Fall 11-21-2023

Analyzing the Impact of an Informal Mathematics Teaching Experience on Preservice Teacher Mathematics Teaching Self-Efficacy

Kayla Fruth
fruthk@bgsu.edu

Analyzing the Impact of an Informal Mathematics Teaching Experience on Preservice Teacher Mathematics Teaching Self-Efficacy

Kayla N. Fruth

College of Education and Human Development, Bowling Green State University

HNRS 4990: Honors Project

Dr. Gabriel Matney & Dr. Jacob Burgoon

November 21, 2023

Introduction

Should teacher preparation programs provide opportunities for preservice teachers to grow their efficacy before they graduate and enter the profession as in-service teachers? A teacher's sense of efficacy has been defined as "the teacher's belief in his or her capability to organize and execute courses of action required to successfully accomplish a specific teaching task in a particular context" (as cited in Knoblauch & Woolfolk Hoy, 2008, p. 166). A teacher's sense of efficacy affects their teacher behaviors, such as the amount of effort, persistence, and commitment they put into teaching (Knoblauch & Woolfolk Hoy, 2008). All these teacher behaviors impact student achievement and attitudes (Knoblauch & Woolfolk Hoy, 2008). Additionally, less efficacious teachers will encounter more stress while teaching (Matney & Jackson II, 2017). At this Midwestern university, the informal mathematics teaching experience is a service-learning opportunity that provides preservice teachers with a low-stakes environment to work with other preservice teachers to lead a one-day mathematics camp for kindergarten through twelfth-grade students. This informal mathematics teaching experience is part of a Midwestern university's mathematics teacher preparation program that helps prepare preservice teachers to become educators.

Research Questions

Primary Question: How does participating in an informal mathematics teaching experience affect a preservice teacher's mathematics teaching self-efficacy?

Secondary Question: Does the informal mathematics teaching experience create a higher or lower sense of mathematics teaching self-efficacy among the preservice teachers who volunteer to help?

Literature Review

Informal Mathematics Teaching Experience

This informal mathematics teaching experience focuses on providing professional development for preservice mathematics teachers to practice teaching kindergarten through twelfth-grade students about mathematics in a low-stakes environment (Matney, 2017). Throughout this informal mathematics teaching experience, preservice teacher volunteers enact mathematics camps that promote student enjoyment while engaging in the mathematical problem-solving process (Matney, 2017). This experience simulates a school environment where the preservice teachers are responsible for the students (Colabianchi & Matney, 2020). Throughout the informal learning experience, the preservice teachers reflect and revise their teaching to adjust to their group of students (Colabianchi & Matney, 2020).

Every preservice teacher will fulfill one of the three major roles at each mathematics camp: Executive Leader, Team Leader, or Mathematical Task Leader (Matney, 2017). Executive Leaders oversee the planning and operation of each camp (Matney, 2017). Team Leaders work directly with a group of students to build rapport and stay with their team of students all day (Matney, 2017). Mathematical Task Leaders lead each team of students in a specific mathematical task (Matney, 2017). Every role works together to enact the camp but also provides a unique opportunity to learn through different perspectives (Matney, 2017).

As students arrive for the mathematics camps, they check in and then meet their Team Leaders. Once most of the students have arrived, they learn some norms for the camp, as well as a song associated with the camp. Then the students spend time with their teams, where the Team Leaders will engage their students in some activities to build rapport and learn about their team

mathematician, song, and dance. After the students get comfortable with their groups, they receive a brief snack break, and then they engage in Brain Challenge. Brain Challenge is a team-based activity, where the Team Leaders need to guide their students through several mathematical tasks. Once that activity is complete, each team will rotate through multiple mathematical activities led by the Mathematical Task Leaders. Then the students will engage in lunch, a three-part mathematics relay, an effective communication team activity, and team reflection.

