Kentucky Journal of Excellence in College Teaching and Learning

Volume 14 Article 3

May 2017

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Kentucky Journal of Excellence in College Teaching and Learning

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Abstract

Research indicates that mathematics anxiety is particularly high in pre-service teachers (Bekdemir, 2010; Gresham, 2007; Hembree, 1990). These future teachers will soon be entering classrooms of their own, responsible for teaching mathematics to young children, who need strong teachers. A 2013 report from The National Assessment of Educational Progress (NAEP), found that 42% fourth-graders performed at or above the proficient level in math (NCES, 2013. The purpose of this study was to examine elementary pre-service teacher candidates (PSTCs) perceptions of mathematics, through drawings. Drawings were analyzed before and after a semester-long field experience in a constructivist mathematics environment. The participants included 56 PSTCs with a field placement in K-5 settings. The researcher used open-coding to evaluate the pre- and post-field experience drawings. Three overarching themes emerged from the data: (1) emotions related to mathematics, (2) the mathematics environment, and (3) experiences within the mathematics environment. Over the course of the field experience semester, the number of negative and isolated perceptions of mathematics decreased. The results of the study hold implications for teacher preparation programs in planning field experience placements for their teacher candidates. Purposeful field placements can allow PSTCs to evaluate and inform their own understanding of mathematics, and learn pedagogical strategies to benefit their future students.

Keywords: elementary, pre-service teacher, perceptions, mathematics, drawings

Everyone seems to come from a different mathematical background. Some are enthused with the prospect of putting problem solving into action, while others harken back to an isolated, anxiety filled classroom. How do you visualize mathematics? This study sought to gain insight into elementary pre-service teacher candidates' perceptions of mathematics through drawings. The pre-service teacher candidates (PSTCs) in this study will soon be entering classrooms of their own, responsible for teaching mathematics to young children. In 2013, a report from The National Assessment of Educational Progress (NAEP) found that 42% of fourth-graders performed at or above the proficient level in math (NCES, 2013). One possible means of increasing the performance of mathematics learners is by preparing teachers who are comfortable with their own mathematical abilities and capable of delivering instruction. Teachers must know and understand deeply the mathematics they are teaching and be able to use that knowledge in their teaching (NCTM, 2014). It is crucial for those preparing future teachers to understand the perceptions that exist towards mathematics, particularly when sensitivities may be present.

Literature Review

Mathematics Experiences

People's understanding of mathematics, along with their ability to solve problems, are shaped by the teaching they were afforded throughout their education (NCTM, 2014). Pre-service teacher candidates bring with them a variety of experiences related to mathematics. Most of these occurrences come from time spent as a K-12 student. Unfortunately, some PSTCs may have experienced anxiety related to mathematics from their times as a student. Research reveals that mathematics anxiety is particularly high in pre-service teachers (Bekdemir, 2010; Gresham, 2007; Hembree, 1990). Furthermore, those who have negative experiences in a mathematics classroom tend to have higher anxiety related to mathematics, and these experiences tend to increase as one advances through school (Bekdemir, 2010). For those choosing to become educators, previous mathematics experiences may influence their preparation as teachers.

Baloĝlu and Koçak (2006) categorize mathematics anxiety into three major groups: situational, dispositional, and environmental. Situational causes of anxiety relate to the circumstances in which mathematics is being used. Dispositional anxiety includes personality-related factors one brings to the setting. Lastly, environmental causes of mathematics anxiety include prior perceptions, attitudes and experiences that have impacted an individual. Some PSTC may have experienced one or more of these anxieties, which makes analyzing the perceptions that exist an important component of teacher educator programs.

A teacher can also have an impact on their students' anxiety level toward mathematics (Vinson, 2001). Educators' anxiety towards mathematics may not only impact their students, but their ability to teach math and their confidence in how much they know. Anxiety can also influence the decisions teachers make about what to teach and how often, particularly in early grades (Geist, 2015). Fortunately, pre-service teacher candidates' attitudes towards mathematics can be changed, even over a short period of time (Hodges & Kim, 2013).

