Breaking the Math Barrier: Female Students' Perceptions of Math and Their Involvement in a Math Practice Workshop

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Abstract: *A qualitative case study research design was used to examine American female elementary students' perceptions about mathematics before and after participating in a math practices workshop designed specifically for females. The workshop sought to address perceived barriers to learning math by applying math concepts to real-life situations while engaging in fun, exciting projects during a summer program sponsored by a city recreation department. Drawing on data from interviews, observations and artifacts, initial findings revealed that the majority of the participants had negative perceptions about math and their abilities in math. Findings suggested that when math is presented through hands-on, collaborative activities, the participants felt that math was more relevant to their lives and held more positive perceptions about math. The implication of the findings suggests that perceptions about math can change to be more positive. Challenges that these participants face in learning math and recommendations for supporting their learning are discussed.*

Keywords: female students, upper elementary school-aged children, math practices, mathematics education, perceptions

INTRODUCTION

Red flags have been raised about gender inequality in math achievement and careers for years (Eriksson, 2020; Gholami, 2023; Selimbegovic et al., 2007). Worldwide, women are still underrepresented in science, technology, engineering, and math fields (STEM) (Kuschel et al., 2020; National Science Foundation [NSF], 2015; UNESCO, 2020). Additionally, women comprise the lowest number of mathematics majors in higher education and are underrepresented in professional fields requiring mathematics skills (National Center for Science and Engineering Statistics [NCSES], 2017). There is a widespread misconception that males are innately better in math than females (Eccles, 2011; Szczygiel, 2020). Girls in particular can develop negative perceptions about math based on the expectations of their families, friends, and teachers (Bieri Buschor et al., 2014). In the short term, the myth that boys

are better than girls in math can lead to girls having negative perceptions about math regardless of their actual abilities (Rodriguez et al., 2020). In the long run, this can negatively affect females' choice of career.

Perceptions

Lindsay and Norman (1977) defined perception as the process of interpreting and organizing sensation by individuals to make meaning of the world, while Gregory (1997) stated that perception is a process that includes constructing inferences thorough what we experience. Knowledge and past experiences play critical functions in our interpretation of reality, which then influence our perceptions. In other words, individuals' unique perceptions of phenomena reflect their own constructed reality of the world. Vygotsky (1978) first articulated that individual perceptions and attitudes are grounded in social construction, purporting that knowledge and perceptions about various social phenomena are constructed in constant negotiation with other people and socio-cultural norms. Thus, a cognitive representation of a certain thing (e.g., math) is considered fundamental in developing attitudes and perceptions.

Perceptions of math

Research suggests that social cognitive factors such as students' perceptions, attitudes, motivations, interests, and values critically influence their math achievement (Fisher et al., 2012; Ganley & Lubienski, 2016). There is a strong correlation between students' math achievement and the way they perceive themselves in math. Personal factors, including perceptions of self-efficacy, how one thinks about oneself as a learner, and basic self-concept, a set of beliefs one holds as who one is, are often proposed as mediating variables that can affect math achievement for better or worse (Lichtenfeld et al., 2022; Marsh et al., 2005). Perceptions are also correlated with students' attitudes towards, their motivation and performance in mathematics (Fisher et al., 2012, Eriksson, 2020). A recent study by Gjicali and Lipnevich (2021) used representative data from US high school students' mathematical performance on large-scale assessment data from the Programme for International Students Assessment (OECD, 2013) to investigate the predictive value of beliefs and attitudes in math achievement. Their findings revealed that students' attitudes, subjective norms, and perceived behavioral control beliefs accounted for 21.1% of the variation in future intentions to major in math, 59.4% of the variation in behavioral engagement with math learning, and 30.7% of the variation in math performance. These statistics underscore the importance of how perceptions about math can either discourage or encourage female students to pursue math.

In a meta-analysis conducted by the Camacho-Morles et al., (2021) sixty-seven studies were reviewed to examine the relationship between emotions like enjoyment, boredom, anger and frustration and students' academic performance. Results indicated there was a positive relationship between enjoyment of learning and a negative relationship for both anger and boredom. A longitudinal study by Lichtenfeld et al. (2022), investigated the development of mathematical enjoyment, boredom, and anxiety in 670 second- to fourth-grade German students, as well as the relationships between these feelings and the student's math achievement. Data was collected from annual examinations of students' emotions while studying and taking exams in math, as well as their school grades and math achievement test results. The findings revealed that enjoyment declined over time among these students, while boredom and anxiety remained consistent across these years. Furthermore, the data suggest

that emotions and achievement are inextricably connected across time. Enjoyment positively predicted achievement, and achievement positively predicted enjoyment. Anxiety and boredom negatively predicted achievement, and achievement negatively predicted anxiety and boredom (Lichtenfeld et al., 2022). The association between students' performance and emotions was also evident in a recent study by Pekrun et al. (2023), who found that receiving good grades positively predicted students' positive emotions over time, which then positively predicted grades. Conversely, receiving negative grades predicted students' negative emotions, which again negatively predicted their grades. These findings emphasize how important it is to highlight students' feelings as well as achievements during the elementary education years.

Developing perceptions

Identifying early interests, perceptions, and attitudes (e.g., self-efficacy, motivation, value) toward math offers a promising means of investigating how these factors affect educational and career ambitions (Eccles, 2011; Ganley & Lubienski, 2016). Children start developing perceptions of their abilities and preferences for various subjects at an early age, often even before beginning their formal educational journey (Bieri Buschor et al., 2014; Muzzatti & Agnoli, 2007). Indeed, Sadker et al. (2009) described how girls encountered barriers and challenges to pursuing STEM education and careers starting early in their academic experiences; by sixth grade, girls often begin to avoid mathematics and science courses.

