

Article

“Dear Math, I’m Not a Fan of You”: Shifting Middle School Girls’ Perceptions of Mathematics

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Abstract

Girls can develop poor perceptions of mathematics and themselves as doers of mathematics relatively early in their schooling. Strengthening their content knowledge and attitudes toward mathematics can improve their participation in voluntary math-related pursuits, including careers. The purpose of this research was thus to investigate the role of one potential support strategy: a one-week residential summer mathematics program for middle school girls. We examined 48 girls’ pre- and post-perceptions of mathematics while attending such a program. At the program’s beginning and end, the girls wrote a brief “Dear Math” letter to share their perceptions of and relationship to mathematics, and they were asked to draw and explain a picture of themselves doing mathematics. Participant data were analyzed into themes, and program beginning and end data were compared for evidence of change. The data showed favorable movement, particularly in viewing mathematics as a more collaborative and less procedural endeavor than participants previously thought. The program’s atmosphere and approaches were deemed integral to the outcomes achieved, some of which were unique to out-of-school-time programs and some of which might be applied to formal schooling. Implications for pedagogy, research, and out-of-school time programs are discussed.

Keywords: mathematics education; STEM education; middle school students; out-of-school time programs; informal education; dispositions; attitudes; girls; females



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1. Introduction

US women are underrepresented in many STEM (science, technology, engineering, and mathematics) disciplines, which are mathematics-based fields (e.g., [Martinez & Christnacht, 2021](#); [National Science Board, 2024](#)). Preparation and interest in mathematics (hereafter called mathematics and math interchangeably), specifically, associates with pursuit of STEM fields more broadly and successful career outcomes in general ([Black et al., 2021](#); [E. Leyva et al., 2022](#)). Therefore, women’s greater participation in high-paying, high-status STEM occupations can be personally beneficial (e.g., [Okrent & Burke, 2021](#)), while also serving societal goals ([National Science Board, 2024](#)).

Unfortunately, girls can develop poor perceptions of mathematics and themselves as doers of mathematics relatively early in their schooling ([Sullivan & Bers, 2019](#); [Wiesermann et al., 2020](#)). Strengthening girls’ attitudes toward mathematics—in addition to their content knowledge—is thus important in addressing gender imbalances in STEM careers ([Casanova](#)

et al., 2021), with middle school being a critical crossroads (Almeda & Baker, 2020; Xu et al., 2024). Out-of-school time (OST) STEM programs, such as summer camps, can serve this effort well (Wiest et al., 2021; Xu et al., 2024).

Broadening participation in the STEM disciplines to greater inclusion of underrepresented groups, such as women, can help develop a robust STEM workforce for enhancing scientific advancement and economic growth (Nweje et al., 2025; Okrent & Burke, 2021). Unfortunately, unfavorable stereotypes and experiences can influence women's pursuit of and perseverance in STEM. For example, through interviews with undergraduate and graduate students at STEM institutions, Parson et al. (2021) found that male and female participants described scientists and mathematicians as masculine. Female participants also reported reluctance to speak in class because of these perspectives, showing that "doing mathematics = doing gender = doing masculinity" (L. A. Leyva, 2017, p. 413). Perceptions and experiences such as these can cause girls and women to have weaker STEM self-concepts and aspirations than boys/men (Beroíza-Valenzuela, 2025). Dispositions (e.g., attitudes) in mathematics are especially important because they can influence cognition and, hence, learning outcomes (Kamid et al., 2021).

Mathematics attitudes are formed by factors such as students' achievement, self-perception, and self-confidence in relation to mathematics, some of which are influenced by key adults, such as parents and teachers (Aguilar, 2021; Levine & Pantoja, 2021). These attitudes can influence students' engagement and willingness to learn mathematics (Wang et al., 2022; Wigfield & Eccles, 2000). Cvencek et al. (2021) found that girls, more so than boys, can develop negative mathematics attitudes as early as the first grade, possibly caused by math anxiety and math-gender stereotypes. They state, "Children first form implicit attitudes about math via influence from the prevailing attitudes of adults in their culture, perhaps through implicit observational learning" (p. 951). The expectancy-value theory holds that as students' expectations for their success (math confidence) and their value for mathematics (perceived enjoyment) improve, so does their mathematics achievement (Hwang & Son, 2021). Math attitudes are thus a potential target for intervention, especially for young women (Casanova et al., 2021).

Students' attitudes and values toward mathematics can shape their mathematics identity, which is the degree to which students view themselves and believe others view them as a "math person" (Fernandez et al., 2024). Influences on math identity can include personal beliefs and attitudes, parent perspectives, sociocultural influences, intersecting identities (e.g., race and gender), classmates' perspectives, teachers' attitudes and behaviors, and past math experiences (Bondurant & McConchie, 2024; Fernandez et al., 2024; Suárez et al., 2024). Math identity is important not only because it is associated with attitudes and feelings, but also because it has been linked to math achievement and participation, such as intent to pursue STEM careers (Bohrnstedt et al., 2024; Fernandez et al., 2024). While girls tend to show weaker identification with mathematics (Davey et al., 2025; Starr & Simpkins, 2021), it is encouraging that math identities are generally considered to be malleable (Heffernan et al., 2020; Radovic et al., 2018).

