THE MEANING OF A WORD: ELEMENTARY PRE-SERVICE TEACHERS' PERCEPTIONS OF MATHEMATICS

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Abstract

Elementary pre-service teachers often enter teacher preparation programs with negative beliefs about mathematics. In this study, elementary mathematics content methods instructors explored the beliefs of pre-service teachers at the beginning and end of the semester by asking them to complete the phrase 'Math Is…' using one word. Analyses of pre-service teachers' one word responses and their justifications revealed most pre-service teachers shifted from negative or neutral to positive words by the end of the semester. Three Sparks of Change influencing pre-service teachers' perspectives emerged from additional analyses of the data: field experience, self-perception, and self-efficacy or confidence.

Keywords: pre-service teacher preparation, mathematics education, beliefs

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Introduction

Elementary pre-service teachers often start their teacher preparation journey with a set of fixed beliefs about mathematics as well as the teaching and learning of mathematics based on their previous experiences (Philipp, 2007; Briley, 2012). When these experiences are acknowledged and explored in a teacher preparation program, there is the potential for elementary pre-service teachers' perceptions to be reinforced or possibly changed. This study explored whether pre-service teachers' perceptions of mathematics changed over time based on their experiences in a field-based math methods course. Pre-service teachers shared their perceptions by completing the phrase 'Math is…' using one word.

Literature Review

"One teacher can have a long-lasting impact on a student's outlook on mathematics" (Guillaume & Kirtman, 2010, p. 139). This impact can be positive or negative. For many pre-service teachers, their experiences are negative and impact how they think about teaching mathematics (Lutovac, 2020). Pre-service teachers often carry these feelings into their teacher preparation programs. So, what are the perceptions pre-service teachers have about mathematics in general and about teaching mathematics? What role do teacher preparation programs have in changing or reinforcing these perceptions?

Perceptions About Mathematics and Mathematics Teaching

Mathematics is a discipline that causes fear and at times anxiety for some students, including elementary pre-service teachers (Bates et al., 2011). Often, elementary pre-service teachers perceive doing mathematics as following given rules or memorizing facts rather than understanding concepts (Liljedahl et al., 2006). Pre-service teachers often

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hold on to the idea that math is something you "do" rather than an understanding or an experience. In other words, they perceive mathematics as something that is done to a person rather than an experience involving the learning of concepts. These perceptions about mathematics, in general, color pre-service teachers' perceptions as they move through their educational journey to become a teacher.

The impact of pre-service teachers' perceptions about mathematics and mathematics learning on their teaching practices is well-researched (Swars, 2006; Burton, 2012). Swars (2006) found that pre-service teachers with positive experiences with mathematics had positive beliefs about mathematics teaching. Conversely, pre-service teachers with negative experiences had negative beliefs. Experiences, whether positive or negative, seem to be a common factor that influences pre-service teachers' beliefs about mathematics. Gresham (2009) also found that negative attitudes about mathematics can lead to doubts about pre-service teachers' own effectiveness in teaching mathematics to children. Furthermore, pre-service teachers often progress from more traditional concepts of mathematics teaching and learning to a more problem-solving approach towards mathematics during a methods course, which changes their beliefs about mathematics (Liljedahl et at., 2006). Therefore, methods courses in teacher preparation programs provide spaces where pre-service teachers' perceptions can potentially change.

Teacher Preparation Programs

Pre-service teachers' training and perspectives as future educators do not begin when they enter teacher preparation programs. Rather, as Guillame and Kirtman (2010) noted:

> U.S. teachers are products of the school systems that they pass through as students and reenter as professionals. These years of experiences with mathematics in school (and out) influence convictions, beliefs, and values that teachers bring with them to their professional program and to the classroom. (p. 124)

Furthermore, one of the most common college degrees in the US is a generalist in elementary education. This degree often provides pre-service teachers with limited preparation for effectively teaching mathematics (Jeffery et al., 2018; Aud et al., 2012; CBMS, 2012). Considering elementary pre-service teachers' prior experiences in and out of school in conjunction with limited preparation of effective mathematics teaching, it is not surprising that many elementary pre-service teachers do not have positive perceptions about mathematics teaching and learning. However, studies have shown that pre-service teachers' beliefs can be influenced by teacher preparation programs (Beswick, 2006; Gill et al., 2004; Swars et al., 2007). There is hope that elementary pre-service teachers can enter the profession with a more positive outlook on mathematics teaching and learning.