Female students' math perceptions

Students' negative perceptions toward mathematics might be attributed in part to the impact of social stereotypes (e.g., gender) (Eccles, 2011; Eriksson, 2020; Gunderson et al., 2012; Sadker et al., 2009; Smeding, 2012;). The pernicious influence of social stereotypes on female perceptions of self-worth as related to math is currently at the center of much education research: phrases like "math is not for ladies; let the guys do it" or "I don't do math and that's okay…I am a girl," illustrate this phenomenon (Muzzatti & Agnoli, 2007; Smeding, 2012). The widespread stereotype that math is a male subject remains prevalent (Smeding, 2012). Students of various ages seem to share the idea that mathematics and science careers are less accessible to females than to males (Eccles, 2011).

Perceptions are especially essential for female students. Females show significantly less interest in mathematics than males (Frenzel et al., 2007); females also show less confidence in their ability to succeed in math (Ganley & Lubienski, 2016). These perceptions are compounded by higher math anxiety in females (Gunderson et al., 2012). A study by Rodriguez et al., (2020) found that girls in 5th and 6th grades demonstrated lower levels of perceived competence and motivation and higher levels of anxiety about mathematics. However, there were no significant differences when it came to academic performance between boys and girls. Taken together, these findings suggest that females lack of confidence about their math abilities compared to males' may help explain why females tend to avoid math-heavy STEM careers (Bieri Buschor et al., 2014; Ganley & Lubienski, 2016).

Factors that influence perceptions

Attitudes held by teachers, family member, peers, and class environment all play an important role in girls' beliefs and perceptions about their own math abilities (Szczygiel, 2020). The presence of math-gender stereotypes is considered an important social factor influencing females' interest in math. If children believe that boys are better than girls at math, girls may

be discouraged from participating in such pursuits. Many possible reasons may contribute to girls' lower interest and motivation in math, including culture and a lack of sufficient, early experiences in STEM fields (Cheryan et al., 2017; Eriksson, 2020; Sadker et al., 2009). For example, boys spend more time engaging in age-appropriate technology and STEM activities, which may provide them with more likelihood of developing self-efficacy (Nugent et al., 2015). This in turn may influence boys' statistically superior performance in STEM subjects. Another possible reason is that teachers' attentions may affect students' motivation and performance. Bassi et al., (2018) pointed out that teachers interact with girls and boys in a manner that often favors boys. Differences in teacher behaviors in their interactions with boys versus girls are statistically significant in terms of criticism, acceptance, call on, and call out. The issues that some girls have in math, such as anxiousness, lack of confidence and low motivation in math, are not necessarily intrinsic female characteristics; rather, they are frequently caused by other factors such as the structure of the classrooms in which they learn math and the role models female students interact with either at school or at home (Muzzatti & Agnoli, 2007).

Indeed, Muzzatti and Agnoli (2007) emphasize that the misconception that girls' math abilities are worse than boys' grows stronger with age and has long been connected to teachers and parents' expectations about gender ability and skills. Research suggests that the influence of family members, teachers, and classmates profoundly affects female students' perceptions regarding math (Bieri Buschor et al., 2014; Gunderson et al., 2012; Szczygiel, 2020). It was evident that teachers' feelings about math play an essential role in children's attitudes: when teachers feel anxious about math, they are more likely to transfer their negative feelings to female students (Szczygiel, 2020). These findings illustrate the stark need for research-based strategies to modify the way we teach math to girls.

Changing perceptions: math activities and summer workshop

Providing effective, meaningful math activities (Al Khales et al., 2022; Baran et al., 2019; Didik et al., 2023; Williams et al., 2021) and interventions can play a potent role in changing perceptions and attitudes. As the National Council of Teachers of Mathematics (2000) states, "Some students may need further assistance to meet high mathematics expectations… and…additional resources, such as after-school programs" (p. 13). Summer programs that include meaningful practices and activities have the potential to enhance attitudinal outcomes depending on the type of the program as well as focus, duration, and attendance (Binns et al., 2016; Matsudaira, 2008). A limitation throughout the literature, however, is its propensity for studying older students, rather than focusing on younger learners. We attempted to address this issue in part by focusing on younger female learners, ages 10 to 12.

METHOD

Purpose of the study

This qualitative case study explored the perceptions of elementary-age female students—fifth and sixth graders from the United States between the ages of 10 and 12 years—who participated in a summer math practices workshop. Most previous research regarding female math-skills acquisition has been based on quantitative methodologies. While these approaches help in exploring the breadth of the topic, they often fail to adequately explain the findings in personal

terms. The lack of explanatory depth in quantitative research underscores the need for sound qualitative approaches to help us better understand how perceptions of math and their own math skills and learning may affect elementary-age female students' math acquisition. This case study was designed to fill a gap in the qualitative data by exploring elementary female students' perceptions of math and whether a workshop with math activities designed to appeal to elementary-age girls could modify their feelings and perceptions about math and their own math skills.

The following research questions were posited to obtain data about how female elementary students in our age group perceived math before and after participating in a summer math practices workshop designed specifically for females:

1. How do elementary female students perceive mathematics before participating in a math practices workshop?
2. How do elementary female students perceive mathematics after participating in a math practices workshop?

Theoretical stance and research design

To better understand the participants' perceptions and experiences, a qualitative study was conducted using a constructivist theoretical stance where individuals construct meaning from their interactions (Crotty, 1998). Lev Vygotsky (1978) first articulated the precepts of this theory, suggesting that knowledge about various social phenomena is constructed in constant negotiation with other people or socio-cultural norms. With constructivism, the researcher and participant co-create meaning through interaction; the focus of the study is on a participant's perspective based on their own experience. A constructivist approach emphasizes using participant observation and interviews to generate unique and novel data about a phenomenon, and to understand the phenomenon being studied from the lived perspective of the participants (Merriam, 2009).

Researcher stance – researcher 1

When I created this summer math workshop, I wanted the participants to be aware that math is a real-life problem. Making sense and creating meaning to view math from a positive perspective were my ultimate goals in developing the math workshop. It is my belief that female students have the same capability to be effective in math as male students; however, they need a community of people who believe in their skills and give them the chance to help them develop their skills and abilities. Teachers need to show acceptance, encouragement, maintain high expectations and responding positively to student efforts, focusing on the learning process as well as the end result. Above all, teachers need to be positive and enthusiastic about their teaching, their students, and their subject matter.