However, before preservice teachers can engage as volunteers for the mathematics camps, they must participate in a collegiate camp, which utilizes preservice teachers who are further along in their program, by having them teach less experienced preservice teachers about the program by having them engage as students in the mathematics camp (Matney, 2017). This yearly event prepares more preservice teachers for how to conduct mathematics camps for kindergarten through twelfth graders (Matney, 2017).

According to Colabianchi & Matney (2020), preservice teacher participants in the mathematics camps experienced positive professional impact. The preservice teachers stated that they gained confidence while engaging in the informal learning experience (Colabianchi & Matney, 2020). Colabianchi & Matney (2020) hypothesize that this could be because the preservice teachers felt as though the mathematics camps provided a safe professional learning space where they could try new techniques and make some mistakes.

Self-Efficacy

Bandura (1977) defines self-efficacy as an individual's belief that they can successfully execute a task to produce a specific outcome. A person's perceived self-efficacy influences one's

behavioral settings because people will experience fear and avoid threatening situations (Bandura, 1977). Additionally, one's efficacy determines how much effort one will exert and how long one will persist against obstacles (Bandura, 1977). People with stronger perceived self-efficacy will persist longer against threatening situations (Bandura, 1977).

Teaching Efficacy

Teacher efficacy has been defined as "the extent to which the teacher believes he or she has the capacity to affect student performance" (as cited in Tschannen-Moran et al., 1998). According to Tschannen-Moran et al. (1998), a student's motivation and performance reinforce a teacher's behavior. For instance, if a teacher has a high sense of efficacy, then the teacher believes that they can influence their students' achievement and motivation.

Another theory surrounding teacher efficacy grew from Bandura, where teacher efficacy is a type of self-efficacy, meaning that people will "construct beliefs about their capacity to perform at a given level of attainment" (as cited in Tschannen-Moran et al., 1998). These teacher beliefs influence how much effort they will put into teaching, how long they will persist against obstacles, their resilience against failures, and how much stress they experience (Tschannen-Moran et al., 1998).

Mathematics Teaching Efficacy Beliefs Instrument (MTEBI)

The Mathematics Teaching Efficacy Beliefs Instrument (MTEBI) is one way to measure a preservice teacher's Personal Mathematics Teaching Efficacy Belief (PMTE) and Mathematics Teaching Outcome Expectancy (MTOE) (as cited in Enochs et al., 2000). PMTE is the belief in one's ability to teach effectively, while the MTOE is the belief that teaching effectively will positively impact student learning outcomes. The MTEBI consists of twenty-one items, thirteen

of which focus on accessing Personal Mathematics Teaching Efficacy, while eight items focus on Mathematics Teaching Outcome Expectancy (as cited in Enochs et al., 2000). Preservice teachers will indicate the degree to which they agree or disagree with each of the twenty-one items (Appendix A) (as cited in Enochs et al., 2000). Then, the results of each preservice teacher's MTEBI can be scored (Appendix B) (as cited in Enochs et al., 2000).

Methods

The participants of this study were thirty-six preservice teachers who volunteered at an informal mathematics teaching experience at a Midwestern university. Every willing participant received a consent form and survey where they measured their current mathematics teaching efficacy using the revised version of the Mathematics Teaching Efficacy Beliefs Instrument (MTEBI) (Appendix A). This was given out at the beginning of the training meeting for the informal mathematics teaching experience. Since the training meeting was two days before the experience, the preservice teachers rated their self-efficacy before engaging in the informal teaching experience. Immediately following the teaching experience, participants received the same survey where they rated their efficacy again. The participants completed this survey immediately before the full-group post-camp reflection.

Once the information from the second survey was collected, I completed some statistical analysis on the quantitative data to determine whether there were increases or decreases in the preservice teachers' sense of efficacy (Appendix B). I noticed that some volunteers experienced significant increases or decreases in their sense of mathematics teaching efficacy. I conducted ten-to-fifteen-minute interviews with three students who had an increased sense of efficacy and two who had a decreased sense of efficacy. The goal of this was to gather qualitative data on

their experience during the learning opportunity, with the hopes of creating an understanding of how their sense of mathematics teaching efficacy was impacted. The interview questions were intended to help me gather data about their experience teaching mathematics at the mathematics camp. Additionally, to study how a preservice teacher's mathematics teaching self-efficacy was impacted by the informal teaching experience, only data collected about the personal mathematics teaching efficacy belief items of the MTEBI were analyzed to draw conclusions about the data. During the analysis, I completed a paired t-test (results found in Table One) and a Wilcoxon Signed Ranks Test (results found in Table Two).

