How Pre Service Elementary School Teachers' Mathematical Dispositions are Influenced by School Mathematics

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Abstract

The National Research Council (2001, 2009) includes a productive disposition toward mathematics as a key component to mathematical proficiency, and researchers have discovered that the mathematical dispositions of elementary school teachers have an impact on the mathematical dispositions of their students. Working from this relationship between disposition and mathematics achievement, this paper will examine how four preservice elementary school teachers formed their mathematical dispositions, focusing on the experiences that the preservice teachers believed were integral to forming those dispositions.

Keywords: mathematical disposition, elementary school mathematics, teacher education

The Role of Mathematics Experiences in Forming the Mathematical

Dispositions of Preservice Elementary School Teachers

Negative mathematical dispositions have been shown to hinder student mathematical achievement (National Research Council, 2001; 2009); and Beilock et al. (2009) link elementary school students' negative disposition toward mathematics to negative mathematical dispositions in their teachers. This relationship is troublesome, as there are many elementary school teachers in the United States that have negative opinions toward mathematics (Hembree, 1990 & Karp, 1991); math anxiety (Beilock et al., 2009), or both (Beilock, 2011). In fact, many students entering elementary education programs do so with the belief that the mathematics required to teach the subject in elementary schools is not rigorous (Mahlzan, 2010).

It is because of this symbiotic relationship between mathematics disposition and achievement that it becomes important to understand the mathematical beliefs and attitudes of elementary school teachers. In order to better understand the teacher's mathematical dispositions, this paper will examine how preservice teachers formed their attitudes and opinions about mathematics.

Mathematical Disposition

NRC (2001) first introduced the concept of mathematical disposition when they define a productive disposition towards mathematics as a "habitual inclination to see mathematics as sensible, useful, and worthwhile, coupled with a belief in diligence and one's own efficacy" (p. 116). The NRC (2001) lists productive disposition along with strategic competence, adaptive reasoning, procedural fluency and conceptual understanding as the five interwoven strands of mathematical proficiency. According to Beyers (2005), a productive mathematical disposition is defined as:

A [person's] beliefs and attitudes about mathematics support the inclination to see mathematics as sensible, useful, and worthwhile. Mathematics self-concept constitutes the [person's] belief in his [or her] own efficacy and influences his [or her] belief that diligence leads to successful learning. (p. 150)

Because a student's disposition toward mathematics need not be productive, let *mathematical disposition* be someone's (a) beliefs and attitudes about mathematics, (b) their mathematical self-efficacy, and (c) the role he or she believes diligence plays in solving mathematical tasks. Further, define a *productive mathematical disposition* as a productive disposition toward mathematics as defined by NRC (2001) and an *unproductive mathematical disposition* as its natural opposite.

It is important to note that mathematical disposition is not a single sliding scale, but rather a multi-dimensional manifold of overlapping intellectual and emotional factors related to completing tasks that require mathematical thinking or processes.

Thus, an individual may have a productive mathematical disposition in one area and an unproductive one in another. For example, a student may be reluctant to attempt a task that he or she sees as mathematical in nature (an unproductive response) but upon reflection see their mathematical skills as being above average. Alternatively, a student may possess an enthusiasm toward doing mathematics and confidence in his or her ability to do mathematics, but also believe that mathematics is a skill only a few people possess. Neither of the above dispositions is completely productive or unproductive, but both contain elements that would be classified as productive or unproductive.

While possessing a productive mathematical disposition is integral to mathematical proficiency, having an unproductive mathematical disposition is equally damaging. Not only do individuals with unproductive mathematical dispositions avoid mathematics, but they also perform more poorly than their abilities would suggest when they are exposed to mathematical topics.

This is because [unproductive mathematical dispositions are] not simply a proxy for poor math ability. Rather, the fears that people with unproductive mathematical dispositions experience when they are called on to do math— whether it is working through a problem at the chalk board as an entire class looks on, taking a math test, or even calculating a restaurant bill—prevent them from using the math knowledge they possess to show what they know. When worries and self-doubt occur, thinking and reasoning can be compromised. (Beilock, et al., 2010, p. 1860).