While there is extensive research about pre-service teachers' perceptions about mathematics and mathematics teaching, this study explored if pre-service teachers could clearly and succinctly articulate beliefs about mathematics and express if their beliefs changed over time.

Research Questions

The purpose of this study was to explore pre-service teachers' perceptions of mathematics by answering the following research questions:

1. What are elementary pre-service teachers' perceptions of mathematics, and how do these perceptions change from the beginning to the end of a mathematics methods course based upon their single-word responses to the prompt 'Math is ...'?
2. What justifications do pre-service teachers offer for their single-word choices?

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Methodology

To gain insight into elementary pre-service teachers' perceptions of mathematics, the researchers gathered and analyzed pre-service teachers' single-word responses they used to complete the phrase 'Math is ...' at the beginning and end of a mathematics methods course during the spring semester of 2019. Thus, an opportunity to observe possible changes in perceptions emerged as these data were collected at the beginning and end of the course. Single-word responses were collected rather than a different mode of expression, such as drawings (Burton, 2009), because often students have weak connections between mathematical concepts and the words or language used to explain the mathematics (Shockey & Pindiprolu, 2015). Also, in mathematics, communicating with others and using language in mathematics are important habits of mind (Seeley, 2014).

124 pre-service teachers across six classes of an elementary mathematics methods course at a midsized university in the south participated in this study during the semester directly before their student-teaching experience. The classes met once a week for 3-hours as part of a block of content-focused courses that included mathematics, science, social studies, and classroom management. During these course meetings, pre-service teachers explored and discussed research-based practices for teaching mathematics to elementary students, planned mathematics lessons, and reviewed elementary mathematics content. In addition to important mathematics content, the elementary mathematics methods courses focused on active learning, group-worthy tasks, hands-on learning with manipulatives, station-based exploration, and other research-based elementary mathematics practices and pedagogy (e.g. Featherstone et al., 2011; Parks, 2020). The pre-service teachers spent 4 weeks in a field placement in local elementary schools where they were required to teach at least one math lesson to students.

As an introductory activity in their first course meetings, pre-service teachers provided their single-word responses. The researchers, also the instructors for the course, held on to these responses until the end of the semester. During the final course meetings, the pre-service teachers revisited their original word and provided a second word to complete the sentence 'Math is …'. Additionally, the researchers asked the pre-service teachers to write a few sentences describing why they selected their word choice and why their words changed or stayed the same as compared to what they provided at the beginning of the semester.

The researchers conducted an iterative, thematic analysis of pre-service teachers' single-word responses (Corbin & Strauss, 2008; Miles et al., 2014). During the first round of analyses, the researchers organized and analyzed the words that students submitted at the beginning and end of the semester to begin to make sense of the kinds of words students were using. During the initial pass through the data, there emerged a clear delineation between negative words and positive or neutral words to describe mathematics. Examples of these types of words are provided in Figure 1. For the second round of analyses, the researchers used the identifiers of Positive, Neutral, and Negative to code all words submitted by the students.

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Figure 1

Examples of Positive, Neutral, and Negative Words

Positive	Neutral	Negative
Complex	Alright	Challenging
Dynamic	Okay	Confusing
Everywhere		Difficult
Exciting		Frustrating
Fun		Hard
Hands-on		Struggle
Interesting		Tricky
Rewarding		
Teachable		

For the final round of analyses, pre-service teachers' single-word pairs (beginning and end of semester words) were categorized into four groups: Same Word, Positive/Neutral-to-Positive/Neutral, Negative-to-Positive/Neutral, and Positive/Neutral to Negative. These analyses allowed the researchers to observe changes or no changes to participants' perceptions of mathematics based on the type of words students were using to describe mathematics. These categories were determined based on whether or not the pre-service teachers used positive or negative words to describe mathematics and whether or not their beginning and end of semester words changed. The Same Word category indicated that the pre-service teacher used the exact same word to describe math at the beginning and end of the semester. The other three categories indicated that the pre-service teacher used a different word when revisiting the sentence 'Math is ....' If it was unclear whether or not a word was positive or negative, the researchers reviewed participants' written responses about their word choice selections for clarification.