Students can develop greater motivation for learning mathematics if they are shown its use and value, which seems to happen infrequently in general mathematics classrooms (Vos et al., 2024). They are also more likely to exert effort toward learning mathematics that they consider to be useful (Dobie, 2019). The utilitarian value of math has been shown to be especially important to girls (e.g., Hill & Hunter, 2023). Girls who identify with mathematics and see its application to other fields and to everyday life activities are more likely to persist in STEM (Fernandez et al., 2024).

Constructivist learning techniques, which include actively developing meaning for mathematics and engaging in hands-on learning, group work, real-world applications, and

problem-solving activities, have been shown to increase girls' interest, participation, persistence, and performance in mathematics (Di Tommaso et al., 2024; Fernandez et al., 2024; Xu et al., 2024). In general, girls prefer actively participating in the learning process rather than passively receiving information (Fernandez et al., 2024). This type of engagement can substantially raise girls' interest in STEM subjects (Xu et al., 2024).

Girls have been further shown to benefit from exposure to and mentoring relationships with women role models in STEM. These experiences can generate enhanced enjoyment of mathematics, expectations for success in mathematics, perceptions of the importance of mathematics, and motivation and aspirations in STEM, and they can reduce stereotypes about women in STEM (González-Pérez et al., 2020; Tal et al., 2024). Role models and mentors can create a more comfortable, affirming environment for younger women. In their work with undergraduate women in STEM, Freedman et al. (2023) note, "Women mentors can be an ongoing source of guidance and support for younger women in STEM. . . . Participants' interactions with women role models and mentors helped combat their insecurities and increase their confidence within their field" (p. 9). Teachers can also serve as role models. They can favorably or unfavorably influence students (e.g., be encouraging or foster stereotypes) (Cvencek et al., 2021; Fernandez et al., 2024; Tal et al., 2024).

Rehumanizing mathematics is a recent effort that might be especially important for supporting minoritized groups, such as girls, who value the pro-social (e.g., utilitarian) aspects of math engaged in a collaborative, respectful environment (Hill & Hunter, 2023). Huber and Karaali (2025) point out that "mathematics has always flourished as a human endeavour and it is perhaps the reduction to sterile algorithms that has stripped it of interest for many students" (p. 1). Essentially, rehumanizing mathematics means building an inclusive community that is student-centered, participatory, and dynamic (Gutiérrez, 2018; Jessup et al., 2021).

The purpose of this research was to gauge the potential value of an OST STEM program by investigating middle school girls' pre- and post-perceptions of mathematics during participation in a one-week summer program. An instrument designed to gauge girls' perceptions of mathematics as a discipline and of themselves as doers of mathematics was administered at the start and end of the camp. The data showed favorable shifts in that regard.

2. Materials and Methods

The central research questions for this study were:

- What influence does participation in a five-day, out-of-school-time mathematics program have on middle school girls' perceptions of mathematics?
- What influence does participation in a five-day, out-of-school-time mathematics program have on middle school girls' perceptions of their relationship with mathematics?

Participants consisted of 48 girls ages 12–13 who attended an OST math- and technology-focused camp on a university campus in the western United States. Since 1998, the program has sought to increase girls' knowledge, skills, and confidence in mathematics and technology. Another overarching goal is to enhance mathematical and technological competence in girls' personal, academic, and occupational lives. The program is a five-day residential summer camp for girls entering grade seven or eight the following year. During the camp, which serves as the context for this study, the girls engage in mathematics content that is considered particularly important for students in general or for girls in particular (e.g., areas in which they tend to demonstrate weak performance and/or dispositions). All participants have classes on geometry, measurement, problem solving, and spatial skills. The rising seventh graders also have lessons on data analysis/probability and the rising eighth graders on algebra.

The mathematics lessons, which are the mainstay of the camp week, take place in person in a traditional classroom setting and comprise about 18.5 h of instruction across the week. Participants also spend about 4 h in a computer lab using code.org (younger group) or desmos.com (older group) to enhance mathematics knowledge and skills taught in the camp. The remaining academic-oriented time consists of about 2.5 h of directly engaging in person with women STEM professionals and learning about historical or contemporary women who have had substantial impacts on STEM. The campers have three meals per day on campus and a mid-morning and mid-afternoon snack break. They also attend two on-campus STEM-oriented field trips on a mid-week afternoon, and every evening, they participate in recreational activities, such as swimming at a nearby pool or a conducting a camper talent show. Finally, participants' parents attend an opening introductory session and an end session in which they watch campers give presentations of their learning and engage in parent-child problem solving.

The camp staff are women role models chosen for their expertise in mathematics content and pedagogy, as well as their ability to work well with young adolescents. Staff members are individuals known directly by the camp directors, or they are recommended by university professors or local education leaders. The veteran staff, who typically have at least 10 years of teaching experience, teach the main subject matter. Novice educators (upper-level preservice teachers or early-career teachers) teach brief segments on problem solving and spatial skills and monitor and lead campers throughout the week during the day and overnight. The main instructors teach only their assigned topic (e.g., geometry), choosing a subset of the national mathematics teaching standards for their campers' upcoming school year and using their own activities and methods in doing so. However, all instructors are expected to use contemporary teaching strategies, per the national mathematics standards, that lean heavily on problem solving and hands-on approaches involving the social construction of mathematics understanding. The campers work in randomized groups of four, which change daily, during their mathematics lessons and spend substantial time articulating their thinking to their peers and to the class at large.