Research stance – researcher 2

In my high school, two females were the undisputed best math students in the school (I was a distant third). Therefore, I grew up believing that females were better at math than males. I did not know until college that there seemed to be a myth that males are better at math. As I have grown older and taught undergraduates and graduate students from many different parts of the world, I have heard that this myth is not merely something common to the United States, but other parts of the world as well. As a husband, father of a female and grandfather of several

females (at least one of whom at least is extremely talented in math), and a teacher who is concerned about how disinterest in mathematics can limit people's future career possibilities, I was very pleased to join Researcher 1 to examine her data from her workshop and analyze the content of what she had done.

Participants and setting

Participants included seven elementary-school age females between 10 and 12 years with a range of mathematical and learning abilities. Four had been identified as "at risk" in mathematics, either by state assessment as "not proficient in math," or by having an Individual Education Plan (IEP) addressing math needs. Two were identified as having a learning disability (LD). Three others were identified as having attained proficiency in math, indicating that they were either at or above proficiency level. Of these, one was identified with Emotional Behavior Disorder (EBD). Six of the seven participants were Hispanic; while all of them were fluent in English, several students spoke Spanish at home, and one participant lived with her grandfather who spoke no English. Please see Table 1.

Name	Sarah	Kaylee	Lyndsee	Tanya	Elysia[a]	Maya	Emma
Math Proficiency[b]	NP	NP	NP	P	P	NP	P
Program[c]	LD	LD	GE	GE	EBD	GE	GE
Grade	6th grade	5th grade	6th grade	5th grade	5th grade	6th grade	5th grade
Race	Hispanic	Hispanic	Hispanic	Hispanic	White	Hispanic	Hispanic

Notes: Names are pseudonyms.
[a] This student was also in the gifted and talented program until the last year.
[b] Math proficiency is defined by annual state assessments: NP=Not Proficient, P= Proficient,
[c] Program: LD=Learning Disability services, EBD=Emotional Behaviors Disorder services, GE= General Education

Table 1. Participants – math proficiency, program in school, and grade

Prior to starting the workshop, the first researcher met with the participants' parents to explain the study's purpose and procedures. Parents provided written consent to allow their children to participate in the study. Participants were selected by the director of a city recreation department summer program following criteria outlined by the researcher – female elementary school students in 5th and 6th grade who were at or below grade proficiency level in math. The summer program offered various activities and content instruction for district students; the workshop consisted of 2-hour sessions three days per week for a total of seven weeks. A staff of four volunteers – two in-service teachers and two pre-service teachers – assisted in the workshop along with the first researcher.

Data collection tools

The data-collection methods used in the study consisted of observations, artifacts, and interviews. Interviews were conducted one on one in a quiet room; all interviews were recorded on the researcher's laptop. At the same time, the researcher took notes in a journal. The same journal was used to record observations during the workshop. The participants created two main artifacts – a house and a math journal – which they took with them at the end of the workshop. The researcher took photographs of these artifacts.

The workshop

This workshop was specifically developed to teach math to pre-adolescent girls in a non-threatening, fun way. The first researcher decided to incorporate her main interest in teaching mathematics and apply it to another primary interest – teaching girls in primary grades, including those identified with disabilities. The workshop format enabled her to engage girls in both easily observable activities (watching as the girls build crafts) and interviews (gathering data from conversations occurring while engaging in the activity). Ørngreen and Levinsen (2017) point out that workshops are ideal for research on how attitudes and perceptions affect math learning because they enable a more organic interaction between researcher and participant, allowing for co-creation.

Project	Brief description of Tasks	Skills and knowledge thought	Standards	Approximate Duration
Create a story book (journal) using real life math problems	Determine the main characters and write a short life story that includes math facts. Demonstrate and write the life story with drawings or taking pictures. Create and design the frame of the journal	Reading skills, narrative story, math skills, Creativity skills, solving problems, self-direction. Real word problems, analyzing and productivity	Number & Operations—Fractions. Operations & Algebraic Thinking. Statistics & Probability.	One session for each task
Build a house	Sketch and outline house dimension and design by measuring parameters on draft. Use provided materials to start building the house. Complete the work on building the house and add the final touch of adding furniture and painting.	Measurement, operations, creativity, responsibility, self-direction, planning, solving problems, collaboration.	Measurement and data. Expressions & Equations. Number & Operations—Fractions. Geometry.	One session each task

Table 2. Projects – Description, targeted skills and related standards

The math course workshop was intended to develop and enhance young girls' perceptions regarding achievement in math by building self-esteem, self-regulation skills and enable them to make correct choices in using math operations. This was accomplished by providing the girls with activities, tools and strategies that increased their confidence in using math in practical ways. During the workshop, the first researcher developed a list of educational activities that were delivered in 2-hour sessions during the 7-week summer program. Sessions included skills and math concepts that were introduced and taught to the students, and practiced through hands-on and collaborative activities (see examples in Appendix A and C). All

activities were designed to reinforce concepts, skills and knowledge introduced and taught during other sessions. The purpose and objectives of implementing each session aligned with the 4th grade Common Core State Standards in math. Some activities could be completed in one session; other activities required more time to explore the concepts in depth. Each participant engaged in two main projects: creating a story math book (journal) and building a model house out of foam-board. In addition, there were other math activities and games to attract students' attention and foster engagement. During every 2-hour session, the participants worked for the first hour on creating their house and in the second hour, they worked on designing their math journal. Between the two hours, the participants had a break to have snacks and free time as well as other math activities. Even playtime had goals and aims to develop math skills. Two projects that were implemented during the workshop are described in Table 2.

Observations

During the workshop, the first researcher observed students and recorded her reflections, basing observations on how well the girls engaged in the activity and interacted with each other. Other participant behaviors and comments indicating enjoyment of the activities were observed and recorded to help confirm research notes and observations.