After the single-word response pairs were categorized, we conducted additional analyses on participants' written responses about the reasons for their word choices to identify key themes that arose across and within the four groups. From these thematic analyses, the researchers identified three key factors, or what were deemed Sparks of Change, identified by pre-service teachers in their written responses that resulted in changes in their perceptions about mathematics including: Field Experience, Self-Perception, and Self-Efficacy or Confidence.

Results and Findings

Overall, 124 pre-service teachers participated in this study with one participant only completing the original single-word response and another participant only completing the final single-word response and description. These two pieces of data were omitted from the analyses since they were incomplete. Thus, we analyzed 122 pairs of single-word responses and pre-service teachers' descriptions of their word choices. For this study, the researchers wanted to gain insight into not only what perceptions pre-service teachers held about mathematics at the beginning and end of the semester of a mathematics methods course but also how these perceptions changed and what factors influenced pre-service teachers' changing or unchanged perceptions.

'Math Is…' Words Analysis

To make sense of pre-service teachers' perceptions at the beginning and end of the semester of a math methods course, the researchers focused their analyses on students' use of positive or neutral and negative words to describe mathematics as well as how pre-service teachers' word choices shifted at the end of the semester. Table 1 shows how

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many positive and negative words pre-service teachers chose at the beginning of the semester as compared to the end. These results indicate that while the majority of pre-service teachers in our elementary mathematics methods courses initially held negative perspectives towards mathematics at the start of the semester (53% of 122 words), these perspectives overwhelmingly shifted over the course of the semester with a majority of students using positive words (94% of 122 words).

Table 1
Type of Word in Pre- and Post-Context

Word Type	Beginning of Semester	End of Semester
Positive	52	114
Neutral	5	1
Negative	65	7

Additionally, the researchers analyzed how the pre-service teachers' words changed at the end of the semester. Table 2 shows how many different instances of each of the four types of single-word response pairs occurred in the sample of 122 pairs.

Table 2
Categories of Single-Word Response Pairs

Category	Number of Pre-Service Teachers
Same	32
Positive	25
Neutral	1
Negative	6
Positive/Neutral-to-Positive/Neutral	27
Positive-to-Positive	23
Neutral-to-Positive	4
Negative-to-Positive	61
Positive-to-Negative	2

Both Table 1 and 2 demonstrate that a majority of pre-service teachers that chose a positive word when describing mathematics maintained a positive perspective towards mathematics at the end of the semester with only one participant switching from a positive to a negative word choice. This participant originally chose *Engaging* to describe mathematics but switched to *Challenging*. In her brief reflection on why she chose her new word, she stated: "…because children are on so many different levels, and I would worry about that. I'm not as comfortable teaching math as I thought."

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Alternatively, most of the participants that started with a negative word choice switched to a positive word. Of the 65 original negative words, only six pre-service teachers maintained a negative word using the same word they originally used. These words were: *Hard*, *Challenge*, *Challenging* (3 instances), and *Tricky*.

Sparks of Change

Based on participants' written responses about why their word choices changed or stayed the same, the researchers identified three Sparks of Change, or factors, influencing participants' perceptions of mathematics. These factors included: 1) Field Experience, 2) Self-Perception, and 3) Self-Efficacy or Confidence. The researchers also found that while some participants' words did not change, their reasons or justifications for their word choices indicated a change in their motivation or reasons for their word selections related to the Sparks of Change.

Field Experience

Many participants identified Field Experience as a key factor influencing their choice of words. In the context of their classroom experiences in their field placements, participants identified that their observations, teaching of mathematics to actual students, and relationships with and guidance from their mentor teachers often shifted their perceptions about mathematics. One participant stated, "I changed my word to multi-faceted because I realized my students all approached math problems differently. There are multiple paths to arrive at the same correct answer." This participant's experience observing student learning in her field placement showed her that students do solve mathematics problems in many different ways, an important idea emphasized throughout the math methods course.

Another participant reflected about her experiences in her field placement classroom based on the content that was covered: "There was heavy focus on reading. I didn't get to see kids learning [math]." This participant originally chose the word *Exciting*, but she changed her word to *Underappreciated*. Her field experience influenced her word choice as she observed a lower emphasis on mathematics teaching and learning in her field placement classroom in favor of reading instruction. In contrast, another participant wrote, "My mentor teacher showed me many ways to make math more hands-on and interactive." This participant originally chose the word *Boring*, but she changed her word to *Interactive*. She identified her mentor teacher in her field placement as a major influence on her shifted perception as communicated through her word choices.