Results

Table One

	Pre-Survey Mean	Post-Survey Mean	N	df	t-value	Two-Sided p-value
Personal Mathematics Teaching Efficacy Belief	**52.44**	**54.847**	**36**	**35**	**-3.410**	**.002**

The first test that I ran was a paired t-test to help me view the data as though it was symmetric. This allowed me to analyze the mean of the pre- vs the post-personal mathematics teaching efficacy belief. The PMTE showed a mean increase of 2.407. Additionally, these results were statistically significant, due to the PMTE having a t-value of 3.410 with a two-sided p-value of .002. Since the PMTE has low p-values and high t-values, this gives us confidence that the change was due to participation in the informal mathematics teaching experience.

Table Two

Personal Mathematics Teaching Efficacy Item	Percent of total people with increases in PMTE	Significance (based on p-values)
I will continually find better ways to teach mathematics.	19.4%	
Even if I try very hard, I will not teach mathematics as well as I will most subjects.	19.4%	
I know how to teach mathematics concepts effectively.	44.4%	✓
I will not be very effective in monitoring mathematics activities.	41.7%	✓
I will generally teach mathematics ineffectively.	33.3%	✓
I understand mathematics concepts well enough to be effective in teaching elementary mathematics.	27.8%	
I will find it difficult to use manipulatives to explain to students why mathematics works.	33.3%	✓
I will typically be able to answer students' questions.	19.2%	
I wonder if I will have the necessary skills to teach mathematics.	41.7%	
Given a choice, I will not invite the principal to evaluate my mathematics teaching.	25%	
When a student has difficulty understanding a mathematics concept, I will usually be at a loss as to how to help the student understand it better.	13.9%	
When teaching mathematics, I will usually welcome student questions.	5.6%	
I do not know what to do to turn students on to mathematics.	33.3%	

Next, I conducted a non-parametric Wilcoxon test, which allowed me to compare each item on the pre- and post-surveys from each volunteer at the mathematics camp. The Wilcoxon test provided me greater insight into the impact of each question on the pre- and post-surveys.

Additionally, these tests helped me determine which items experienced statistical significance. Then I connected qualitative information collected from the interviews to the results. After running the test, four items assessing personal mathematics teaching efficacy beliefs were statistically significant, with a significant percentage of people experiencing an increase in PMTE for each item.

Item five of the MTEBI assessed whether preservice teachers feel like they know how to teach mathematics concepts effectively. For this item, 44.4% of the total preservice teachers experienced an increase on the post-survey compared to the pre-survey. Before the camp, one of my interviewees was feeling nervous about teaching mathematics to the students since she was unfamiliar with the current content taught at that grade level. However, once the camp started and she saw the content, "[she] felt pretty good giving them hints and tricks… for it. It was not hard at all." After the camp, this preservice teacher believed that she could teach the mathematics concepts effectively.

Item six of the MTEBI focused on assessing a preservice teacher's effectiveness at monitoring mathematics activities. For this item, 41.7% of the total volunteers ranked this item higher on the post-survey than on the pre-survey. During the informal teaching experience all preservice teacher volunteers, no matter their role at the camp, are involved in monitoring mathematics activities.