Mathematics Instruction & Learning

The learning environment has the ability to strongly influence the outcomes of students (LaRocque, 2008). The learning environment is not just influential to children, but also pre-service teachers. Protheroe (2007) suggests that an effective math environment includes teachers who:

- Project a positive attitude toward mathematics and about students' ability to "do" mathematics.
- Demonstrate acceptance of students' divergent ideas.
- Influence learning by posing challenging and interesting questions.

Teachers have the ability to change attitudes by using effective instructional techniques, focusing on what students are able to do, encouraging multiple outcomes, and being sensitive to previous frustrations and failures (Furner & Duffy, 2002).

Pre-service teachers should be provided with a variety of examples related to concepts in mathematics, which can allow for individual growth (Bekdehmir, 2010). Teacher candidates are better able to understand mathematics concepts and procedures when they are presented on the pictorial or concrete level. What they understand, they are able to teach (Vinson, 2001). Additionally, research from Gresham (2007) suggests that pre-service teachers prefer doing mental math or working with others to solve problems.

The process of thinking about math mentally encourages learners to build on number relationships to solve problems rather than relying on memorized procedures (Parrish, 2010). To many of us, it may be hard to imagine mathematics in a classroom setting where the use of paper and pencil, calculators, and textbooks are not the focal point of instruction. Yet, people do not often have access to such tools when encountering, say, a 25%-off sale at a department store. Indeed, most individuals perform these calculations mentally. Unfortunately, in an age of assessment and accountability, learners are often taught to "show" their work according to teacher-prescribed procedures. However, mental math encourages learners to concentrate on number relationships and use these relationships to develop efficient, flexible strategies with accuracy, rather than hold quantities and procedures in their heads (Parrish, 2010).

Mathematics Discourse

Mathematical discourse involves conversations about mathematics. Discourse provides a means of communicating ideas and clarifying understanding. Through communication, ideas are reflected upon, refined, discussed, and amended (NCTM, 2000). The quality of dialogue between teachers and learners, and among learners, is of crucial importance to learning and educational attainment (Mercer & Sams, 2006). Furthermore, when students are challenged to communicate their thinking to others, they must be clear, convincing, and precise in their use of mathematical language (NCTM, 2000).

A teacher's role in establishing a classroom of discourse is not to be a disseminator of information. Rather, the teacher is responsible for establishing an environment in which discourse can take place. The National Council for Teachers of Mathematics (2000) suggests that a teacher of mathematics can facilitate discourse by:

- Posing questions and tasks that elicit, engage, and challenge students' thinking.
- Listening carefully to students' ideas.
- Asking students to clarify and justify their ideas.

In addition, creating an environment that accepts, respects and considers all student responses encourages discussion (Parrish, 2010). Listening to others' explanations provides learners with opportunities to develop their own understanding (NCTM, 2000). When discussing a problem, supplying a variety of solutions may create mathematical conflict, allowing students to consider the context of a problem and the reasonableness of the solution (Cengiz, 2013). This allows students to engage in the process of mathematics. Student explanations should include mathematical rationales and arguments, not just descriptions of procedures (NCTM, 2000). When students are engaged in mathematical dialogue of rationale, they do not easily back down from their thinking, and often must be convinced by their peers, which requires discourse to take place. Conversations that allow for mathematical ideas to be explored from different perspectives help participants refine their thinking and make connections (NCTM, 2000). Noticeably absent from this type of mathematical engagement is a list of teacher-prescribed procedures for solving problems.

Perceptions through Drawings

In education, drawings have been commonly used to evaluate children's feelings or perceptions. These drawings can be especially important in regulating emotions (Drake & Winner, 2013). Additionally, drawings are considered a technique that can provide insight into a subject's inner world, rather than relying on verbally expressed perceptions (Regev & Ronen, 2012). In elementary settings, drawings are often used as a tool to help foster writing. Research suggests that drawings are an effective form of rehearsal for narrative writing, and in some cases more beneficial than discussion (Caldwell & Moore, 1991).