Artifacts

Because the workshop involved the participants creating objects (a house and a journal), these artifacts were recorded as part of the data. However, the final product was not the main interest. Rather, researchers were interested in the creative activity itself, particularly in participants' use and application of mathematical principles, and the problem-solving skills they applied to their creations. The researchers recorded conversations to determine how mathematical concepts were being used by the participants. The house project consisted of a 3D foam board construction similar to a doll house, approximately 36 inches wide by 24 inches deep by 8 inches high. The footprint was an irregular rectangle shape. The participants cut each piece of the house, assembled these, then customized their house by adding windows and doors, floor coverings and wall paper; every activity required using math measurement and calculation skills. The math journal consisted of a blank journal which the participants used to describe each activity and enter their calculations.

Figure 1. Activities: M&M, Marshmallow, Shapes

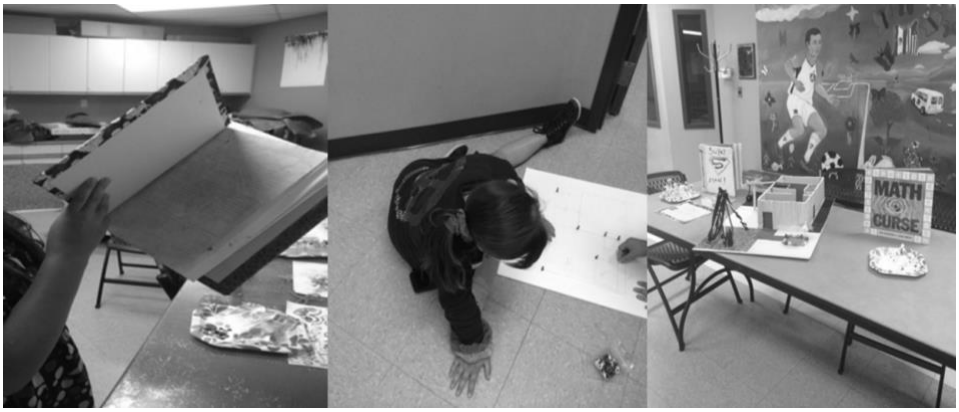

Figure 2. Products: Journal, House Sketches, Final Products

Interviews

The first researcher carried out semi-structured pre-and post-interviews, consisting of ten open-ended questions, adapted from her previous research. Interview questions were chosen and worded following Merriam's (2009) suggestions for developing good questions, focusing on experience, behavior, opinion, feelings, knowledge, and demographics. Three independent, experienced researchers evaluated the wording, clarity, and maintenance of focus within the questions, and understandability. See Table 3 for examples of interview questions.

Interview questions before and after the workshop	
Before	How do you feel about math? Tell me about your math class, how do you usually do in math class? How do you think math can be useful for you in life? What is your opinion about your math teachers you have had? How can you tell if your teacher liked to teach math or not? When you think of a person who uses math best, who is it? How do they do it?
After	How do you feel about math? Where math can be used? How do feel about summer program and math course project? What do you like the best about the math course project? What do you like the least about math course project? What color would you choose to describe math course project? Why?

Table 3. Examples of interview questions

Interview procedure

Internal review board approval was obtained prior to the workshop. Initial interviews lasted approximately 30-60 minutes to answer the first research question regarding the students' previous perceptions of math. Each interview was audio recorded on a phone and laptop. Students were interviewed one-on-one in the director's office to minimize interruption and provide students with a comfortable environment. The interview guide was used with each participant to elicit relevant data regarding her perceptions about math and her own abilities in that discipline. Each interview item was read aloud by the first researcher, and students were

allowed to ask for clarification. Follow-up interviews were completed to clarify or expand upon unclear responses. Iterative questioning was used to minimize the impact of unclear answers. The researcher duplicated some of the questions on the prior interview and presented them in different words to see if the answers to these questions matched. The researcher chose to eliminate contradictory data. Another session using the same procedure was administered at the workshop's end to answer the second research question. Recordings were stored on the first researcher's password-secured laptop and the interviews were transcribed by the first researcher and two other colleagues.

Finally, the researcher created a reflective commentary journal, outlining initial assumptions about the study's outcomes. The journal was used in each stage of data collection and analysis to record thoughts and ideas during each stage of the research. The researcher compared the ideas and comments from the data collection and analysis stages with emerging themes to determine whether these had any direct influence on the recognition of data patterns and to help delineate the researcher's stance and limit any biases or assumptions.

Data analysis

The research was carried out in accordance with Braun and Clarke (2006), who define six steps to thematic analysis: a) familiarizing yourself with the data; b) producing initial codes from the data; c) sorting codes into initial themes and arranging the data within those themes; d) reviewing and refining the themes in respect to the overall pattern of the material; e) defining the themes and clearly stating what they are and are not, and f) producing the report after having finalized the themes and subthemes. In this study, comments from interviews, observations, and activities were combined to create data for analysis. NVivo 11 was used to code and analyze the data. Relevant information was identified by highlighting the text to examine emerging patterns. Specifically, both researchers reread the transcripts and color-coded participant responses regarding emerging patterns. Next, the first researcher created a table depicting individual's typical responses to each emerging theme. This graphic aided researchers in re-examining and refining the coding of designated categories to better identify them. Categories formed from this thematic coding were perceptions of: a) mathematics; b) individual abilities in math; c) the usefulness/applications of math; d) the influence of others in shaping perceptions of math and e) math after the workshop. Two additional colleagues reviewed the data to identify emerging themes. Their individual findings were compared with the themes identified by the study's researchers. Frequent debriefing meetings between the researcher and her colleagues helped ensure trustworthiness of the findings, helping to widen the study's perspectives and scope and interpret the data under the supervision of experienced professionals. This professional guidance was necessary to eliminate mistakes and improve the quality of the study during both data collection and analysis stages.

RESULTS

After analyzing the interviews, observations, and interactions while building the artifacts and researcher notes, five themes were found to be relevant. Four themes identified perceptions of the participants before the workshop: Perceptions of Mathematics, Perceptions of Individual Abilities in Math, the Influence of Others in Shaping Perceptions of Math, and Perceptions of the Usefulness/Applications of Math. The fifth theme dealt with Perceptions of Math After the Workshop.