Unproductive mathematical dispositions have been recognized as an impediment to mathematical achievement (Zazkis, 2011) and unproductive mathematical dispositions in early childhood teachers have particularly widespread consequences because of the increased effect the teachers' mathematical disposition have on their students (Phillipou, &Christou; 2002). This is especially troubling as it has been shown that many preservice elementary school teachers have negative mathematical dispositions (Gresham, 2007). When these preservice teachers who have an unproductive mathematical disposition are charged with teaching mathematics to early-grade elementary students, their anxieties about mathematics may be transmitted to their students.

Methodology

The study looked to examine the mathematical beliefs and attitudes of prospective elementary school teachers as they have progressed in the program. This was exploration research (Creswell, 2012) with the intent of snow-ball sampling the participants. However, due to lack of participant interest, only four participants elected to participate in the research.

This study took place at a large Midwestern university during an elementary school mathematics methods course co-taught by the researchers. This course focused on constructivist principles, reform-based mathematics pedagogies, and how to implement these techniques into elementary school mathematics. Embedded within the methods course that entailed over eighty hours of engaged field experience; which culminated with the candidates designing, planning, implementing, and reflecting on an integrated mathematics theme day in the elementary classrooms in which they were placed.

From these candidates in the class, four early childhood preservice teachers, Jane, Kristin, Megan and Sammie (pseudonyms) agreed to be part of a study to investigate and assess their own mathematical disposition. The participants agreed to take a survey to determine their mathematical disposition (see appendix A) and be interviewed after the conclusion of the course regarding their opinions and beliefs about mathematics. The survey is an adaption of the Fennema-Sherman Mathematics Attitude Scale (1976) and an instrument used by the Better Math Through Literacy teacher development seminar (Rice &McKeny, 2012). Each was scored from 0 to 50, with higher numbers indicating more productive mathematical dispositions. The interviews were semi-structured and occurred after the students had completed the course. The researcher used an interview protocol adapted from instruments found in Ferdinand (1999). The interviews were first analyzed within each case and then across cases using grounded theory (Marshall & Rossman, 2006; Creswell, 2012) and were coded by hand using two-cycle coding (Saldaña, 2009).

Themes

Of the participants, Jane's survey responses reflected the most positive mathematical disposition, (32of 50), followed by Sammie (24), Kristin (19) and Megan (14) (all pseudonyms). Although none of the participants scored particularly highly on the Mathematical Disposition survey, it became evident from interviews that Sammy and Jane possessed more productive mathematical dispositions than Kristen and Megan.

Interestingly, when the participants were asked to recall experiences that they felt were important in their mathematical life, they consistently chose experiences that happened during their elementary school years. This could be an artifact of their recent experiences in elementary school classrooms, but it could also serve to reinforce the notion that mathematical dispositions are formed early in one's school career (Ferdinand, 1999).

Sammie and Jane were both positively influenced by a parent doing mathematics with them on a regular basis. Sammie especially saw mathematics as a way to bond with her father, Sammie: Both my parents came here from [another country], so they couldn't help me with writing or stuff like that, because they still spoke and wrote [English] not good. But my Dad could help me with math, so it really became a bonding experience between us. Sammie went on to say how she and her father bonded while solving mathematics problems.

Sammie: My dad really liked math and we would solve math problems for fun. I really liked getting to the end of it and the sense of accomplishment I got from completing them. It always made me feel really good.

Another factor that helped influence Sammie's productive mathematical disposition was her successes doing school mathematics.

Sammie: I remember all the time in elementary school I got the highest grade on these school-wide math tests and it made me feel really good every time. I was always like 'This is AWESOME'! I always felt so smart every time the principal would come on the intercom and read my name and my score.

Researcher: How often did these tests happen?
Sammie: We did them once a month.
Researcher: And how often were you the highest score for your grade?

