagogical STEM content expert. It is interesting to note the change in terminology and the gendered history behind this chosen term. When compared side-by-side, the term expert was described as more academic than pedagogical, with excessive emphasis on the content.

In contrast, the facilitator was described as a teacher good at the practical application of content through effective pedagogy. From the participant's perspective as a practitioner, the application of content in the form of pedagogy takes on more weight than the awareness of expertise in content. It could be possible that the participants were

more focused on applying their knowledge rather than seeing themselves explicitly as experts in content. It seems that these participants challenged gendered norms in practice and yet, at the same time, were not fully free from the gendered constraint, which is consistent with poststructural feminist theory.

Sub Question 2: What are teachers' perceptions of how their identity as PSTEMCE influences their interactions with female middle school students?

Aligned to their preferred terminology of a facilitator as opposed to an expert, participants described application of facilitator through the roles of nurturer, teacher, team member, and guide. Adopting a role as nurturer or guide, the participants were split in describing how they related to their students. Outwardly, half of them said they saw themselves as part of the "team" and half as standing outside the "team." However, when they described experiences related to these positionalities, they described spaces in which they assumed each role at different times, depending on the situation.

Using juxtaposition to highlight this contradiction, the majority of the participants were able to describe situations in which they both identified *with* and *from* their female students, indicating a fluid rather than fixed pattern of interaction with their female students. They had fluid identities within themselves and also saw the multiplicity within their female students and adapted to the needs of their students in a given situation. Miller (2005) takes up the concept of fluid identities, "identities and difference are constructed in and through the dynamics of our engagement with each other over time, not only in the service of oppressive relations such as racism and sexism but also in the service of the contestation of such oppression" (p. 181). In allowing for fluid and multiple identities as a means to resist, reveal, interrupt, and reconstruct meaning and power relations within

and outside the classroom, these participants formed complex relations with their female students.

From my findings, I can understand the possibility that the participants' fluidity in relating to their female students allowed them to create a possible safe classroom space traditionally encircled by gendered norms and to model silent resistance and risk-taking for their students. Breaking free of these barriers and moving towards identities not confined by the socially prescribed gender norms, they openned the possibility of new, multiple visions of what a female STEM educator or female STEM professional could look like. Notably, each participant was not free from their gendered stereotypes as it is impossible to completely freeing ourselves of the patriarchal system. However, I can see various ways in which the participants were able to navigate around power structures and power relations to provide support for their female students in building an inclusive community to support students' growth in STEM.

Sub Question 3: How are these teachers' perspectives on negotiating multiple identities reflected in their teaching?

Broadening beyond interactions with students, the fluid, multiple identities of the participants are reflected in their teaching through the diverse ways they resist gendered norms and societal expectations of what a teacher should be towards what a STEM teacher can be. Taking risks in adopting new pedagogies that challenged the traditional lecture-style teaching, especially when it was the expectation in her school, Amy sought out new content knowledge. She applied it in a new, innovative way through project-based learning. By adopting an attitude of, "I can figure it out," Cynthia and Danielle each took chances and risks to create a new way of teaching in their small districts when

developing a multiple grade-level STEM program. Challenging the gendered norms and stereotypes of wife, mother, teacher, and woman, they sought expertise in skills and content within various areas of STEM, including robotics and coding. They applied it through innovative new pedagogical approaches.

All four participants negotiated their multiple identities and enacted various forms of resistance towards the traditional middle school classroom teaching based on lecture-style instruction. They allowed for openness towards a new way of learning through challenging gendered power relations.

> The problem is not teachers, for, as we have demonstrated, they are ensnared too. The problem has complex and multiple causalities, within which we have come to understand ourselves and act in terms of the discursive practices that define us. Blaming teachers is like blaming mothers for failing to make the fiction of social democracy work. We claim that the mastery of mathematical discourse is not a certain control over the properties of physical objects but rather a discursive shift that makes statements about the generalizable properties of those objects to have the power of anything (Walkerdine, 2004, p. 166).

Creating space for their multiple identities and teaching STEM curriculum, participants became both the creator and facilitator of the content, and in their own unique ways, resisted the discursive practices that confined female educators within gendered boundaries.