Before the workshop

Perceptions of mathematics

> Math is fun, sometimes boring … really, you gotta focus…you've got to pay attention…you've got to understand it… it's going to take you a while…you really just need to be patient…it's going to stress you out…you gotta be calm and just get it over with. (Elysia, participant)

During pre-interviews, most participants were unsure about their feelings towards mathematics, sometimes stating that mathematics was good, easy, amazing, exciting, and that they liked it, but also commenting that math was boring, hard, confusing, and stressful, making them feel worried and frustrated. For example, Sarah said that math made her feel "overwhelmed and worried about not passing the test, or failing, or doing something wrong." "I don't really enjoy math," she said, "I don't really want to learn about [math] but I have to." However, she also stated that mathematics was amazing and exciting, "because math is everywhere" Tanya also had some contradictory responses regarding her perceptions of mathematics, saying, "Sometimes I get bored"; "Your brain hurts," and "It's so confusing." On the other hand, Tanya described math as fun, important, tricky, and "I was, like, so good at it. I just really liked that. It was fun," and "I like math." Another student, Emma, linked her feelings about math to her ability and performance: "Sometimes I get really scared when I get to math class ... some of the positives are that once I get really caught up into it, I know what I'm doing, and I understand what I'm doing." Her perceptions fluctuated depending on her understanding of particular concepts. This view was also shared by Elysia, who noted: "I'd say [math is] fun, sometimes boring, maybe a little. Really, you gotta focus.... You've got to pay attention. You've got to understand it. It's going to take you a while. You really just need to be patient. It's going to stress you out. You gotta be calm and just get it over with."

Only one participant, Lyndsee, showed consistent positive feelings about math. She said, "Whenever someone says 'math,' I get all excited." While most participants expressed contradictory feelings about math, the dominant statements were negative, and repeated several times during interviews.

Perceptions of individual abilities in math

> "…if somebody else asks for my help, I'd be like, "I don't know how to do this!" I get…We'd both be in trouble." (Tanya, participant)

When asked to describe their beliefs about their own skills and abilities in mathematics, the seven participants gave a range of answers. Two had positive perceptions. Lyndsee (NP in Math), said, "You use your brain a lot…math makes me focused." Elysia (P in Math, EBD) claimed she was good at math because she was fast and knew the content. She set high goals; she started at the 80% goal in a class but worked hard to achieve the 100% goal, which she did three times in a row.

Five students (three of them NP in math) displayed negative perceptions regarding their abilities. They described working hard, struggling to acquire the concepts, and giving up when math became too hard. Sarah stated that developing math skills was hard for her and her teacher had pushed her to follow the instructions: "My mind doesn't want to learn math. It like…tells me… no, you won't pay attention." When asked about her perceptions of her ability, Sarah responded, "I don't know how I got into the advanced class…my teacher had to push me a lot

to help me develop in math." Tanya reflected that "I'm not good in [math]." However, she also stated that she was good at multiplication problems, Maya felt that she had trouble with math, explaining, "Sometimes I don't get the questions… sometimes I get it wrong" and noting that her first year "was really hard. I got a really bad grade on a test and I felt really bad." However, like Tanya, she pointed out that she considered herself "good at multiplication and division". Emma, who was proficient in math, said "I'm not that good at division," and "I'm just working so hard to get it done, and some days I just give up and don't even do it."

Most of the participants said they were not proficient at solving math problems and that math was confusing. With one exception, students struggled either setting up or solving problems. Kaylee explained that "ten and um [pause] two and ten times two equals…it equals…doesn't it equal fifteen?" but finished by saying, "I don't remember." Tanya began her math example with, "When I fix my bike, you have to…measure the wheels," but then talked about finding the dimension of the inner tube, and concluded with "we had to figure out the price again."

Perceptions of the usefulness/applications of math

"I like math because, um, I get to solve questions that really challenge me...[but]… sometimes I get really scared when I get to math class" (Emma, participant)

Although most of the participants repeated the phrase "Math is everywhere" or "It's 24/7," the actual application of mathematics concepts they described as useful in daily life was very limited. Six of seven participants stated that mathematics was used in daily life mainly for counting money, paying bills and measuring. Lyndsee's example was, "Mom counts how much money she has in her bank; dad [counts his] cash register and counts his money." Maya responded that people need math in life "when you buy something to know how much money you have to give them." Sarah articulated, "In life you need math because if we didn't have math then, um…, people would be paying less and the cashiers and people wouldn't care if they were and no one would get money back and they'd be losing money and people just wouldn't understand the world because we don't have math." Elysia viewed mathematics in her life as measurement skills saying, "If you want to build a house when you get older, an architect, you have to know all these math things and stuff."

The influence of others in shaping perceptions of math

"…the teacher's not really having fun with the math, they just go on and on and on and on" (Sarah, participant)

One theme that emerged from the interviews was how often other people were mentioned as helping develop participants' image of mathematics: friends, family and teachers. Friends and classmates were seen as more proficient in math, particularly boys. Kaylee reported that "[a classmate] is really good at math…he knows A LOT" and "he kinda helps me, but he goes too fast for me." Some girls were seen as good at math - Tanya pointed out that "My friend, Hayley…is really good at math…she wants to be a math teacher." Others were cast as not so proficient: "They don't like to do math."

Most participants mentioned family members' experiences with mathematics. In general, the majority of participants knew at least one family member who was not good at math. Either the mother or father was perceived as not providing their child math help and support. In addition, the majority of the participants had sisters who hated math. By contrast, most of them had brothers who were good in math. While Tanya thought that her mother was good at math,

she indicated that her little brother "is like brain science, oh my gosh, I am amazed by him and he is, like, five." Emma pointed out that her parents "don't like math, they…help me with math, but they don't like it."

Of the four participants who performed below proficiency in math, three did not receive parental help or support. However, they all had brothers who were good at math. For example, Kaylee related how "my brother loves math," and "my sister – not so much…my dad never liked math because he doesn't really understand math homework and when I ask him for help, he is like, 'I don't know, ask your mom' and mom doesn't know it." Lyndsee responded that "my mom just is not that good at math," and "my step-dad uses it the best." Sarah repeatedly referred to her perception of being a disappointment to her family. She stated that "I'm just still kind of developing in math."