Sammie: Well, each grade had their own test, and I was always the highest in my grade. But [the principal] would also say who got the highest score overall, and that was usually me. Maybe like once or twice a year that would be someone else, but it was usually me.

Similarly, Jane described having constant positive reinforcement for her mathematical success, both privately and publically.

Jane: What I remember from elementary school were the time tests—but I really liked the timed tests.
Researcher: What did you like about them?
Jane: I thought of them as a competition.
Researcher: And did you win?

Jane: Yeah, I was really good at them…I was really good at [time tests and math games] and I enjoyed showing it off. To be honest, I liked humiliating my classmates who weren't as smart as me.

Jane saw the timed tests as a competition that she could win and that she frequently won. However, while Jane's success in mathematical competitions helped foster her productive mathematical disposition, not being successful in competitions can lead to unproductive dispositions.

For example, Megan's shared an experience where a mathematics competition led to an experience that harmed her mathematical disposition:

Researcher: You said your teacher played games with multiplication facts?

Megan: Yeah. She would put us into groups and have us stand on a chair to answer. And we would play for extra-credit on the tests. So if you got something wrong everyone hated you, and you felt like you were letting everyone down. And I was always like, "Man, I don't know anything, I am going to screw this up and everyone will hate me."

Researcher: Even though it was just extra credit?

Megan: Yeah, I know it was silly, but I always felt like there was a lot of pressure on me and that I could never beat the people I was against. I always felt like I was the kid in kickball that everyone moved up [from the outfield] to get out.

Researcher: So did you think this game was fun?
Megan: No, not at all. I hated… H-A-T-E-D it! I was terrified.
Researcher: So do you think that had an effect on how you thought about math?

Megan: Yeah, for a long time I had trouble with my multiplication facts, and I think this just reinforced how much trouble I was having. And all this stuff always just made me realize how dumb I am [laughs].

Megan recounted a series of powerful traumatic events in her early mathematics education history, which negatively affected her mathematical disposition and even her views of her overall intelligence. Rather than reinforcing multiplication facts, the mathematics games only served to publically shame her for her lack of skill. Megan was a student struggling to memorize the multiplication facts, and the added pressure made reciting those facts more quickly than her competition made learning nearly impossible for her. Perhaps worse though, Megan continues to this day to equate multiplication facts with the stress of these games.

Similarly, Kristen described an experience that happened to her in 3rd grade that influenced her views of mathematics:

Kristin: It's not that I don't like math. I love the puzzles in it... I like steps, and I like to follow steps. I would just [mess] them up. My third grade teacher… was very picky with steps. I remember I was doing a multiplication problem, and I got the right answer. But she counted it wrong, and when I asked her, she said I didn't "do it right."

Researcher: What did she mean by "right"?

Kristen: The way she did it. In fact, she made three of the smart kids come up and show me their papers, and they were all the same [had identical work]. She yelled at me more and after all that I ran out of the class crying.
In this instance, the teacher used peer pressure and public humiliation to try to reinforce a mathematical procedure, and in doing so left an indelible impression on Kristen's mathematical disposition.

Discussion

Students' mathematical disposition are formed early in a students' mathematical career, and is very difficult to alter later in life. As Phillipou and Christou (2002) point out

Once attitudes and beliefs about [mathematics] are developed, they have a degree of stability and intensity. Emotions, attitudes and beliefs from a hierarchical scale, or linear continuum, which is characterized by an increasing level of the cognitive component and stability, by a decreasing trend of the effective component. That is, emotions are highly effective and of a short duration, while beliefs are based on cognitive experiences are normally less affective and quite stable… Change in one's beliefs is feasible but not easy; it can occur only under conditions in which the individual is faced with new information and experiences that conflict with established beliefs. (p. 213)

When asked about the experiences the participants thought was most important in their mathematical history, the majority of instances described occurred in elementary school. Thus it would seem that most of the experiences that form positive (and negative) mathematical dispositions happen before middle school, with experiences that happen after that either confirming their already existing disposition or being outliers to the event. For example, Sammie (who scored second best of the instrument) said that she liked mathematics even after "having a terrible math teacher" in college. Similarly, Megan (who scored the lowest) said that she had "awesome" mathematics teachers in college, yet she still disliked mathematics.