Vygotsky (1978) suggests that drawing is a pictorial language, allowing children to find concrete visual means of representing their thoughts, much like its own form of speech. These visual means of representing thoughts hold implications for mathematics. When a student gains access to mathematical representations, and the ideas they express, they can create images that capture mathematical concepts or relationships. This process allows students to acquire a set of tools that can significantly expand their capacity to model and interpret physical, social, and mathematical phenomena (NCTM, 2014).

The *Campaign for Drawing* suggests that drawing is a vehicle for helping both children and adults understand the world. Drawings can also be used to help think, feel, shape, and communicate ideas (www.campaignfordrawing.org). Drawings have previously been used as data in exploring perceptions among adults, including those in the field of healthcare (Mays et al., 2011). Research on drawings with adults in education, including pre-service teachers, has been much more limited. The few instances of such research have often been connected to a teacher preparation methods course (Burton, 2012; Lee & Zeppelin, 2014; Rule & Harrell, 2006) rather than field experience. Rule and Harrell (2006) found that the use of drawings could help students connect to previously unconscious images of mathematics, and in so doing, shifts the mathematics anxiety complex toward a more positive framework. In a similar study, conducted with pre-service teacher candidates enrolled in a mathematics methods course, Burton (2012) suggests having PSTCs draw math at the end of an internship experience to see how perceptions of mathematics have changed.

Methods

The participants for this study included 56 pre-service teacher candidates enrolled in a field experience course for elementary education, all of which were female. The participants were working toward an EC-6 teaching endorsement from the state in which they resided. Participants came from five different sections of a field experience course. As part of the course, participants were placed in a K-5 university charter school classroom four days a week, three hours each day, over the course of twelve weeks. The field experience included a one-hour lab that met once a week to discuss a variety of components related to their placements. Furthermore, PSTCs were enrolled in a science, social studies, and online mathematics methods course in concurrence with their field experience placement.

As part of the field experience requirements, PSTCs were required to teach lessons related to math, science and social studies. All grade-level placements included *number talks* associated with *mental math* as part of their daily mathematics. Parrish (2011) describes number talks as 5-15 minute conversations around specific computation problems solved mentally, also referred to as mental math. During these talks, students are able to communicate their thinking and justify solutions to problems performed mentally. The goal of number talks is to develop more accurate, efficient, and flexible problem-solving strategies. PSTCs observed number talks daily and were responsible for leading whole group number talks as a required teaching component of the field experience.

Data Collection

Prior to PSTCs being placed in their field experience setting, they were required to attend three days of orientation. The orientation included information about the objectives of the field experience, discussion of the course timeline, and the kind of professionalism expected in the classroom. It was during orientation, prior to placement in the field, that the pre-field experience drawings were collected. Participants were informed verbally and in writing that their participation in the study was voluntary.

PSTCs were specifically asked, "What do you think of when you hear the word mathematics?" Participants were then instructed to draw their impressions of mathematics. PSTCs were told that their impressions might include previous experiences, emotions, or any other image visualized when the term mathematics was heard. After being provided an opportunity to draw impressions of mathematics, PSTCs were asked to write a few sentences to describe or clarify their drawing. Participants were asked not to filter images. The researcher assured participants that their drawings were confidential. These same procedures were followed in the collection of post-field experience drawings, at the completion of the field experience semester.

Data Analysis

The drawings and descriptions of the pre- and post-field experience drawings were open-coded by the researcher in an attempt to closely examine any similarities and differences (Mertens, 2005) between drawings. There were three overarching themes that emerged from the data: (1) emotions related to mathematics, (2) the mathematics environment, and (3) experiences within the mathematics environment.

In the first category, the researcher coded drawings based on emotions related to mathematics. Emotions were categorized as positive, negative, or neutral. Specific drawings, like smiling or frowning faces, were determining factors in classifying emotions. A drawing was categorized as neutral when neither a positive or negative emotion was specified. Participants' written descriptions regarding particular emotions were also used to categorize drawings.