Only data from girls who attended the full camp and completed both the pre- and post-assessments were included in this research. Of the study sample, 26 were rising seventh-grade students (i.e., would attend the seventh grade the following fall), and 22 were rising eighth graders. More than one-third of the girls (37%) self-identified as racial/ethnic minorities. One-third (33%) were granted financial-need scholarships by providing evidence of their family's eligibility for the federal government's free/reduced-price lunch program, and almost one-third (30%) attended Title I (low-income) schools. Because participants in the summer program were drawn randomly from those who applied, the girls had varied ability levels and backgrounds.

Participants completed the same instrument at the beginning and end of the camp in a quiet classroom setting. They were asked to write a letter directly to "Math" and to draw a picture of themselves doing mathematics with a description of what appears in the drawing (see Appendix A). Drawings were included to provide another way to gain insight into students' perceptions of mathematics and themselves in relation to mathematics (Cappello et al., 2019; Gracin & Kuzle, 2018; Hatisaru & Murphy, 2019; Quane et al., 2023). The use of drawings for data collection is particularly beneficial for children and youth from various cultural contexts due to reducing reliance on language proficiency and providing a different mode of expression (Bondurant & McConchie, 2024; Cappello et al., 2019). A drawing can confirm, contradict, or enhance verbal data provided by the same participant (Booton, 2018). Essentially, this research drew on researcher perspectives that some ways to investigate attitudes, beliefs, and emotions toward mathematics are to have students draw pictures

and do reflective writing, such as math autobiographies, and that these methods should be easy to implement (Bondurant & McConchie, 2024; McGuire, 2024; Quane et al., 2023).

Student responses were anonymized by a program intern and given to the researchers with codes corresponding to demographic information. Participant responses were compiled, and the three research team members independently analyzed the data for themes using line-by-line open coding. Through this process, the researchers generated a list of codes and met to adjust them jointly. They then categorized the codes into two broad categories as *more favorable* (e.g., math as utilitarian, positive dispositions, communicative approaches) and *less favorable* (e.g., math as procedural, negative dispositions, teacher-oriented) in terms of participants' views of mathematics as a discipline or of themselves as mathematical doers and thinkers in relation to dominant perspectives espoused by the mathematics education community (e.g., Hill et al., 2021; Li & Schoenfeld, 2019).

The researchers independently analyzed the data (pre-camp letters, pre-camp pictures, post-camp letters, and post-camp drawings) into the codes they had created. They then jointly examined the codes and coding to refine prior codes and assignment of data to codes (Emerson et al., 2011). (See Appendix B for the final code list). Counts of codes were determined such that no more than one tally was assigned to a participant for a specific code for their total pretest or posttest data. A count of 1 for a code meant that the code appeared in the letters or the drawings. For example, if a participant mentioned that math was frustrating several times, it was coded as 1 for that theme.

During team discussions, the lead researcher took notes on the nuanced meanings of each code and discussion points highlighted by the team. For example, for code 2, "math as utilitarian" was used to code letter and drawing components if the participant mentioned or illustrated how math was useful or helpful to accomplish something specific and external (e.g., schoolwork, cooking, finances). However, in our discussions, we noticed that "helpful" had other, nuanced meanings that included internal and more general, unspecified reasons, as in comments about mathematics helping students to learn and to calm down. Other comments were more general, indicating that "math helped in life and I am so happy math is a thing, it makes things easy," and "math, you just keep going and never end, you have helped me so much."

A coding example follows the camper's pre-drawing that appears in Figure 1.

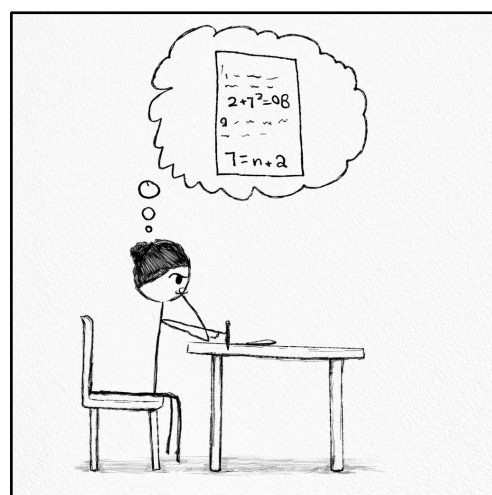


Figure 1. A camper's pre-drawing with explanation and letter to math.

My drawing is of me sitting at a table while doing math homework or just some math practice. I will usually have my hair tied up and chewing a piece of gum to help me focus on whatever I am doing.

Dear Mathematics,

Math. I have known you for many years now. I know stuff about you like adding and subtraction through angles and exponents. Math you have mostly come easily to me. However, you always have ways to make me think really hard or be confused on why I still “talk” to you. On the other hand, you have helped me greatly and I think you will always keep being the helpful “person” you have always been. You inspire me to learn more about you and do the jobs you are involved with. You want to make me be a nurse with dosages or a forensic scientist. I will admit that you do sometimes find ways to make me frustrated. Sometimes knowing you can be a big struggle when I don’t understand you. When I don’t understand you, I get upset at myself rather than being frustrated at you. Although in more recent years, you have become easier with the little things.