Adopting a new vision of themselves as STEM educators, they were able to change their consciousness and disrupt the power systems that confined them. Freire (2013) describes a teacher no longer as one who merely teaches but one who also teaches

in dialogue with students, and beyond the traditional authority of the teacher, "authority must be on the side of freedom, not against it" (p. 80). They stepped outside of gendered norms, implementing new pedagogical approaches. Each participant demonstrated a shift in their authority role, engaging in developing and guiding their students to be active participants in creating content and developing experiences for their students and themselves to co-learn together. The application of such an approach is depend on teachers who can hold tensions among multiple, historically conflicting identities such as content expert, teacher, facilitator, guide. In doing so, the participants demonstrated an ability to navigate their multiple identities to allow new teaching methods to emerge in their STEM classrooms. However, they are not free from the imprint of the system. With the moments I observed and learned about their experiences where they stepped out of some gendered norms, I still could see other barriers created by gendered power relations so the participants needed to navigate continually.

Main Question: How do female middle school teacher participants identify as pedagogical STEM content experts, and how does their multiple identities influence their teaching practice?

Perhaps the most noteworthy takeaway from this study was the continued presence of gendered norms and contradictions towards teachers' self-identifying as an expert. With the teacher's gendered and socially displaced role, my participants continued to view the terms of expert and teacher as opposing identities. I utilized juxtaposition to identify these participants' gendered perspectives and visualize their stories and experiences as they described how they did or did not self-identify as a pedagogical STEM content expert. Numerous times, each participant described expertise in both

content and pedagogy but refused to self-identify as a pedagogical STEM content expert in the interviews, focus groups, or writings.

By describing moments of teaching in the in-between space, we may better unpack this contradiction. Drawing from the poststructural feminist concept of *difference,* I refer to the space in-between what is assumed through cultural, societal, or gendered assumptions and what can be (Scott, 1988). When I interviewed the participants, they all verbally resisted the title of expert. Instead, each participant described, in detail, moments in which they were immersed in new content, shared stories that demonstrated expertise in both content and pedagogy and taught new skills such as coding. Through these teaching practices and curricular choices, they resisted the assumed roles of a female educator, took on content and skills that challenged the historically gendered notion of the female teacher, and disrupted the power system to step into the in-between space of *difference*.

> One foundational and necessary humanist precept that keeps the binary 'insider, outsider' in place is the assumption that both knowledge and power, constructed and produced by either side of the binary, are unified, stable, unchanging – and 'possessed.' But as Foucault (1980a) argued, through his term 'power/knowledge,' there is no inside or outside of power. Power is not possessed but rather 'exercised.' Power is everywhere and inescapable; it operates in innumerable places, taking many forms that may or may not work together (Miller, 2005, p. 173).

The participants exercised power to question what it means to teach and challenge us to rethink the role of teachers with liberatory intentions (Lather, 1989). Through the

interactions with their students, they navigated their multiple identities. They cultivated the possibility of new spaces in which a new vision of female STEM teachers can thrive while continuing to navigate the changing systems of power around them.

Returning to our metaphor of the rainforest ecosystem as a system, we are, in a sense, dependent on each other for our survival. We do not learn and grow in isolation but are constantly intertwined with each other. The metaphorical ecosystem in which our students develop needs the same level of complex diversity as the Brazil Nut Tree, and they need to experience varied perspectives and experiences to grow into a cultured, open and diverse mindset to step into society, challenging the assumptions and norms already present. Within an ecosystem such as a rainforest, systems within an ecosystem are constantly in flux. Resources change, new species migrate in, species go extinct, and organisms must continually adapt in order to in order to survive. Drawing from this metaphor, my participants were not finished in their journeys. There is no clear answer to any of the questions posed in this study, and there is still always work to be done and systems to circumnavigate. Yet, within the power relations of a middle school STEM classroom, ensuring opportunity and access for those historically underrepresented is a challenge that needs further studies and understanding. Equity is best achieved through diversity (Hershock, 2012). Diversity in content and expertise are essential to the future of STEM. All genders and types of people are needed to provide a diverse knowledge base to cultivate students with a STEM mindset in which they can critically analyze the systems in their world, solve problems, and think creatively about what could be.

Limitations of the Study

A particular limitation of a case study is that this methodology is situated in time and place. Therefore, this study was a momentary and bounded glimpse into how female teachers self-identify as pedagogical STEM content experts and how this influences their teaching practices in the classroom. My study also relied on participants' perspectives and experiences, as I did not make classroom observations due to the COVID-19 pandemic situation.