Participants also talked about their teachers and their perception of their impact on participants. Four of the seven participants indicated that they had a negative experience with at least one math teacher. However, two participants who performed below proficiency and one who performed at average/ above proficiency felt they had positive experience and support from their teachers. Sarah mentioned that "When I was in 1st, 2nd, and 3rd grade, the teachers wouldn't really push me to become a better student in math…sometimes the teachers don't really like teaching math and they don't seem to care if we know how to do math or not." Sarah also concluded that sometimes her teachers sounded bored, and that "If the teacher isn't excited about learning and teaching math, then the students (are) not going to be excited about math." Tanya reflected that "my teacher seemed like she liked math, but she'd get a little tired of it, like in between for her." Regarding her other teachers, she said, "[One teacher] didn't really like teaching math…she'd be, like, "Okay, I don't understand this" or "I need to fix this; I don't get this."

Although most participants were surrounded by female friends, family, or teachers who did not like math, some participants felt their teachers were supportive of them and their abilities in math. Kaylee described her teacher as, "She is nice …[if] we got something right, she made us feel better with [our] math book…[math] was her favorite subject when she was little." Kaylee also regarded other teachers in a similar fashion, "They like to teach math," and" They wouldn't teach math if they didn't like math." When asked whether she thought that her mathematics teacher believed in her ability in math, Kaylee responded, "Yes," adding that, "Every teacher does." Likewise, Lyndsee expressed that her teacher was "confident about me passing to the 6th grade…she would always say 'good job'."

After the workshop

Perceptions of math after the workshop

"Teachers should make math a little fun instead of just saying you have to do that and make it like a little more active..." (Maya, participant)

"I like the book, because you get to take the book home…and get to put pictures in it…and you get to bring memories about your friends" (Kaylee, participant)

After their initial interview and subsequent Math Practices Workshop, the participants were re-interviewed to see how their perceptions may have changed. In the workshop, all participants were able to successfully complete several hands-on projects, including a house and a journal, using mathematics to solve daily problems, recount stories, facts, and activities. Participants

were first interviewed to get a sense of their perceptions of math and math abilities. They then participated in the workshop and were re-interviewed. All seven described their workshop experience in positive terms, using words/phrases like "fun," "exciting," "using hands-on activities" (for a complete listing of each participant's perceptions before and after the workshop, please see Appendix B).

Sarah, whose initial interview contained such phrases as "I don't really enjoy...it is math" and "I couldn't develop in math as quick as other kids," mentioned afterward that the "summer program and math workshop [were] exciting" and that what she liked "best about the math workshop is the houses and the books because I get to create things and just be myself." Sarah commented that she didn't "have to worry about being looked at as a disappointment in math," in contrast to her other experiences in math. She also commented about the advantages of participating in the workshop, saying, "I think the summer program and math workshop are very exciting and they really help me like learn life skills, sometimes not even life skills, just like skills and the math workshop helps me just develop more in math, more than…I really am."

Tanya, whose original comments were that math was not fun, boring and that she wasn't good at math, said "I like it. I really do. It's fun. Whenever it's Mondays and Wednesdays, I get so excited." Tanya also mentioned that it gave her the chance to experience math activities related to her interest and she felt math belonged to her: "It's been like the really fun thing for me, 'cause we are working on our houses."

Similarly, Kaylee who initially felt that math was frustrating and stressful, claimed the workshop gave her the opportunity to be part of math activities and to connect math concepts to her life by creating books (journals) that involve math problems. Kaylee mentioned, "I like the book, because you get to take the book home…and get to put your pictures in it…and you get to bring memories about your friends…It's fun and you get to do a lot …like you don't usually get to do in math."

Emma's initial perceptions of math were that she struggled and was frequently distracted in math, said after the workshop that "I would really go back to this place if I had to … the math workshop was amazing."

Lyndsee, who had positive perceptions regarding math during the initial interview still enjoyed the workshop and the positive perceptions it offered her: "I really like it," "[I can] do activities," "it's only girls" and "it is all fun." This workshop seemed to reinforce and strengthen the positive perceptions Lyndsee had.

Observations during the workshop

The participants were very engaged in the activities of the workshop. They were eager to work on hands-on activities, but were less interested in paying attention during the reading circle. Elysia, who had high academic grades, calculated the problems mentally without using a calculator; she tended to work independently and spent less time interacting with the other participants. However, some of the other participants had difficulty staying on task for very long; they needed multiple short tasks and more assistance. Lyndsee had problems working out how to calculate the measurements of a shape that was uneven, neither a square nor a rectangle. She was unable to do this by herself or with a peer; she required explicit instruction about the steps required to complete the task. Student feedback, both verbal, body language, and self-

reporting by checking a face (happy, sad, neutral) on the face board, allowed the first researcher to make adjustments and corrections after each session.

DISCUSSION

This study focused on understanding the perceptions of young female students toward mathematics and demonstrated that even students as young as 10 to 12 years old are able to articulate their perceptions and lived experiences. Before the workshop, almost all participants expressed negative perceptions of mathematics or of their own abilities in the subject. Participants reported several words and phrases reflecting anxiety and low confidence in math: being stressed, frustrated, tired, scared, overwhelmed, and worried. These findings align with common themes in previous studies that a negative perception and increased stress toward mathematics is common among female students (Eccles, 2011; Ganley & Lubienski, 2016; Gjicali & Lipnevich, 2021).