From the code list, the pre-camp *drawing and explanation* were assigned the following codes during analysis:

- 8. Effort/perseverance/indication of focus in doing math
- 19. Solitary approach to doing math (working separately in some manner)

The pre-camp *letter* was assigned the following codes during analysis:

- 1B. Positive affect in the letter to math
- 2. Math as utilitarian (useful/practical/helpful/important outside of school)
- 12. Math as challenging: good
- 14. Constrictive view of math (traditional: procedural, computational, symbolic, prescriptive, one approach, always right. . .)
- 18. Math as confusing/frustrating, but (qualifies with a more positive view of self or math)
- 23. Expression of hope for future success in math or excitement about future math learning (includes career aspirations)

Forty-eight pre-/post-drawings with captions and letters to math were coded as described above (see Figure 1). Totals for pre-drawing, pre-letter, post-drawing, and post-letter were tabulated, and differences for each code across from program beginning to end were determined (see Appendix C).

3. Results

In this section, we first discuss dominant changes in theme frequencies across the two data checkpoints. We then discuss participants’ perceptions of mathematics and themselves as mathematical doers and thinkers. This includes their relationship with mathematics and perceived engagement in mathematics learning.

3.1. Dominant Changes in Themes

The theme that showed the most substantial positive gain during the program was a shift in perception of mathematics from independent to collaborative work, which was specifically encouraged during the camp. The pre- and post-letters and drawings by the same participant at the beginning and end of the camp week (Figure 2) illustrate this theme and how it shifted. The camp beginning and end drawings illustrate an initial perception of mathematics as a solitary endeavor that evolved into mathematics work portrayed as collaborative by the end of the program. In the written responses, both letters indicate some degree of usefulness of mathematics, but a major change in perspective articulated from the first to second letter narrative is dispositional in nature, from tending to see math as “annoying and boring” to fun/enjoyable, presumed to have been influenced in part by daily learning that takes place in supportive micro and macro communities. The important role of the teacher and hands-on learning also appears in the end-of-week commentary,

with the latter picture showing manipulative materials in the middle of the table that are used jointly by the group while engaged in mathematics learning.

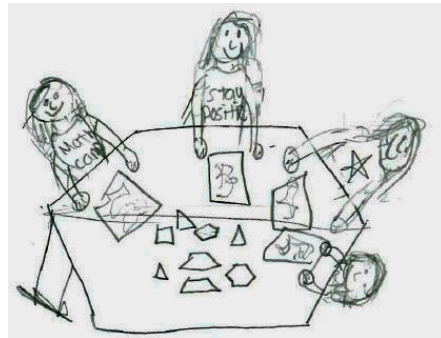


Figure 2. Pre/post letter and drawing by the same participant.

Pre-letter and Drawing

Dear Math,

I don't like you the most, but you can be helpful (even though 80–90% of what we learn is a waste). You can be used to help art and animation, but you can't help too much. You are the point of both dead-end jobs and good ones. You only help in math class and (not to be rude) you are annoying and boring sometimes. During school, sometimes you were stressful, but you have to be. In conclusion, you are good and bad depending on how you look at it.



Post-letter and Drawing

Dear Math,

I really enjoyed learning about you all week; it was super fun. I have been frustrated by you a lot but I really think math is fun. I had a really good time and I still like math even after 4th grade. And I want to go into a field using math and science. I think math looks complicated but when you have good teachers who make it more hands-on it is way more enjoyable than it already is.

The second-largest shift during the week was in improved mathematics competence, described as understanding and skills. Participants indicated in both post- letters and pictures that the program helped them “understand geometry better” (a topic offered at the camp) and that it “has made my math skills a lot better.” Noticeable growth also occurred in a contemporary view of mathematics, meaning an expanded conception in which mathematics is considered to have multiple solutions, use learning aids, be activity-oriented, and include non-computational areas. This was accompanied by a significant decline in viewing mathematics as a solitary pursuit.

3.2. Perceptions of Mathematics

Codes assigned to perceptions of mathematics were examined specifically to determine patterns or implications for middle school girls in an OST program. Additionally, pre- and post-data were compared to investigate whether views of mathematics had changed. Each code was tabulated to indicate the number of times it occurred in the pre/post letters and drawings. For example, in the pre-letters, math was mentioned as utilitarian 21 times (code 2). In contrast, in the post letters, it was mentioned 8 times, with a difference of −13, indicating that the prevalence of this theme decreased after the OST math camp experience. A positive number indicates an increase in occurrence, and a 0 shows no change. (Recall that a specific theme was only coded once per participant for pre-data and post-data regardless of the number of times the theme arose.) Table 1 shows the pre- and post-differences in codes for perceptions of mathematics for participant letters and drawings.

Table 1. Pre–post differences in perceptions of mathematics.

Perception of Mathematics Codes	Letters	Drawings
2. Math as utilitarian (useful/practical/helpful/important)	−13	0
3. Modern view of math (multiple solutions, use of learning aids, activity-oriented, noncomputational topics)	0	+7
6. Math as understandable/easy/makes sense (in general or a specific problem)	−6	+2
12. Math as challenging in a good sense	−8	0
14. Traditional view of math (procedural, computational, symbolic, prescriptive, on approach, always right. . .)	−3	−12
15. Math as confusing/hard to understand/doesn’t make sense	−1	−3
17. Math as frustrating	−13	0
22. View of math varies by situation, teacher, or math topic	+2	+1

Note. Code numbers are maintained from the original list. The expectation was that favorable perspectives would increase and unfavorable ones would decrease.