Interviews and writings come with their own set of limitations. People portray themselves as they want to be seen, sometimes presenting in-authentic identities to the researcher. I made efforts to combine different instruments and approaches to the data collection, so that there was a lower chance of misreading participants. The participants did not gain or lose anything in participating, and participation itself was entirely voluntary, so there was no incentive in portraying themselves as inauthentic, but the researcher/participants relationship may have some influence in their presentation of themselves. With every methodology, there are strengths and limitations. The limitations presenting themselves using a case study methodology were minor in comparison to the strengths of using it to provide in-depth accounts of experiences, discourses, and participant-derived meanings to answer my research questions.

Recommendations and Future Studies

Future recommendations for research areas based on this study's findings include adding data source of classroom observations on how the multiple identities of female middle school STEM teachers influence their teaching practices. During this study, classroom observations were not possible due to the COVID pandemic. A follow-up study observing teacher-student interactions related to gendered norms in the middle

school classroom would be beneficial as most research focuses on undergraduate or high school. Recent studies confirm that middle school is the largest area of disengagement for females in STEM (female's Quick Facts, 2017). Another area of future study is the role of professional development in how teachers self-identify as pedagogical STEM content experts. Particular interventions or techniques could be analyzed based on pre-and post-self-assessments over time.

The most creatively exciting part of this study was discovering new ways to use juxtaposition for qualitative data analysis. As a central element in my analysis, the role of juxtaposition was integral to the retelling and interpretation of my participant's stories. With so many points of contradiction and in-between spaces, it shows new ways to demonstrate how my participants navigated their multiple identities. Based on some of the techniques used in this study, further investigation into ways to demonstrate juxtaposition in post-structural feminist studies would benefit the qualitative research field.

Practical Implications

Upon completing this study, steps have already been taken to implement the findings into the practices of a local Regional STEM Ecosystem. Based on the findings of this study, especially teachers' resistance to self-identifying as a pedagogical STEM content expert and their positive or negative interactions with female students, staff at the Regional STEM Ecosystem are discussing various ways to improve their work. These discussions include implementing more inclusive language when talking to educators to encourage a positive self-perception related to expertise and designing rituals and practices to cultivate more inclusive classrooms for female students. Implications in

partnership with a local Regional STEM Ecosystem also include using qualitative analysis and juxtaposition to visualize the stories of students and educators within the ecosystem, which will be used to direct policy, programming, and strategy.

In developing future programs for the Ecosystem, I plan to use a similar methodology to plan and implement a new partnership model with schools in a particular geographic area. This model will use qualitative methods and coding analysis to bring together multiple aspects of a partner school in regards to their current educational culture, as well as their needs to further their STEM strategic plan. The ultimate goal of this project is to develop a true collective impact model with informal, higher education, and industry partners to provide STEM-focused services and interventions. The vision of collective impact is to bring together diverse partners in a structured way for social change (Collective Impact Forum, 2022). Through interviews and focus groups, this methodology will help to understand the experiences within the schools in order to pull in informal partners to provide services matching their needs and interests. The use of this methodology is similar in the way juxtaposition was used to compare and contrast the student, family, teacher, and administrative interests, perspectives, and barriers without reducing them to a single set of issues.

Another practical implication would be to develop curricula for pre-service teachers based on best practices for creating inclusive STEM classrooms for females. Currently, even though new courses on STEM have been developed in some teacher education programs, targeted STEM training for pre-service teachers is still limited as this is a newer interdisciplinary content area. As females continue to be underrepresented

in STEM, extra time should be given to ensure educators are prepared and equipped with strong pedagogy and content expertise in engaging females in STEM.

Researcher Reflection

First, implementing a study during a global pandemic is very hard. Starting, I had a particular plan and had to quickly adjust in response to the safety measures that needed to be put in place and replace the format of conducting interviews face-to-face or classroom observations. Yet, through all these changes and revised planning, I believe I managed to probe deeper into the lives of my participants. No longer shrouded in thinking about what a classroom should be or what a teacher should be, I entered the research setting with flexibility to follow participants' ever-changing experiences. In embarking on this study over Zoom, I still achieved the understanding of my participants' lived experiences even though I could not see them in person.

Second, the experience conducting this study has been enlightening. Throughout each step, I engaged in conversations with stakeholders in my community, asking similar questions to the ones I posted to participants in this study. The intellectual gains in going through this process have been life changing, allowing me to expand what I originally self-identified as a researcher to a new vision of myself as a qualitative researcher. I learned the value of qualitative research in understanding someone's perspective and how to tease out the lessons that can be learned.