Before the workshop, some students reported that they perceived themselves as "really good" at math, despite acknowledging that they were not particularly good at simple math problems such as multiplication or division. However, in spite of this, there was a clear discrepancy in the examples they provided, which reflected unperceived errors in math operations, confusion, or an inability to solve the very problem they posed as an example of their proficiency. They failed simple multiplication questions (e.g., 10 multiplied by 2), claiming they could not remember the answer, and mixed different processes that were unrelated to solving a math problem (how much would it cost to fix a bicycle and the diameter of the wheels). Most participants provided examples that showed incorrect answers or a lack of proficiency. Yet one of the proficient students thought that she was not good with multiplication and division, while one of the below proficiency students stated that she was quite good with multiplication and division. Thus, their perceptions about being good or not good in math seemed related more to how much they struggled with math and grades than to their actual abilities. Many of the participants in this study expressed the opinion that their classmates, especially the boys, were better at math than they were. The idea that everyone else is better, that they will not be able to catch up, was disheartening and supported their negative perceptions about math.

These findings relate to previous findings concerning the generally negative female perception of mathematics (e.g., Ganley & Lubienski, 2016; Gunderson et al., 2012; Selimbegovic et al., 2007). The perception and belief that mathematics is hard, stressful, and boring could be attributed to perceptions of achievement rather than actual ability. Participants in the current study expressed the feeling that mathematics is frustrating because at some point before the workshop they were not able to solve a problem correctly. The emotions behind a "failure" can be very strong and might result in aversion to the source of frustration. Participants' dislike of mathematics might be also attributed to negative experiences in their acquisition of mathematics concepts. As evident from recent studies, there is a relationship between students' achievements and emotions (Camacho-Morles et al., 2021; Pekrun et al., 2023).

It appears that most study participants perceived mathematics as a discipline that can be described in only four operations (division, multiplication, addition, subtraction). Thus, it comes as no surprise that all of them stated that in real life math is only used for measuring things and counting money, which they observed at home.

Evidence from this study implies that awareness and motivation from all education stakeholders is critical in enhancing math performance among female students. One way to do that is by ensuring that our students are taught by highly qualified teachers who are competent in the subject matter and enthusiastic about what they teach. In this study, students were clearly aware of and understood when their teachers were hesitant and unsure about math, and it affected their perceptions about math. When their teachers enjoyed and were excited about teaching math, several of the participants indicated that their teachers were confident that their students would be successful in math. These teachers' attitude and excitement are palpable to their students.

The activities and teaching strategies often used in traditional math instruction can be alienating to some students, especially when the tasks demanded independence rather than interaction. Several of the participants could not stay on task for the entire activity; they needed assistance to break larger tasks into smaller, more manageable units. They also needed more explicit instruction, especially when the task was more abstract. While peer support and collaboration were helpful in building teamwork and camaraderie among the participants, the participants who were not proficient in math needed more assistance from the teacher.

Several participants shared that they did not receive assistance with math homework at home. Their parents did not feel they knew enough math to help them. Coming from a math-weak home increases the chance that the math homework, which is intended to improve students' math skills, might do the exact opposite and reinforce the idea that math is not for them. When the adults at home do not see math as being an important skill, it is less likely that children will consider math as important in their own lives.

Despite their conflicting attitudes and perceptions before the workshop, the participants were overwhelmingly positive and confident both during and after the workshop. We believe that participants' positive responses were due to their introduction to mathematical concepts through active, concrete tasks related to their interests and supported by a competent, enthusiastic math teacher. This outcome is supported by previous studies that found exposure to real-life math applications and exciting math activities positively influenced young learners' perceptions, attitudes, interest, and learning (e.g., Al Khales et al., 2022; Williams et al., 2021).

LIMITATIONS AND FUTURE RESEARCH

Limitations of this study include a small, fairly homogenous sample, which limited our ability to discuss the topic of intersectionality in any meaningful way (Collins, 2015). For instance, all of the participants were female and most were of the same ethnicity; therefore, it is difficult to discuss how race and ethnicity influenced the participants in terms of their perceptions of math. We acknowledge that intersectionality is important for this type of study; while all of the participants were females, we recognize that each person is a unique individual made up of several different identities and characteristics and that, as stated by Bullock (2018) "…intersections of identity categories create different life experiences" (p. 130). Issues of representativeness and intersectionality can be addressed by replicating this study with a larger number of different participants of the same age and math abilities, as well as using the same format (workshop, activities) with female students at different grade levels. Another limitation is the short duration of the study. Expanding the duration to a full school semester or year, perhaps as part of an after-school program, could provide insight into whether changes in

perception are lasting. An important area of future research is exploring the perceptions of females with math-related learning disabilities to learn about the obstacles and challenges these girls face.

RECOMMENDATIONS

Insights from this study led to the following recommendations for math instruction of female students who are not proficient at grade level that were helpful in developing more positive perceptions about math:

1. Teaching and learning math need to be linked to real-world and interesting activities, using a range of instructional strategies and providing math-related activities that are based on the interests of girls.
2. Teachers should encourage discussion and reflections of the importance of math among female students at early age and engage them in collaborative learning environment.
3. Students who do not have support at home, especially those who struggle with math, need to be provided with an after-school math program staffed with a highly qualified math teacher.

CONCLUSION

This qualitative study explored the perceptions of female 5th and 6th graders regarding math during the course of a summer math workshop. Before participating in the workshop, the participants in this study either doubted their ability to perform well in math or had an inflated idea of their math ability, regardless of their proficiency level. The summer math workshop was designed specifically for girls, with practical, hands-on activities that they wanted to participate in – building a House and completing a Math Journal – while encouraging them to use math at their existing skill level. The workshop is an example of how mathematics can be turned into an exciting subject, which girls could enjoy and learn.

As stated in our review of literature, females are more likely than males to be negatively influenced by social perceptions, including the pervasive myth that math is not for girls. However, when these participants were provided with meaningful activities that were clearly connected with math and explicit instruction by a highly qualified teacher, the participants' perceptions of their abilities in math became more positive. Our findings on the positive impact of engaging activities and qualified teachers resonate with the emphasis on promoting positive math experiences in early childhood education found in Al Khales et al. (2022) and Williams et al. (2021). However, unlike these studies that have had broader target audiences and employed different intervention types, our case study specifically focused on girls' math perceptions and the impact of the workshop in perceptions toward math. Moreover, a clear finding of this study suggests that when teachers are competent and excited about math and express confidence in their students' abilities, girls believe in their own abilities. Although this case study involved a small sample, we believe that it is a powerful example of how educators can use appropriate gender-specific examples geared toward the students' true ability levels to encourage girls' interest in mathematical fields.