The pre-letters students wrote to math included several comments about the utilitarian value of mathematics, such as, “You have helped me greatly and I think you will always keep being the helpful ‘person’ you have always been.” On a post-letter, one participant stated, “Thank you math for helping many people including myself. If there wasn’t math in the world there wouldn’t be scientists or doctors and many other important jobs that we need.” One goal of the math camp is to expose program participants to mathematics-based professions, so this statement might reflect increased awareness in that regard. Additionally, the camp seeks to expand the girls’ perceptions of mathematics by providing hands-on experience and focusing on problem solving, discourse, and multiple solution strategies. An important goal is to foster an environment where girls develop positive self-conceptions and a sense of belonging (Broder et al., 2023; Milton et al., 2024).

The code for a traditional view of mathematics (procedural, computational, symbolic, prescriptive, one approach, always right) showed that this depiction of mathematics decreased by 3 in the written data and by 12 in the pictures across the camp experience. In the pre-pictures, participants commonly drew themselves alone, completing a specific computation. The post-pictures often included peers, hands-on materials, and collaboration. The decrease in data assigned to this code might indicate that some girls developed a different view of mathematics after the intensive camp week. In Figure 3, for example, a girl portrayed herself in mathematics class with books on her desk taking a final exam. The students are drawn sitting apart from each other with unhappy or neutral expressions. At the end of the week, the drawing and caption depict students seated in a group facing each other, working collaboratively with manipulative materials. They have happy facial expressions.

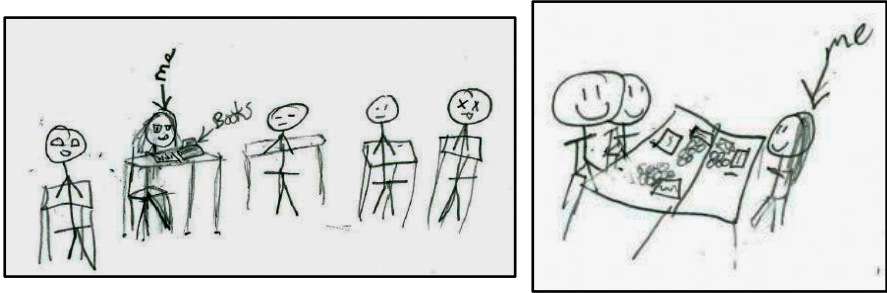


Figure 3. Pre/post drawings by the same participant. Note. **Left** picture caption: “I am at a desk and I am taking the final for my class. I am focusing hard for the test”. **Right** picture caption: “I am at math camp doing math with others!! I am doing Algebra with the plastic circle things”.

3.2.1. Math Doers and Thinkers

We identified two overarching themes that reflect how the participants perceive themselves as mathematical doers and thinkers. The first is participants’ relationship with mathematics, and the second is their manner of engaging in mathematics learning. In Tables 2 and 3, we list the specific themes within those, as well as the difference in tallies for those codes between the pre-/post-letters and pre/post-drawings. Note that a negative difference shows a decrease in evidence of that theme across the week, which can be favorable or unfavorable based on the specific theme, and perhaps neutral in some cases. A discussion of the two themes follows.

Table 2. Pre–post differences in relationship with mathematics.

Relationships with Mathematics Codes	Letters	Drawings
1. Positive affect (e.g., expressed or apparent pleasure)	0	−2
7. Math as empowering/confidence-building	−2	2
10. Good performance (as a general descriptor of oneself in math)	−2	−3
11. Improved performance or understanding	10	6
13. Negative affect (expressed or apparent sadness, boredom, etc.)	−1	−1
17. Math as frustrating (inc. unexplained comments)	−13	0
21. Poor performance (as a general descriptor of oneself in math)	0	0
23. Expression of hope for future success in math or excitement about future math learning (includes career aspirations)	−2	0

Note. Code numbers are maintained from the original list. The expectation was that favorable perspectives would increase and unfavorable ones would decrease.

Table 3. Pre–post differences in engagement with mathematics.

Engagement with Mathematics Codes	Letters	Drawings
4. Group/peer work in doing math (any work with others, presumed group work if at tables)	3	16
5. Hands-on approach to doing math (manipulatives, constructing things, baking. . .)	0	3
9. Communicative approaches (verbal interactions, speech bubbles. . .)	0	0
18. Math as confusing/frustrating, but. . . (qualifies with/ a more positive view of self or math: persevered, grew to like, teacher was bad. . .trend towards positive)	3	1
19. Solitary approach to doing math (working separately in some manner)	0	−22
20. Teacher-oriented approaches (looking at a teacher receptively as opposed to working with a teacher)	0	−1

Note. Code numbers are maintained from the original list. The expectation was that favorable perspectives would increase and unfavorable ones would decrease.

3.2.2. Relationship with Mathematics

How students felt about doing and thinking about mathematics trended toward favorable movement across the camp week, especially in reducing negative and increasing

positive perspectives overall (See Table 2). In particular, expressions of improved or good performance or understanding rose notably in the letters and drawings (e.g., “I learned a lot of new stuff” or the drawing shown in Figure 4). Positive and negative affect in general (#s 1 and 13), such as commenting on enjoyment and fun versus annoyance and boredom, and perceptions of math as empowering/confidence-building (#7), such as math “makes me feel good about myself,” remained about the same overall in that small increases and decreases seemed to counterbalance each other, and good performance as a general/stable descriptor of oneself in mathematics went down slightly in both modes of expression. Describing math as “frustrating” was used often enough to warrant its own code, but use of this term decreased strikingly (−13) in the post writing. (Note that we did not code any drawings for expression of hope because that could only be assessed with some degree of accuracy in written material, unless participants wrote explanations of pictures that made this evident).