During the interviews, Executive Leaders discussed how they observed an overview of all the mathematics occurring during the camp. The Team Leaders discussed how they monitored two mathematics-focused activities with their team, while the Mathematical Task Leaders

monitored a specific activity for each team. Here is what some of the interviewees discussed regarding monitoring mathematics activities:

> We had a few moments where [students] would get stuck, and they would get to the exact same point that they had reached before, and instead of having them restart, we would just ask them to take a deep breath and kind of recollect themselves, and talk about how much water was in each cup and then go back and talk with their teammates about a new potential solution. (Mathematical Task Leader)

> I got to be more behind the scenes and see like what each Team Leader individually does… So, I thought that was really neat to just be like, okay, that's how they're getting their team to the answer. Or maybe that's not the best approach that they're taking right now. Maybe I should lean in [and] ask another question or something. So, I think it was really interesting to like, be on that side of it to kind of provide my own input where needed. (Executive Leader)

Item eight of the MTEBI focused on a preservice teacher's effectiveness at teaching mathematics. 33.3% of the total volunteers ranked this item higher than they did on the pre-survey. During an interview, one of the Mathematical Task Leaders said,

> I felt great about [teaching mathematics] throughout the day. I think as the day went on, we improved the way we were teaching… Even if [students] were frustrated by the end of it, and they might not have gotten to the extension part of it. They at least got the first part, which was the goal.

This Mathematical Task Leader felt as though his effectiveness at teaching mathematics increased throughout the day. He also felt that each group achieving the first part of the task equated to the students achieving success.

Item fifteen of the MTEBI focused on a preservice teacher's ease toward using manipulatives to explain to students why mathematics works. 33.3% of the preservice teachers ranked this item higher on the post-survey than they did on the pre-survey. Here is some information relating to a Team Leader's use of manipulatives during the informal teaching experience:

> One thing that I tried to do during Brain Challenge is use manipulatives. One of the more specific ones that comes to mind is the triangle … I set the dots up so they could see the formation of it. And then I kind of just let them move stuff around… [This worked to] try and help them see the problem.

Additionally, one Executive Leader discussed how previously as a Team Leader, "during Brain Challenge… I tend to pull out any manipulative that I can so they can see [the problem]." Both interviewees discussed how the mathematics camp gave them an opportunity to practice teaching mathematics with manipulatives.

Based on the data gathered through the MTEBI pre- and post-surveys, we can determine that the informal mathematics teaching experience impacts a preservice teacher's mathematics teaching self-efficacy. Moreover, the data reveals that overall, the informal teaching experience contributes to a higher sense of mathematics teaching self-efficacy among the preservice teachers who volunteer.

Implications for Future Research

Based on the results of this study, participation in this informal mathematics teaching experience contributes to a higher sense of mathematics teaching self-efficacy among the preservice teachers who participate in the camps. As these preservice teachers continue throughout their entire college career, they can participate yearly in approximately seven mathematics camps, providing them with many opportunities to grow their mathematics teaching self-efficacy before they become in-service teachers. Research by Knoblauch & Woolfolk Hoy (2008), states that a teacher's sense of efficacy will affect their behavior while teaching. For instance, it impacts the amount of effort, persistence, and commitment that they exert, which directly impacts student achievement and attitudes (Knoblauch & Woolfolk Hoy, 2008). Furthermore, teachers with a lower sense of efficacy experience more stress while teaching (Matney & Jackson II, 2017). Therefore, by participating in these informal mathematics teaching experiences, not only are the preservice teachers being prepared to become more efficacious teachers, but they are also being set up to positively impact student achievement and attitudes in the mathematics classroom. In the future, it would be interesting to complete a long-term study that follows the impact of the informal mathematics teaching experience on a preservice teacher throughout multiple mathematics camps, since due to time constraints, this study could only be completed on one mathematics camp.

Moreover, participation in this informal mathematics teaching experience is currently unique to this Midwestern university. However, if other universities implemented similar teaching experiences in their teacher preparation programs, then it could positively impact the preparation of their preservice teachers. Furthermore, at this Midwestern university, similar learning experiences are being created for other content areas, such as science and language arts.

Additional research could be done to study if these preservice teachers in other content areas experience self-efficacy increases by participating in these informal teaching experiences.

References

Bandura, A. (1977). Self-efficacy: Toward a unifying theory of behavioral change. *Psychological Review*, *84*(2), 191-215.