Third, in doing this work, I found myself applying my understanding of post-structural feminism and coding to other aspects of my personal and professional life. "By taking these stories apart and seeing how we are caught up in them, we can begin to tell our own" (Walkerdine, 2004, p. 165). These words have never seemed as true as they do

to me upon completing this study. Through the stories of each participant, I have found new aspects of myself and have become more open to all the other educators I work with. This has been a long journey with large learning curves. I was originally trained in scientific, quantitative research using what is assumed as the scientific method. Trying to break free from my own systematic imprint has been a difficult journey, and it is still a work in progress. The openness of qualitative research and the process of understanding multiple possibilities in ever-changing power systems and relationships have been a challenge, and particularly not seeking a single solution is a tensioned position for me to hold. In doing this work and challenging myself to conduct research in a new way, I find myself more open to multiple ways of understanding, and for this alone, I am greatly thankful for this journey.

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APPENDICES

APPENDIX A

Survey Questions

All questions were answered using a Likert Scale (very confident – not confident at all) with open-ended questions at the end.

Basic Demographic Questions

1. Name
2. Email
3. Phone Number
4. Male vs. Female
5. District
6. Grade
7. Courses Taught
8. How many years have you been teaching?

1. Do you self-identify as a Pedagogical STEM Content Expert? (Pedagogical STEM Content Expert - the way in which a teacher can relate their pedagogical knowledge to their content knowledge to make STEM relevant and understandable for their students.)
2. What percentage (on average) is your class composed of female students?

Teacher Identity Questions -Likert Scale (very confident – not confident at all)

1. How confident are you that you are able to successfully facilitate STEM experiences with your students?
2. How confident are you that you are able to explain a STEM concept to middle school students?
3. How confident are you that you have sufficient knowledge of STEM subjects to answer your student's questions during class?
4. How confident are you that you can employ a variety of STEM principles to deepen your student's understanding of Science, Technology, Math and Engineering?
5. To what degree do you believe you have the skills and pedagogy to teach STEM content?
6. To what degree do you believe you are effective in monitoring student's progress in STEM learning?
7. To what degree do you believe you are able to successfully engage both male and female students in your class?

Open-ended Questions

1. What are three strategies you use to empower your female students in succeeding during your STEM lessons?
2. What is your fondest memory teaching STEM?

APPENDIX B

Interview Questions – Interview 1

Interviews were semi-structured in format with room to probe deeper as the opportunity arises. The following questions were used as guiding questions for each interview.

1. How do you define the term pedagogical STEM content expert?
2. In what ways, if at all, does this reflect aspects of your identity? What has contributed to such an identity?
3. Please tell me about an occasion when you believed your identity as a pedagogical STEM content expert was best enacted in your classroom.

APPENDIX C

Interview Questions – Interview 2

1. Thinking back to the last interview, you defined the term pedagogical STEM context expert as: (read first definition from first interview). Do you have any additional thoughts to add to this definition?
2. Thinking back over the school year, what are some of your STEM activities/lessons you believe made the largest impact on your female students?
3. How do you see your female students interacting with the STEM lessons you teach in your classroom?
    a. What barriers, if any, have you run into working with female students while teaching STEM?
    b. What struggles are you currently negotiating in order to better related to your female students?
    c. How do you negotiated your identity to be successful within these constraints and does in what ways does this impact your female students?

APPENDIX D

Interview Questions – Interview 3

1. Thinking back to the last interview, you defined the term pedagogical STEM context expert as: (read first definition from first interview). Do you have any additional thoughts to add to this definition?
2. What is a memorable story you want to share regarding your female students and a STEM lesson you developed and facilitated?
3. What have you learned from your teaching journals?
4. What is one lesson related to female students' learning you have learned while teaching STEM?

APPENDIX E

Teacher Writing Prompt

Participants were asked to submit responses to two writing prompts throughout the study.

1. Have you experienced any conflict between being a woman and being a STEM expert in schools and in the classroom? In what ways? Did anything similar happen when you were a student? How did you deal with the conflicts and how do you do so now? Can you give an example?
2. In what ways has your identity as a pedagogical STEM content expert influenced your interactions with your female middle school students? Can you provide an example of a positive and negative interaction that has occurred in your classroom? What would you have done differently?

APPENDIX F

Focus Group Questions

The focus group was semi-structured in format with room to probe deeper as the opportunity arises. The following questions were be used as guiding questions.