The second category of coded images relates to the environment in which mathematics was represented. These images depicted mathematics in a classroom, real world, or more abstract setting. Classroom images contained visuals like problems on white board, books, tests, etc. Real-world images were represented by images in which math was portrayed outside of the classroom, like finding the distance of two objects. People are able to use their knowledge flexibly when they have an understanding of mathematics. However, students who memorize facts or procedures without a mathematical understanding may have difficulty applying their knowledge (NCTM, 2000). Abstract environments were those that did not reference a specific environment. Examples of abstract images include symbols of mathematical operations (addition, subtraction, multiplication, division) or manipulatives associated with mathematics, like math cubes.

Upon further examination of the mathematics environment, another category became evident: the experiences within the mathematics environment. Based on these experiences, the drawings and descriptions were coded as either "collaborative" or "isolated" mathematics. Collaborative images included children working with one another. These images may have also included a description in which words like "sharing" or "discussion" was evident. Isolated images referred to those in which one individual was depicted, or multiple individuals were present but not interacting, such as sitting in rows of desks. A neutral image was coded as one that did not reference a collaborative or isolated mathematics experience, such as the picture of an equation or mathematical symbol.

Results

Pre-Field Experience Drawings

PSTCs' initial drawings and writings indicated a variety of experiences related to mathematics. A negative experience or image was reflected in 46% of PSTCs' initial drawings. These negative images took a variety of forms. Many of the participants included a student with a frown on their face (see Figure 1) or a question mark above their head. In addition to visual representations of negative images, student descriptions further revealed a negative association with mathematics. One PSTC stated, "I work really hard to understand math concepts and it just doesn't click with me. I get frustrated." Another participant stated, "To me math is very difficult. I always feel behind or like I am the only person who does not understand. Math feels like a foreign language." Other words that PSTC used consistently to describe their images included: "stressful," "nervous," "confusing," and "frustrating."

Ten PSTCs expressed a positive experience or image related to mathematics. Many of these images include a smiley face or an illuminated light bulb. In the coding of descriptions, the researcher identified a few common words (e.g., enjoy and understand) along with phrases, such as "I can do it!" One teacher candidate stated, "I have always enjoyed math. I enjoy challenging myself and thinking about things from different angles" (See Figure 2). Positive images and descriptions represented 18% of participants' drawings.

Sixteen PSTCs (27%) composed drawings that included mathematical symbols or operations (see Figure 3). Examples of these images included base ten blocks, number lines, or mathematical operations. Participant descriptions of these drawings referenced terms like "graphing", "counters", "multiplication", and "division." Since these images and descriptions did not indicate a positive or negative experience with mathematics, they were categorized as "neutral" drawings.

To further examine the drawings, the researcher categorized the drawings based on the setting depicted in the drawings and descriptions. Of the initial drawings, twenty-two PSTCs (39%) provided images or descriptions that represented mathematics in a classroom setting. These images included visuals like a white board, children in rows of desks, textbooks, or a teacher. Forty-six percent of participants' images and descriptions were abstract representations of math, such as mathematic symbols or operations, while eight PSTCs made connections to mathematics in the real world, like in a pet store (see Figure 4).

Further investigation of the mathematics environment led the researcher to categorize experiences within the environment as isolated, collaborative, or neutral. Nine percent of PSTCs' drawings or descriptions were coded as collaborative. These images included pictures of children in a circle, or talking through the use of word bubbles (see Figure 5). Collaborative descriptions included words like "sharing" or "discussion." Forty participants (71%) drew images or provided descriptions that suggested an isolated mathematics-learning environment. Isolated drawings may have included children sitting in a desk by themselves (see Figure 6). A neutral drawing was indicative of 20% of participants. A neutral image did not indicate a collaborative or isolated experience, such as a picture of a mathematical symbol.

Post-Field Experience Drawings

PSTCs' final drawings and descriptions also indicated a variety of experiences related to mathematics. A positive experience or image was reflected in 36% of PSTCs' post-field experience drawings (see Table 1). Examples of these images included children and/or teachers smiling, some with light bulbs above their heads. One PSTC included a continuum of six faces progressing from unhappy to happy. The descriptions included with the drawings also indicated positive experiences related to mathematics. One PSTC stated, "My outlook on math is completely different from the beginning of the semester." Another PSTC stated, "I drew myself smiling instead of frowning because math does not scare me anymore." Other words that PSTCs used frequently to describe their images include: "happiness", "understanding", and "passion". Over the course of the study, the number of images indicative of a positive emotion grew by

18%, while the number of negative emotions decreased by 39% (See Table 1). One participant included the following description: "Before the field experience, I hated math with a passion. I was not good at it. After this experience and being immersed in this new math, I have a better understanding of math. I am more confident in my abilities."