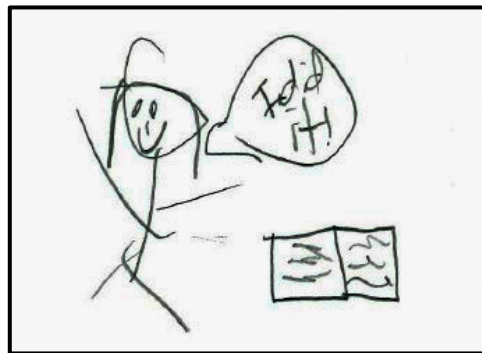


Figure 4. Demonstration of successful performance on a post-drawing.

3.3. Engagement in Mathematics Learning

Several codes were identified as representative of embodying themes on how the participants reported engaging with or doing mathematics (see Table 3). The most notable was a shift toward viewing mathematics endeavors as collaborative instead of solitary. A substantial increase in this regard appeared in the written narratives and drawings, most prominently the latter. In the same vein, the most striking change in this category (−22) was a move away from seeing mathematics as something to be done individually, detected solely in the drawings. See, for example, Figure 5. A modest increase appeared in a perception of hands-on methods being an approach to doing mathematics, with modest decreases in perceiving mathematics as confusing/frustrating. Additionally, perceptions of mathematics as relying on teacher-oriented approaches decreased slightly (by 1).

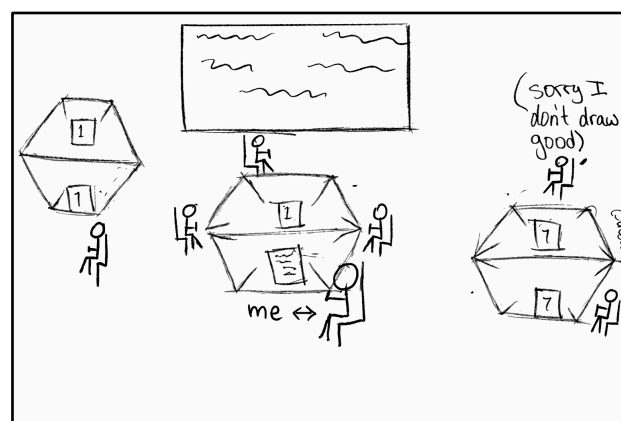


Figure 5. Post-drawing showing working in groups and identifying self with “me” and arrow.

4. Discussion

In this research, we analyzed comments and drawings by middle school girls on their perspectives on mathematics at the beginning and end of an out-of-school-time (OST) program, specifically, a one-week residential summer camp. Regarding participants' perceptions of mathematics as a discipline and their relationship with mathematics (doing and engaging with it), the girls' perspectives showed favorable change overall, but there were some unexpected findings. We briefly discuss our reflections on the dominant findings. We do not address small changes because they can simply reflect the mercurial nature of youth, as well as that which is salient at a given moment, in addition to the fact that, at times, a theme increased across the week by a small frequency count in the letters but decreased by a comparable amount in the drawings.

The foremost favorable change in perspective was in girls' perceptions of engaging in mathematics in structured learning environments from solitary work to collaborative work. This is encouraging because a key goal of the OST program in which the girls participated was student-centered learning that required a substantial amount of structured small-group work and focused discussions, which can yield multiple benefits, including development of advanced cognitive skills (Ceballos et al., 2026). This feature appeared as a significant theme in the post data, pointing to its importance and to perspectives aligned with modern conceptions of doing mathematics. Similarly, it is encouraging that the girls held a less traditional view of mathematics (e.g., prone to procedural and prescriptive approaches) at the end of the program in favor of a more contemporary view (e.g., conducive to multiple solutions and active engagement). The latter conception can foster creative approaches to analyzing and solving problems, thus yielding more highly developed mathematical abilities (e.g., Ibrahim et al., 2024). Further, changes in student dispositions about mathematics can support a growth mindset, or belief that mathematics ability can be developed through effort, which can favorably impact mathematics achievement (Dong et al., 2023). Findings of the present study that reflect more reform-oriented types of mathematics teaching and learning appeared predominantly in participant drawings. We acknowledge, however, that OST programs have fewer constraints than formal schooling for implementing more progressive methods of mathematics instruction, such as lack of accountability for standardized test results and the associated demands for moving through class content at a swift pace.

A substantial increase took place from the camp beginning to end in perceptions of improved mathematics performance or understanding, with a concomitant decrease in expressions of mathematics as frustrating. Participant responses showed slight declines in perceiving mathematics as being hard to comprehend, but they were also less likely to indicate that mathematics is understandable/easy or that it is challenging in a good way at the end of the program. This might mean that perceptions of mathematics as comprehensible and a good challenge varied among the girls, even at the end of the program, or that individual girls did not have a well-integrated perception of mathematics as a whole, perhaps because they held different perspectives toward different mathematics topics that were variably foregrounded based on time and place. We think it is highly likely, however, that because the girls encountered challenging and new mathematics that targeted the grade level they would enter next, perceptions of the challenging nature of mathematics increased for some girls, despite efforts to make it accessible. This is similar to what Dai et al. (2021) found in a survey of the 176 girls in grades 4–6 who participated in a full-day STEM event. The data showed a significant decrease in participants' rated interest in mathematics from the beginning to the end of the program. The authors conclude that participants might have had some "eye-opening experiences in math" and the "program might have shown participants that math can be much more complex and challenging

than they had previously thought. Naturally, this could cause some disorientation and temporarily less overall interest in math" (p. 19). It is also noteworthy that many girls described mathematics as both positive and negative (e.g., math is frustrating but useful) at the beginning and end of the program, although less so at the latter point. This reminds us that student perceptions should not be categorized solely in one direction or the other.