1. Describe some of the ways socializing agents such as family, peers, media, religion, or school has shaped your identity as a woman and woman teacher who teaches STEM.
2. How have these social expectations affected how you self-identify as a pedagogical STEM content expert?
3. How does your identity as a pedagogical STEM content expert influence your teaching practice?
4. In what ways do you perceive your interactions with female students in your STEM lessons?
5. What would be a collective definition of pedagogical STEM content expert and how is this enacted in a classroom?
6. Have you experienced multiple identities and their contradictions in your work as a STEM woman teacher?

APPENDIX G

Informed Consent

Project Title: Teacher self-perception as a pedagogical STEM content expert and its influence on classroom practice.

Name of student researcher	Emily Mortimer
Degree	B.S. Biology & M.S. Teaching, Learning and Leadership
Telephone number	918-704-8779
Email address	Emily.mortimer@okstate.edu

Thank you for agreeing to participate in this research study with Emily Mortimer, a Doctoral Candidate in Curriculum Studies at Oklahoma State University, under the direction of Dr. Hongyu Wang, Curriculum Studies, Oklahoma State University. Your participation in this research is voluntary. There is no penalty for refusal to participate, and you are free to withdraw your consent and participation in this project at any time. This form outlines the purposes of this research study and provides a description of your involvement and rights as a participant. The purposes of this research study are the following:

Purpose of the Study:
The purpose of this study is to understand how female middle school teachers in a mid-west American city self-identify as a pedagogical content expert in the area of STEM and how their identities influence their practices in the classroom.

Main Research Question: How do female middle school teacher participants identify as pedagogical STEM content experts and how does their multiple identities influence their teaching practice?

You are invited to participate in this study by sharing your experiences regarding identifying as a pedagogical STEM content expert and gendered discourses in the classroom through interviews, completing two writing prompts and participating in a focus group via Zoom.

Procedures:
The length of data collection for this study will be one month. Participants can expect the following:

- First, participants will complete an online survey that will take approximately 10 minutes to determine eligibility. The survey will be based on how you, as an educator self-identify as a pedagogical STEM content expert (PSTEMCE).
- Upon selection for the study, within a month, you will participate in three, 45-60 minutes, virtual interviews each week that will be recorded for transcription purposes.

- Participants will submit a writing related to your self-perceptions as a PSTEMCE and how this influences your teaching practices.
- Participants will also participate in a focus group on Zoom.
- Upon the completion of this study (by November, 2021), the interview recordings and writing prompt submission will be returned to you or if it is a digital copy, permanently deleted from the researcher's computer.

Risks:
There are no known risks associated with this project which are greater than those ordinarily encountered in daily life. Participants will be allowed to decline answering questions or submitting materials at any time and are allowed to drop out of the study at any time.

Benefits:
There are no direct, personal benefits from participating in this study beyond furthering the current research in Curriculum Studies and STEM education.

Confidentiality:
The information you give in the study will be confidential. This means that your identification will remain confidential and you will be represented by a pseudonym during the data analysis and any writing associated with this data.. The researchers will not be able to remove your data from the dataset once your participation is complete. Specific details about confidentiality are as followed:

- This data will be stored in a password protected computer indefinitely.
- The researcher will ensure confidentiality to the degree permitted by technology.
- Your participation in this online survey involves risks similar to a person's everyday use of the internet.
- If you have concerns, you should consult the survey provider policy at https://safety.google/intl/en_us/security-privacy/.

Compensation:
You will not receive any compensation for participating in this study.

Participant Rights:
Your participation in this research is voluntary. There is no penalty for refusal to participate, and you are free to withdraw your consent and participation in this project at any time.

COVID-19 Procedures/Policy:
Due to COVID-19, all interviews will be conducted virtually over Zoom. The teaching artifact and journals will also be collected via a contactless method or collected virtually through a secure upload. For any times in which the researcher or participant may come in contact, the following steps will be taken to address the risk of coronavirus infection:

- **Screening:** Researchers and participants who show potential symptoms of COVID-19 (fever, cough, shortness of breath, etc.) will NOT participate in this study at this time.
- **Physical distancing:** Whenever possible, we will maintain at least 6 feet of distance between persons while conducting the study such as receiving or returning teaching journals or teaching artifact.
- **Mask/Covering:** Researchers will wear and participants will be advised to shield their mouth and nose with a cloth face cover or mask during the study at any time the researcher and participant are in face-to-face contact, even when maintaining at least 6 feet of distance. Tissues will be available to cover coughs and sneezes.
- **Handwashing:** Researchers and participants will wash hands before/during (activity) or use a hand sanitizer containing at least 60% alcohol.
- **Disinfecting materials:** When feasible, researchers will clean and disinfect materials prior to returning them to the participant, using an EPA-registered disinfectant or a bleach solution (5 tablespoons of regular bleach per gallon of water) for hard materials and by laundering soft materials. Disinfected materials will be handled using gloves, paper towel, plastic wrap or storage bags to reduce the chance of re-contamination of materials.