To further examine the drawings, the researcher categorized the drawings based on the setting depicted in the drawings. These images included classroom, real world, and more abstract settings. From the pre-field experience drawings, to the post-field experience drawings, the number of images associated with the classroom environment increased by 13% (See Table 2), while the number of images reflecting real-world settings decreased. The number of drawings coded as an abstract setting remained unchanged. One participant described the setting in this way: "Math is not just done in rows of desks or with paper and pencil. It can be done mentally by playing games, using books, during lunch, and through other activities in-class and outside of class."

Drawings were also coded by type of mathematics interaction: collaborative, isolated, or neutral. The number of images coded as collaborative increased by 39%, while drawings with an isolated experience saw a decline of 43% (See Table 3). Illustrations in which neither a collaborative or isolated experience was depicted saw a decrease of 11%. One PSTC stated, "In our class, math is very interactive and openly communicated. Students' minds are constantly moving as they work different strategies and find different solutions." Another PSTC stated, "Learning is a social process. Children can learn from peers and teachers, through discussions and seminars."

Analysis

Pre-service teacher candidates will soon be teaching in classrooms of their own, which makes it vitally important for these future teachers to recognize and understand their own attitudes towards mathematics. The results from the drawings and descriptions associated with emotions related to mathematics, collected in this study, are consistent with other research related to pre-service teachers' attitudes and perceptions (Bekdemir, 2010; Gresham, 2007; Hembree, 1990). Pre-field experience data revealed that 46% of participants held a negative perception of mathematics. Further analysis revealed that these negative perceptions were often accompanied by mathematics experiences in which the participant may have felt isolated, or alone, without support to figure out a math problem.

Post-field experience drawings indicate a negative emotion associated with four of the 56 participants in the study. In comparing pre- and post-field experience data, drawings representative of a negative emotion saw a decrease of 39%. Further analysis revealed that the number of drawings indicative of an isolated mathematics experiences, decreased by 31%. Drawings that depicted a classroom setting increased by 13%, while a decrease of the same percentage was found in the number of drawings illustrating mathematics in the real world.

The coding of the descriptions accompanying the mathematics drawings revealed that 15 participants (27%) referenced the term "mental math". None of the descriptions that referenced mental math accompanied a drawing associated with a negative emotion. The feeling towards mental math may have been influenced by the field experience placement. PSTCs observed number talks centered around mental math on a daily basis and were required to facilitate a number talks lesson in their classroom placement.

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Discussion

Based on the results of this study, the field experience setting seemed to influence PSTCs' perceptions of mathematics. In particular, allowing PSTCs to observe and facilitate instruction related to mental computation, or mental math, through number talks seemed to leave an impression. The majority of PSTCs left this experience with a positive emotion connected to mathematics, which was not the case prior to the field experience. PSTCs observed classroom settings in which students were encouraged to ask questions of each other, rather than look to the teacher for the answer. Consequently, a number of PSTCs' post field-experience drawings reflected an environment in which students were free to share their experiences without judgment or fear of providing an incorrect response. Overall, the perceptions towards mathematics seemed to shift from a negative isolated experience toward a positive and collaborative environment.

The results of this study provide implications for educators in teacher preparation programs, especially those working with PSTCs in field experience settings. Providing field experiences, which allow PSTCs to observe mathematics in a setting where collaboration and discussion are critical components, like a *number talks*, may prove beneficial in aiding future teachers' understanding of mathematics. Additionally, quality field experiences may help PSTCs better understand how to establish collaborative learning opportunities, free from math anxiety, for their future students.