A surprising response was that participants were less likely to comment on the utilitarian value of mathematics at the end of the week (−13). This appeared solely in the letters (but it would be difficult to show this theme in a picture). We believe this could be because the girls were on information and stimulation overload for the week, and, therefore, what was most salient in their minds was more likely the novel and personally meaningful experiences and outcomes they had during the camp week. In other words, many other associations with mathematics arose during the program, and some became more important at the end, such as enhanced understanding and a perception of mathematics as a communal endeavor. In the campers' relatively brief commentary on mathematics, these thoughts might have supplanted the earlier and perhaps inauthentic "rhetoric" the girls might have recited about mathematics being useful, which many youths hear from teachers, parents, and others. However, it is an important reminder that both school and OST mathematics programs should highlight and illustrate specific uses of mathematics in continued academic work, everyday life, and occupations (E. Leyva et al., 2022). Further, role models to which young people are exposed to instantiate practical uses of mathematics should be sufficiently diverse and relatable, and their positions seemingly attainable, so that students can "see" themselves among STEM professionals (Ribeiro et al., 2021).

Regarding the research methods used, combining written comments with drawings was a useful research tool that yielded important insights. We noticed that some things might have appeared in drawings because they are easier to draw, as in mathematics depicted as computation. This is one reason why explaining what appears in drawings is important. Overall, we concur with other researchers (e.g., Gracin & Kuzle, 2018; Quane et al., 2023) that drawings might provide a more natural, candid response from participants. Although drawings are limited in what they can show, they sometimes present different and perhaps more revealing insights into the girls' perceptions. We thus contend that participant drawings were a highly important form of data collection in this research that complemented and were perhaps more credible than written commentary in that they were more "raw" but also intentioned. A challenge, however, is when written and drawn expressions appear to contradict each other. In essence, the written commentary is more direct and elaborate; drawings might be more authentic and reduce language demands, but they require greater interpretation.

As a potential limitation, however, we note that the prompt for the letter to Math should have been more open-ended. We used this prompt: "Please write a letter to Math. What would you like to tell Math? Has Math helped you? Has Math frustrated you? Explain to Math how you feel." The third and fourth sentences might have prompted participants to respond in ways that included attention to those two potential associations with mathematics (helped you, frustrated you) that might or might not have arisen naturally. After analyzing the girls' responses, we recognize that using "Please write a letter to Math. What would you like to tell Math? Explain to Math how you feel." would have been better. Another limitation of the study is the time duration between the initial and follow-up data in that real attitudinal change generally takes time to become ingrained, but this can vary based on the level of emotion involved (Rocklage & Luttrell, 2021). Although the altered perspectives that took place after five days of participating in this program were at times dramatic, claims cannot be made about whether they lasted after the participants returned to a regular school setting. We contend, however, that some of the different perspectives

demonstrated at the end of the camp were deeply important in relation to mathematics teaching and learning. The program might thus, at least, have exposed these adolescents to other ways to think about mathematics and themselves in relation to the discipline that could be valuable at times moving forward. Nevertheless, longer-term assessments of results found in a short-term intervention are important considerations for future research.

The collective data from the two research instruments used in this study reflect student perceptions of mathematics upon program entry, which were likely forged to a large degree by external agents, such as teachers and parents (e.g., Dobie, 2019; Piyakun & Phusee-Orn, 2025) and promise for modified perceptions that might be encouraged by engaging with mathematics in other ways, such as participation in out-of-school-time programs. Again, we acknowledge that OST programs have greater freedom in this regard than school mathematics, but we believe successful outcomes in OST programs can provide important insights for school mathematics, such as use of more holistic approaches (e.g., social, recreational) that encourage greater connections among students and staff.

Our main “takeaways” from this study are that out-of-school-time STEM programs of any length can favorably influence girls’ perceptions of and relationship to mathematics if conducted in an engaging, supportive, and research-based manner. This appears to be true in the short term, with future research on longer-term outcomes of OST programs being warranted. Favorable results, of course, presume careful planning and implementation of constructivist approaches, which seem to serve girls well in STEM learning (Fernandez et al., 2024; Xu et al., 2024). Our findings align with other research on OST STEM programs for girls (e.g., Morton & Smith-Mutegi, 2022; Wiest et al., 2017; Wiest et al., 2021). Like other researchers (e.g., Almeda & Baker, 2020; Xu et al., 2024), we believe middle school is a particularly important time to provide OST support to girls in STEM because it is an important juncture for heightened self-awareness, social sensitivity, and decision making about the future.

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Informed Consent Statement: Participant consent was not required because the data were collected as part of routine program evaluation for this annual summer camp and were thus not classified as research data (see Institutional Review Board Statement).

Data Availability Statement: The original data for this study are openly available at <https://www.scidb.cn/en/s/YJRRny> (accessed on 20 January 2026).

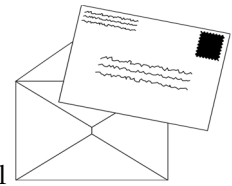
Conflicts of Interest: The authors declare no conflicts of interest.