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APPENDIX A

Examples of Daily Goals and Objectives

Day	Goals and objectives	Materials	Products
1	• Get everyone familiar with format of workshop and each other. • Introduce the projects that students will implement during the workshop. • Students will draw draft for T-shirt measurements and provide them to the teacher. • Students will write a reflection for their journals on what they have learned.	• Name tags (sticky) • Math curse book • Math vocabulary cards • T-shirt designs	• Students' T-shirts drafts measurement. • Reflection
4	• Students will continue drawing house sketch and draft by taking all the measurements in the first hour session. • Students will do some additional activities for five minutes between the two sessions (M&M investigation) • Students will color the house sketch. • Students will write a reflection paper for their journals.	• House materials • Drawing paper • Yard sticks • Colors • Pencils • Display board • Exile paper	• House and book sketches • Presentation • Reflection
12	• Students will assemble and attach the walls, door and grass on the large foam board surface by temporary glue to check if there is any mistakes and missing walls and doors in the first hour session. • Students will draw, take pictures for their work on the house to use them in their story. • Students will write one or two math story problems related to their experience of the first hour session. • Students will do some additional activities for five minutes between the two sessions. (Playing time). • Students will write examples of math story problems especially what they have been experiencing while they working in their two projects on their vintage papers. • Students will one math story problem related to their daily life. • Students will draw, take pictures to use them in their math story book. • Students will write a reflection paper for their journals addressing what they have learned from this session.	• White papers and colored paper. • Pencils. • Calculators. • Scissors. • Colors • Hole-punch. • Cardboard • Popsicle stick • Ribbon • Beads • Rocks • Fake grass • Tooth picks • Wood glue • White glue • Xacto Knife	• House • Journal • Presentation • Reflection

APPENDIX B

Perceptions Before and After Workshop: Examples

Phase	Before the workshop	After workshop.
Pseudonym		
Sarah	"I don't really enjoy it is math" "I couldn't develop in math as quick as other kids" "The teachers not really having fun with the math, they just go on and on and on and on" "My mind DOESN'T want to learn MATH" "My teachers looked at me like they were kind of disappointed in me" "I don't really want to learn about math but I have to"	"Summer program and math course project are very exciting" "Everything is so fun and really just amazing." "Math course project helps me um just develop more in math, more than um more than I - I already am" "I like best about the math course project is the houses and the books because I get to create things and just be myself" " creating houses help me understand measuring more" "I don't have to worry about being looked at as a disappointment in math" "I would encourage kids to be more focused in math and to be math teacher"
Kaylee	"I just not concentrate", "not paying attention" "I have problem reading words", "I don't get them straight" "I need quite time when I do my tests" "Kind of frustrated", "sometimes I get stressed out", "it got harder and harder every time"	"I like the house …because you…you get to do your own…we had to measure what wall I was gonna do" "I like the book, because you get to take the book home…and get to put pictures in it…and you get to bring memories about your friends" "It's fun! and you get to do a lot of a…(inaudible)…like you don't usually get to do in math"
Lyndsee	"I am pretty good, but not like advanced" "Math makes me focused" "I don't feel worried about math" "I love math"	"I really like it" "is fun" "play outside", "do activities" "it's only girls" "it is all fun" "I would encourage them [her future children] to be math teachers…tell them math is everywhere,24/7"

Tanya	"When I heard the word "math" it makes me think of, like…like a lot of writing…in a way", "I have trouble in Math"	"I like it. I really do. It's fun. Whenever it's, like, comes to Mondays and Wednesdays, I get so excited!" "It's fun for me. It really is."
	"Sometimes get bored", "they don't have fun with it"	"I sit there and I'm like, "When is the Math Curse gonna come?" "Math important…"
	"kinda Math…I'm not good in it" "I'm kinda bad at it."	"That we are building out houses and our books, coz…it's been like the really fun thing for me, coz we are working on our houses"
Elysia	"Math is fun, sometimes boring, maybe a little… really, you gotta focus…you've got to pay attention…you've got to understand it… it's going to take you a while…you really just need to be patient…it's going to stress you out…you gotta be calm and just get it over with. "in math, we do a lot of sitting down and stuff."	"I'd say I like it", "we used more hands-on activities", "…and the hands-on stuff like building houses and stuff, so that's what I like."
	"…measuring and stuff, which I'm not very good at…"and "I'm not good at times and, um, dividing, but I'm good at addition, minusing, fractions, and all that kind of stuff."	"I was just building a tent out of sticks and stuff. I, no, I didn't have a ruler or anything, but I still had to measure with the other sticks I was going to use. Like I would say, "Oh, I have to do this," and stuff."
Maya	"Math is like really hard and like a lot of people struggle on it" "Math sometimes is slow..."	"We could explain math in a fun way instead of doing it in a boring way."
	"some teachers are just ... I had one math teacher got to get it done and that's it.	", I like how we make like the houses and, and the primary books that will give all kinds of activity…" "Teachers should make math a little fun instead of just saying you have to do that and make it like a little more active..."
Emma	"I like math because, um, I get to solve questions that really challenge me..." "Sometimes I get really scared when I get to math class ..."	"I would really go back to this place if I had to…. and the Math Project was amazing. It was fun." "I loved all the projects that we did..." "Doing the houses. It was really fun." "I do like measurements and stuff"

APPENDIX C

Samples of Mathematics Materials

Example1: House measurement

1- Choose one house model sketch that your teacher will provide.

2-Draw your house and measure all the dimensions of the eternal and external house.

3- if you want to increase the size of the house, you need to think what is the way to do that.

4-You may measure the demission by centimeter or inches. (It is your choice)

Students' House Measurement

Room	Width	Length	Area
Kitchen			
Bedroom			
Bathroom			
Livingroom			
Patio			
Back yard			
Garage			

Example 2: Measure and Write the Measurement of Your T-shirt.