The results of this study also hold implications for current mathematics educators. There may be countless teachers currently teaching who themselves have a negative perception of mathematics. These teachers may be providing the same anxiety-filled experiences they were afforded as children. Examining the perceptions and attitudes of educators in the field may help administrators identify teachers who could benefit from continued training and professional development opportunities involving mathematics.

In follow-up activities related to the PSTCs' perception of mathematics in field placements, it would be beneficial to investigate participants' content knowledge related to mathematics. Shulman (1986) indicates that subject matter used to be of great importance in the preparation of teachers. This was replaced with an emphasis on pedagogy, culture, and policies. The purpose of this study was not to identify content knowledge, although a few participants alluded to math content. For example, one participant stated "Math use to frustrate me and now it makes more sense to me." From this statement, it is not clear what exactly makes "more sense", the math content itself, or methods for teaching mathematics. Follow-up interviews with participants could help clarify such information.

Although not *all* future educators will have positive perceptions of mathematics, there is hope. Quality field experience placements, in which mathematics is an emphasis, can aide PSTCs in gaining valuable teaching experience. These same field placements may also help build confidence along with a better understanding of concepts and instruction related to mathematics.

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Table 1
Emotions Related to Mathematics

Emotion	Pre-drawings	Post-drawings	Change
Positive	10 (18%)	20 (36%)	10 (18%)
Negative	26 (46%)	4 (7%)	-22 (39%)
Neutral	20 (36%)	32 (57%)	12 (21%)

Note. A neutral image was representative of a drawing in which neither a positive nor a negative emotion was indicated.

Table 2
Mathematics Setting

Representation	Pre-drawings	Post-drawings	Change
Classroom	22 (39%)	29 (52%)	7 (13%)
Real World	8 (14%)	1 (2%)	-7 (13%)
Abstract	26 (46%)	26 (46%)	No Change

Note. An abstract image was representative of a drawing in which neither a classroom nor a real-world image was indicated, such as a mathematics operation symbol.

Table 3
Mathematics Experience

Interactions	Pre-drawings	Post-drawings	Change
Collaborative	5 (9%)	27 (48%)	22 (39%)
Isolated	40 (71%)	24 (43%)	-16 (32%)
Neutral	11 (20%)	5 (9%)	-6 (11)

Note. A neutral image was representative of a drawing in which neither a collaborative nor an isolated experience was indicated.

Figure 1. PSTC-generated drawing depicting a negative impression of mathematics. Characteristics distinguishing this drawing as a negative drawing include the frowning face, low grade, and thunderstorm of mathematics.

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Figure 2. PSTC generated drawing depicting a positive impression of mathematics. Characteristics distinguishing this drawing as a positive image associated with mathematics include the smiling face and acknowledgment of enjoyment.