Self-Perception

Another Spark of Change that emerged from the data was Self-Perception. The researchers found that participants often identified a shift from viewing themselves as a student of mathematics at the beginning of the semester to viewing themselves as a teacher of mathematics at the end of the semester. Often, participants' original words related to their own personal experiences learning mathematics, and their final words related to viewing mathematics from an educator's point of view. One participant originally chose the word *Fun* but changed her word to *Flexible* at the end of the semester. She reflected, "I still think math is fun, but I learned that there is not just one way to solve a problem. I was not taught this way and will definitely show my students many different ways." This participant's words highlight the Spark of Change of Self-Perception highlighted throughout the data set.

The researchers identified a shift from participants viewing mathematics from their own personal experiences as students to viewing mathematics from the perspective of the teacher. This shift in perspective is evident as participants were taking ownership of their future profession in their responses by using language such as "my students" or "our students." Another participant who originally selected *Difficult* but shifted to *Engaging* stated, "Throughout my experience, I noticed that math is not difficult. Students are interested in learning, and our job is to provide engaging lessons to help our students." This participant contrasted her original views about mathematics to her changing viewpoints from the semester when considering her role as an educator.

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A number of participants highlighted a contrast between their views of mathematics as a learner and their views of mathematics as a teacher. One participant stated, "Math is still a subject I like, but it is not my favorite to teach … I had a lot more fun teaching science and history." This participant's response indicates that she had different viewpoints when comparing her experiences as a learner of mathematics to that as an educator of mathematics and other subjects. Another participant noted, "To teach [math], I need to remember exactly what students need to know based on [Texas Essential Knowledge and Skills (TEKS) standards] and not everything I know." In other words, this participant acknowledged that her views on mathematics broadened from being based on her own understandings of mathematics to now considering the mathematics her students were required to learn as determined by standards documents.

Self-Efficacy or Confidence

A final Spark of Change the researchers observed in participants' written responses was related to students' self-efficacy or confidence in mathematics. One participant wrote, "... I've gained more knowledge and confidence in the subject." Math is not *Complicated* to me anymore but rather *Interesting* as I keep learning more." This participant identified an increase in her confidence in mathematics which impacted her perceptions of mathematics as communicated through her choice of words. Another participant identified an increase in confidence specific to the teaching of mathematics. This student originally identified mathematics as *Difficult* but changed her word to *Okay*. She wrote about her experience: "I learned how to teach math using differentiated instruction. My mentor would explain lessons and how to teach them. This built my confidence in teaching mathematics."

The Sparks of Change identified in the data were not always attributed to Negative-to-Positive or Neutral-to-Positive shifts and these Sparks of Change were not mutually exclusive. A participant could identify a field experience that also impacted their confidence in mathematics. Additionally, the Sparks of Change did not always result in a change in word. For example, a participant those chose the word *Fun* both at the beginning and end of the semester stated:

> My word did not change because I've always looked at math as a game. You are solving for an answer, and I find it fun. Another reason that it is fun is because there are so many different ways to teach how to solve a problem.

While this participant's word did not change, the Spark of Change of Self-Perception is highly evident. She originally discusses mathematics from her perspective as a student of mathematics. Then, she shifts to talking about her perspective as a teacher of mathematics. She identifies both of these perspectives as involving fun, but for different reasons.

> Another participant who used the word *Challenging* both at the beginning and end of the semester remarked: I kept my word the same because math is puzzling and challenging. It's also challenging to teach because you have to meet each child's needs and fix broken pieces from previous years. You have to make sure no one gets left behind, and it gets hard at times.

From this participant's response, we can again see that while the word remained the same, the reason or motivation for the word has shifted. This participant continues to view mathematics as challenging, but she has shifted her view from that of a student of mathematics to that of a teacher of mathematics.

These written responses show that while it may seem that participants maintained a negative outlook towards mathematics, the participants that used the same negative words to describe mathematics had thoughtful reasons for their choices. One participant acknowledged that she gained more mathematical knowledge in the course, but still found mathematics to be difficult. Multiple participants expressed needing additional experience in teaching mathematics to become more comfortable with mathematics. These participants' responses focused on their comfort teaching mathematics as heavily influential on their feelings about mathematics itself.