Unfortunately, that means that influencing the mathematical dispositions of preservice or prospective elementary school teachers in teacher education programs is difficult. However, it reaffirms the necessity to improve the mathematical dispositions of prospective elementary school teachers so that their students may benefit from teachers with positive dispositions. This was not a fact lost on Megan, who shared her own concerns about negatively influencing the mathematical dispositions of her future students.

Meagan: I have to be really careful when I am working in my class. I hope I can run my classes in such a way that even if kids are struggling they don't feel like they are awful at doing math. I want them to have a positive outlook on math and not just, "I hate math" in general... I know I hate math, but I don't want that to come out in my teaching at all. I want my students to like math, to not share my fear. I can't put that kinda persona around them. The more negative I am, the more likely they will share my opinion.

Positive mathematical disposition can be attributed to the student (teacher candidate) having regular small positive experiences where they could succeed with mathematics during their elementary school career(e.g. receiving regular homework help from a parent) while negative mathematical dispositions are formed from individual traumatic mathematical events in the teachers' elementary school career (e.g. being publically embarrassed about an assignment).

Conclusion

A student's mathematical disposition is a key component to his or her success learning mathematics, and an elementary school teacher's mathematical disposition is integral to informing the mathematical disposition of their students. It is important for mathematics teacher educators to be mindful of many prospective elementary school teachers' unproductive mathematical dispositions, and create opportunities to discuss those dispositions, the events which may have led to forming those dispositions, and the research linking the teacher's view of mathematics to their students. While we may not easily alter the preservice teacher's mathematical disposition, by making the preservice teacher cognoscente of their own beliefs and how they came to those beliefs, teacher educators may be able to assuage preservice teachers to use teaching strategies that promote positive dispositions and avoid practices that promote negative ones.

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Appendix A: Mathematics Disposition Survey for Prospective EC Teachers

Name:_____e-mail: _____
Campus address: _____Campus Phone: _____

For each statement, chose one option that best describes your feelings toward that statement. Options range from Definitely False (DF) to Definitely True (DT).

Attitude Statement	**Not Applicable (NA)**	**Definitely False (DF)**	**Mostly False (MF)**	**Neutral (N)**	**Mostly True (MT)**	**Definitely True (DT)**
1. Generally, I feel secure about the idea of teaching mathematics to young children.						
2. I find many mathematical problems interesting.						
3. Mathematics makes me feel inadequate.						
4. I am not the type of person who is good at mathematics.						
5. I have always done well in mathematics classes.						
6. I am nervous about having to teach mathematics.						
7. I think I am good at mathematics.						
8. I generally do worse in mathematics courses than in other courses.						
9. I am confident in my ability to solve difficult mathematics problems.						
10. I enjoy learning about mathematics.						
11. I have hesitated to take a course that is mathematics based.						
12. Teaching mathematics doesn't scare me in the least.						

Attitude Statement	**Not Applicable (NA)**	**Definitely False (DF)**	**Mostly False (MF)**	**Neutral (N)**	**Mostly True (MT)**	**Definitely True (DT)**
13. I would get a sinking feeling if I came across a hard problem while teaching mathematics.						
14. At school, my friends would always come to me for help in mathematics.						
15. I am confident in my ability to teach mathematics.						
16. I have trouble understanding ideas that are based on mathematics.						
17. It would not bother me to teach a lot of mathematics.						
18. I do not do well on tests that require mathematical reasoning.						
19. Of all the subjects, mathematics is the one I worry about teaching.						
20. If I taught in a team or with a teaching partner, I would like to have another teacher teaching the mathematics.						
21. I see mathematics as practical and useful.						
22. I tend to not ask questions in math classes because I am afraid I will look dumb.						
23. I get frustrated when I do mathematics.						
24. Overall, I feel confident in my mathematical ability.						
25. Overall, I feel confident in my ability to teach mathematics.						