Colabianchi, K., & Matney, G. (2020). Preservice mathematics teacher professional learning through informal field experiences. *Ohio Journal of School Mathematics*, *85*(1), 37-46.

Enochs, L. G., Smith, P. L., & Huinker, D. (2000). Establishing factorial validity of the Mathematics Teaching Efficacy Beliefs Instrument. *School Science and Mathematics, 100*(4), 194-202.

Knoblauch, D., & Woolfolk Hoy, A. (2008). "Maybe I can teach those kids." The influence of contextual factors on student teachers' efficacy beliefs. *Teaching and Teacher Education, 24*(1), 166-179.

Matney, G. (2017). Peer mentoring professionalism among pre-service mathematics teachers: Safe spaces for community teaching practice. *Investigations in Mathematics Learning, 10*(2), 1-18.

Matney, G., & Jackson II, J. L. (2017). Research projects and secondary mathematics pre-service teachers' sense of efficacy. *Investigations in Mathematics Learning*, *9*(4), 171-186.

Tschannen-Moran, M., Woolfolk Hoy, A., & Hoy, W. K. (1998). Teacher efficacy: Its meaning and measure. *Review of Educational Research, 68*(2), 202–248. doi:10.3102/00346543068002202

Appendix A

MTEBI Efficacy Scale

Each preservice teacher indicated the degree to which they agreed or disagreed with each of the following statements. They did this by circling: “Strongly Agree,” “Agree,” “Neither Agree nor Disagree,” “Disagree,” or “Strongly Disagree.”

Items as they appear on the MTEBI:

1. When a student does better than usual in mathematics, it is often because the teacher exerted a little extra effort.
2. I will continually find better ways to teach mathematics.
3. Even if I try very hard, I will not teach mathematics as well as I will most subjects.
4. When the mathematics grades of students improve, it is often due to their teacher having found a more effective teaching approach.
5. I know how to teach mathematics concepts effectively.
6. I will not be very effective in monitoring mathematics activities.
7. If students are underachieving in mathematics, it is most likely due to ineffective mathematics teaching.
8. I will generally teach mathematics ineffectively.
9. The inadequacy of a student's mathematics background can be overcome by good teaching.
10. When a low-achieving child progresses in mathematics, it is usually due to extra attention by the teacher.

11. I understand mathematics concepts well enough to be effective in teaching elementary mathematics.
12. The teacher is generally responsible for the achievement of students in mathematics.
13. Students' achievement in mathematics is directly related to their teacher's effectiveness in mathematics teaching.
14. If parents comment that their child is showing more interest in mathematics at school, it is probably due to the performance of the child's teacher.
15. I will find it difficult to use manipulatives to explain to students why mathematics works.
16. I will typically be able to answer students' questions.
17. I wonder if I will have the necessary skills to teach mathematics.
18. Given a choice, I will not invite the principal to evaluate my mathematics teaching.
19. When a student has difficulty understanding a mathematics concept, I will usually be at a loss as to how to help the student understand it better.
20. When teaching mathematics, I will usually welcome student questions.
21. I do not know what to do to turn students on to mathematics.

Appendix B

MTEBI Scoring Instructions

Step One:

Assign the listed values to each degree as follows: Strongly Agree=5, Agree=4, Neither Agree nor Disagree=3, Disagree=2, Strongly Disagree= 1.

Step Two:

Reverse the scores for the following items: 3, 6, 8, 15, 17, 18, 19, 21.

Step Three:

The MTEBI measures Personal Mathematics Teaching Efficacy Belief and Mathematics Teaching Outcome Expectancy. To determine the total score for each participant for each of these measures, participants' scores within each of these categories needed to be added together

Items 2, 3, 5, 6, 8, 11, 15, 16, 17, 18, 19, 20, 21 measure Personal Mathematics Teaching Efficacy Belief.

Items 1, 4, 7, 9, 10, 12, 13, 14 measure Mathematics Teaching Outcome Expectancy.