Contacts and Questions: As a participant in this research, you are entitled to know the nature of my research. You are free to decline to participate, and you are free to stop the interview or withdraw from the study at any time. No penalty exists for withdrawing your participation. Feel free to ask any questions at any time about the nature of the research study and the methods I am using. Your suggestions and concerns are important to me. Please contact me or my dissertation advisor, Dr. Hongyu Wang (hongyu.wang@okstate.edu) at the addresses/email provided above. If you have questions about your rights as a research volunteer, please contact the OSU IRB at (405) 744-3377 or irb@okstate.edu.

Signatures:
Participant: I have read and fully understand the consent form. I sign it freely and voluntarily. A copy of
this form has been given to me.

_____ _____
Signature of Participant Date

Researcher: I certify that I have personally explained this document before requesting that the participant
sign it.

_____ _____
Signature of Researcher Date

APPENDIX H

IRB Approval Letter

Oklahoma State University Institutional Review Board

Date:	04/30/2021
Application Number:	IRB-21-216
Proposal Title:	Teacher self-perception as a pedagogical STEM content expert and its influence on classroom practice.
Principal Investigator:	Emily Mortimer
Co-Investigator(s):	
Faculty Adviser:	Hongyu Wang
Project Coordinator:	
Research Assistant(s):	
Processed as:	Exempt
Exempt Category:	

Status Recommended by Reviewer(s): Approved

The IRB application referenced above has been approved. It is the judgment of the reviewers that the rights and welfare of individuals who may be asked to participate in this study will be respected, and that the research will be conducted in a manner consistent with the IRB requirements as outlined in 45CFR46.

This study meets criteria in the Revised Common Rule, as well as, one or more of the circumstances for which continuing review is not required. As Principal Investigator of this research, you will be required to submit a status report to the IRB triennially.

The final versions of any recruitment, consent and assent documents bearing the IRB approval stamp are available for download from IRBManager. These are the versions that must be used during the study.

As Principal Investigator, it is your responsibility to do the following:

1. Conduct this study exactly as it has been approved. Any modifications to the research protocol must be approved by the IRB. Protocol modifications requiring approval may include changes to the title, PI, adviser, other research personnel, funding status or sponsor, subject population composition or size, recruitment, inclusion/exclusion criteria, research site, research procedures and consent/assent process or forms.
2. Submit a request for continuation if the study extends beyond the approval period. This continuation must receive IRB review and approval before the research can continue.
3. Report any unanticipated and/or adverse events to the IRB Office promptly.
4. Notify the IRB office when your research project is complete or when you are no longer affiliated with Oklahoma State University.

Please note that approved protocols are subject to monitoring by the IRB and that the IRB office has the authority to inspect research records associated with this protocol at any time. If you have questions about the IRB procedures or need any assistance from the Board, please contact the IRB Office at 405-744-3377 or irb@okstate.edu.

Sincerely,

Oklahoma State University IRB

VITA

Emily Mortimer

Candidate for the Degree of

Doctor of Philosophy

Dissertation: TEACHER SELF-PERCEPTION AS A PEDAGOGICAL STEM CONTENT EXPERT AND ITS INFLUENCE ON CLASSROOM PRACTICE

Major Field: Education

Biographical:

Education:

Completed the requirements for the Doctor of Philosophy in Education at Oklahoma State University, Stillwater, Oklahoma in July, 2022.

Completed the requirements for the Master of Science in Teaching, Learning, and Leadership at Oklahoma State University, Stillwater, Oklahoma in 2012.

Completed the requirements for the Bachelor of Science in Biology at Missouri State University, Springfield, Missouri in 2004.

Experience:

Vice President, Tulsa Regional STEM Alliance	January 2022-Present
Program Director, Tulsa Regional STEM Alliance	September 2018-2022
Adjunct Instructor, Oklahoma State University	August 2019-December 2019
Program Manager, Tulsa Regional STEM Alliance	May 2015-2018

Professional Memberships:

Computer Science Teachers Association	January 2020- Present
National Science Teachers Association	January 2018-Present
Family Math Coordinating Committee Member	January 2019-Present