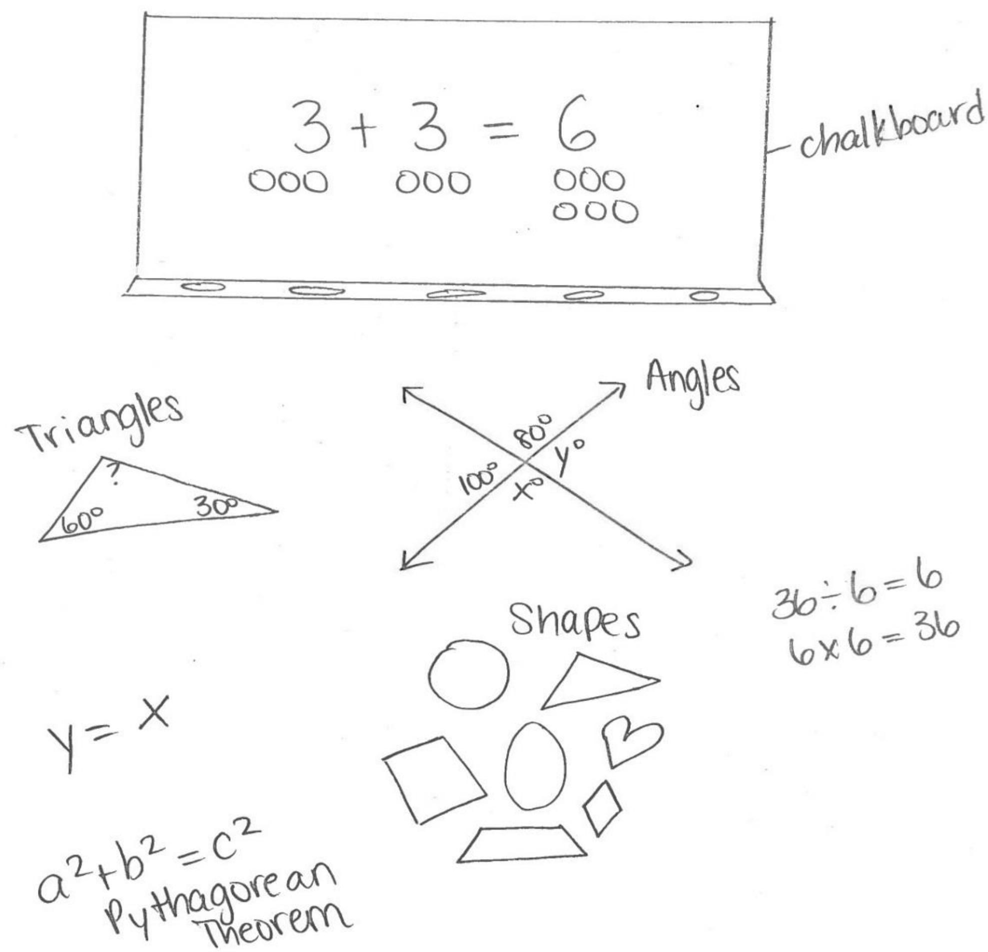

Figure 3. PSTC-generated drawing depicting a neutral impression of mathematics. Neither a positive or negative experience is evident from the drawing. Characteristics in this neutral image associated with mathematics include the use of shapes and mathematical operations.

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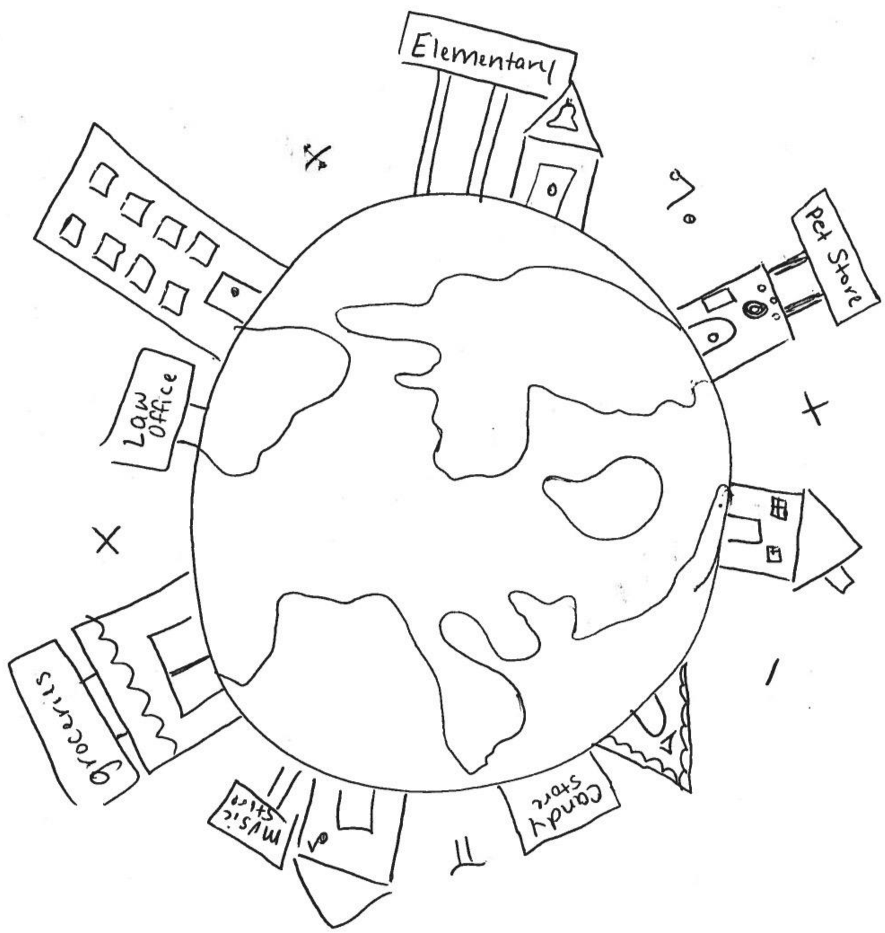