Appendix A

(Pre/Post Letter)

Name: _____

Letter To Math



Please write a letter to Math. What would you like to tell Math? Has Math helped you? Has Math frustrated you? Explain to Math how you feel.

(Pre/Post Picture and Description)

Name: _____

Draw a picture of yourself doing math.

Please explain your drawing here:

Appendix B

1. (A and B) Positive affect (e.g., expressed or apparent pleasure in drawing/caption (1A) or letter to math (1B))
2. Math as utilitarian (useful/practical/helpful/important)
3. Modern view of math (multiple solutions, use of learning aids, activity-oriented)
4. Group/peer work in doing math (any work with others, presumed group work if at tables)
5. Hands-on approach to doing math (manipulatives, constructing things, baking...)
6. Math as understandable/easy/makes sense (in general or a specific problem)
7. Math as empowering/confidence-building
8. Effort/perseverance/indication of focus in doing math
9. Communicative approaches (verbal interactions, speech bubbles...)
10. Good performance (as a general descriptor of oneself in math)
11. Improved performance or understanding
12. Math as challenging in a good sense
13. Negative effect (e.g., expressed or apparent sadness, boredom, etc.)
14. Traditional view of math (procedural, computational, symbolic, prescriptive, one approach, always right...)
15. Math as confusing/hard to understand/doesn't make sense
16. Math as frustrating
17. Math as confusing/frustrating, but... (qualifies w/ a more positive view of self or math: persevered, grew to like, teacher was bad...trend towards positive)
18. Solitary approach to doing math (working separately in some manner)
19. Teacher-oriented approaches (looking at a teacher receptively as opposed to working with a teacher)
20. Poor performance (as a general descriptor of oneself in math)
21. View of math varies by math topic (would add varies in general, mixed)
22. Expression of hope for future success in math or excitement about future math learning (includes career aspirations)

Note. #16 is missing because it was a code for a tentative theme that was later combined with another.

Appendix C

Pre Draw	Post Draw	Change	Codes
6	6	0	1A. Positive affect in written caption.
6	4	−2	1B. Positive affect in picture (e.g., smiling).
7	5	−2	2. Math as utilitarian (useful/practical/helpful/important)
0	1	1	3. Expanded view of math (more modern: multiple solutions, use of learning aids, activity-oriented, spatial tasks, coding)
1	6	5	4. Group/peer work in doing math (any work with others)
1	2	1	5. Hands-on approach to doing math (manipulatives, constructing things, baking. . .)
2	2	0	6. Math as understandable/easy/makes sense
1	1	0	7. Math as empowering/confidence-building
3	0	−3	8. Perseverance in doing math
1	1	0	9A. Communicative in written description(s).
1	1	0	9B. Communicative in picture
2	2	0	10. Good performance
2	3	1	11. Improved performance
3	1	−2	12. Math as challenging: good
3	2	−1	13A. Negative affect in written description(s).
1	0	−1	13B. Negative affect in picture (e.g., sad, frustrated).
10	7	−3	14. Constrictive view of math (traditional: procedural, computational, symbolic, prescriptive, one approach, always right. . .)
0	1	1	15. Math as confusing/hard to understand/doesn't make sense
1	0	−1	17. Math as frustrating (inc. unexplained comment)
4	3	−1	18. Math as confusing/frustrating, but (qualifies w/ a more positive view of self or math: persevered, grew to like, teacher was bad. . .)
9	5	−4	19. Solitary approach to doing math (working separately in some manner)
2	0	−2	20. Teacher-oriented approach
0	0	0	21. Poor performance

Pre-Letter	Post-Letter	Change	Codes
35	28	−7	1A. Positive affect in written description(s).
0	2	2	1B. Positive affect in picture (e.g., smiling).
0	0	0	2. Math as utilitarian (useful/practical/helpful/important)
2	9	7	3. Expanded view of math (more modern: multiple solutions, use of learning aids, activity-oriented, spatial tasks, coding)
2	18	16	4. Group/peer work in doing math (any work with others)
1	4	3	5. Hands-on approach to doing math (manipulatives, constructing things, baking. . .)
0	2	2	6. Math as understandable/easy/makes sense
0	2	2	7. Math as empowering/confidence-building
13	2	−11	8. Perseverance in doing math
3	6	−3	9A. Communicative in written description(s).
3	3	0	9B. Communicative in picture
6	3	−3	10. Good performance

Pre-Letter	Post-Letter	Change	Codes
0	6	6	11. Improved performance
0	0	0	12. Math as challenging: good
0	0	0	13A. Negative affect in written description(s).
4	0	−4	13B. Negative affect in picture (e.g., sad, frustrated).
28	16	−12	14. “Straightforward” view of math (traditional: procedural, computational, symbolic, prescriptive, one approach, always right. . .)
3	0	−3	15. Math as confusing/hard to understand/doesn’t make sense
0	0	0	17. Math as frustrating (inc. unexplained comment)
1	1	0	18. Math as confusing/frustrating, but (qualifies w/ a more positive view of self or math: persevered, grew to like, teacher was bad. . .)
41	19	−22	19. Solitary approach to doing math (working separately in some manner)
5	4	−1	20. Teacher-oriented approach
0	0	0	21. Poor performance
0	1	1	22. View of math varies by math topic
0	0	0	23. Expression of hope for future success in math or excitement about future math learning

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