In summary of the study results and findings, most pre-service teachers began the semester with a neutral or negative word identified for completing the sentence 'Math Is…'. At the end of the semester, a majority of the students had shifted their word to a positive term. Additional analyses showed that participants' written responses about why their word choices changed or stayed the same, highlighted three Sparks of Change: 1) Field Experience, 2) Self-Perception,

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and 3) Self-Efficacy or Confidence. Also, even when participants' words did not change, often their reasons or justifications for their word choices indicated a change in their motivation or reasons for their word selections.

Discussion

The findings from this study suggest that field experiences have the potential to shift pre-service teachers' perceptions and beliefs about mathematics teaching and learning. Based on participants' responses, the researchers found that the three Sparks of Change often resulted from and were tied to the pre-service teachers' time and experiences in their field placement during the semester prior to student teaching. Mentor teachers and stakeholders supporting pre-service teachers in their field placements have opportunities to reinforce negative viewpoints or help with positive shifts in pre-service teachers' perceptions about mathematics teaching and learning. Ronfeldt (2015) suggested that school settings substantially influence teachers' beliefs, perceptions, and efficacy. Understanding the role that field experiences play in the development of elementary pre-service teachers, especially with respect to mathematics instruction, is very important for teacher preparation programs to consider. Are pre-service teachers' field placements reinforcing negative perceptions or do classrooms, curriculum, and stakeholders in these placements support and align with the recommended pedagogies and practices that are often taught in mathematics methods courses? One thing this study demonstrates is that change can occur over the course of the semester.

Additionally, the findings from this study highlight that pre-service teachers' perceptions about mathematics teaching and learning are often more complex than just a positive or negative viewpoint. Instead, the participants in this study indicated that their perceptions about mathematics and mathematics teaching were multifaceted and influenced by previous learning experiences (Hiebert, 2003), teaching experiences, beliefs, feelings, people, observations, and other factors. In other words, there was not a single catalyst, lever, or experience for shifting participants' perspectives about mathematics and mathematics teaching to positive perspectives that emerged from the data. The data also showed that some pre-service teachers were flexible enough in their thinking to let go of long-held beliefs as they shifted from student to teacher perspectives.

This work adds to the growing body of research that examines pre-service teachers' multiple representations of perceptions of mathematics teaching and learning rather than depending on traditional methodologies such as survey instruments. These findings support the work of Utley et al. (2020) as well as Jao (2016) that suggested mathematics methods courses provide different opportunities for pre-service teachers to represent their thinking about mathematics teaching and learning using multiple modalities. Providing opportunities for pre-service teachers to express their beliefs in various modalities can move pre-service teachers forward in their development as novice mathematics educators.

Implications

This study revealed that pre-service teachers' perceptions of mathematic teaching and learning often changed, as evidenced by a shift in word choice for completing the phrase 'Math Is…' and that factors influencing these changes in a positive way often related to their experiences in their field placements. The results of this study have implications on practice in three areas: 1) elementary mathematics methods coursework in teacher preparation programs, 2) corresponding field-based partnerships, and 3) future study of pre-service teachers' perceptions and beliefs about mathematics teaching and learning.

Elementary mathematics methods coursework and field-based experiences tied to these courses have the potential to positively influence elementary pre-service teachers' perceptions and beliefs about mathematics teaching and learning. First, consideration should be placed on the content and learning opportunities pre-service teachers have in mathematics content methods courses allowing for alternative methodologies to explore beliefs and perceptions including word analogies, drawing pictures, digital renderings, and other representations. Secondly, in light of the findings of this study, additional time and energy should be put towards establishing, growing, and maintaining productive school partnerships. Mentor teachers and other field-based stakeholders are pivotal contributors to pre-service teachers'

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preparation, and therefore have considerable influence over pre-service teachers' perspectives and beliefs about mathematics teaching and learning. Additionally, further research examining what specific aspects of field experience are catalysts for change of perceptions of mathematics teaching and learning is needed.

Lastly, studies of elementary pre-service teachers and their experiences in teacher preparation programs should continue to evaluate what factors influence pre-service teachers' experiences and consider what factors have the potential to impact their perceptions and beliefs about mathematics teaching and learning. This study illustrates a first step in this process by identifying field-based experiences as particularly influential on pre-service teachers' changing perspectives.

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