Figure 4. PSTC-generated, real-world image associated with mathematics. Characteristics in this real-world image associated with mathematics include the reference to locations beyond the classroom such as a grocery store, law office, and candy store.

Figure 5. PSTC-generated drawing depicting the collaboration of mathematics. Characteristics depicting collaboration in this drawing include the two students working together while problem solving.

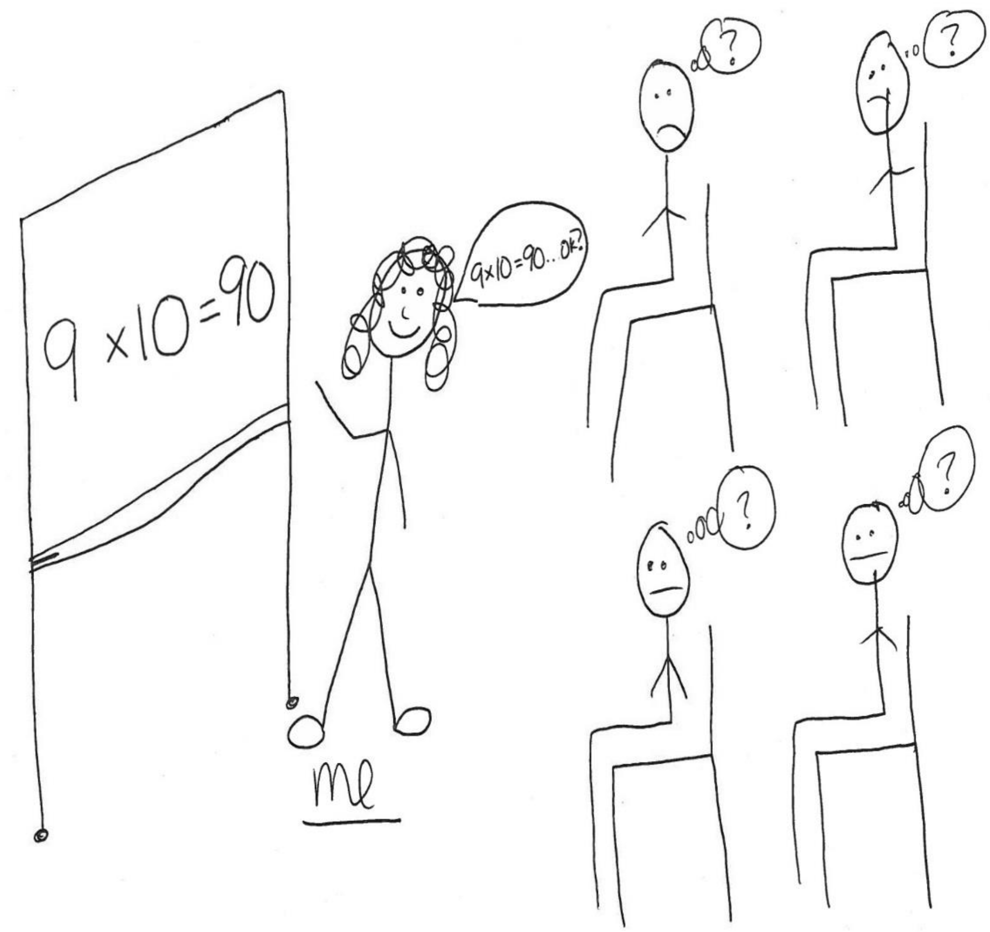

Figure 6. PSTC-generated drawing depicting the isolation of students in mathematics. Characteristics depicting isolation in this drawing include the students sitting in rows unengaged with each other and appearing to be direct taught.

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