Teacher Candidate Perceptions of Learning through Simulation Technology

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Abstract

This study explores the perceptions of mathematics teacher candidates regarding the use of simulation technology in their professional growth. Simulation technology, initially used in fields such as nursing and aviation, has been adapted for teacher education to provide a realistic and safe environment for practicing instructional skills. This phenomenological qualitative study involved six participants from a Midwest university, who engaged in a simulated classroom scenario with student avatars to practice teaching and reflect on their experiences. The findings reveal that the simulation technology enhanced the candidates' openness to diverse student solutions, improved their rapport-building skills, and increased their confidence in teaching.

Keywords: Pre-service teachers, clinical experiences, mathematics teacher educator mentors, mathematics education

1 Introduction

Mathematics educators continually strive to improve their teaching, with efforts often beginning in initial teacher education programs that include practicum and field experiences. During these experiences, mathematics teacher candidates (TCs) work with practicing teachers and students. However, because teaching is complex, some nuanced aspects—like specific student misconceptions—may not surface in the field. To address this gap, many programs are turning to simulation software that replicates real classroom scenarios, allowing TCs to practice teaching and reflect on student responses. This study aims to deepen our understanding of how simulation technology supports the professional growth of secondary mathematics TCs by exploring their perceptions of its use. We ask, "How do secondary mathematics TCs perceive the use of simulation technology in relation to their development as educators?"

2 Related Literature

Simulation Technology

Simulation technology is a pedagogical technique that uses realistic elements or practice proxies for learning or assessment (Sanko, 2017). For teacher candidates (TCs), this technology serves two primary purposes: (1) providing students with opportunities to learn through clinical simulations, and (2) assessing students' understanding of a given concept. Originally developed in the field of nursing (Sanko, 2017), simulation technology has since expanded to support instructional methods in various fields, including aviation, the military, education, and social work (Decker et al., 2020; Washburn and Zhou, 2018).

The most commonly cited benefit of simulation technology is that it offers a safe environment for pre-professionals to practice in a realistic setting (Epps et al., 2020; González-Martínez et al., 2019). This approach enables novices to hone their skills and learn from mistakes without risking harm to actual individuals. In mathematics education, for example, a teacher candidate (TC) can practice teaching a concept without negatively impacting a real student's mathematical learning or identity. Simulation technology also supports active learning, encouraging learners to engage in hands-on activities and reflect on their actions and outcomes (Brame, 2017). Additionally, simulation is one of the few methods available for skill development outside of clinical experiences (Epps et al., 2020). While clinical experiences are invaluable for mathematics TCs to build their skills, opportunities to practice outside these settings can be limited. Simulation technology helps bridge this gap, offering mathematics TCs the chance to continue developing their skills and confront challenges that may not naturally arise during field work.

Openness and Building Rapport in Mathematics Classrooms

Mathematics is a field of study in which there are often several different methods to solve a problem. Previous studies have cited the importance and benefits for mathematics teachers to understand and accept the uses of various different problem solving methods. By being open to different solution pathways, teachers have the ability to enhance the quality of mathematics teaching and learning and develop students' conceptual understanding on key mathematics topics (Bingobali, 2011). In addition, dialogues about different solution pathways have been shown to improve the classroom environment, empowering students to freely express each solution they develop (Cobb et al., 1997). This shows the importance of mathematics teachers being open to a multitude of student solution pathways.

In addition to being open to different solutions, the relationship between a student and a teacher are important in mathematics classrooms. The teaching of mathematics is a very social endeavor, and thus the relationship that students have with their teacher will strongly affect the learning that takes place. It is important for mathematics teachers to have strong rapport building skills. Previous studies have shown that positive student-teacher relationships are strongly associated with high mathematics achievement (Olsen & Green, 2024). Thus, by having strong relationships with their students, mathematics teachers are more likely to have improved teaching and learning in their classrooms.

3 Methodology

This study was a phenomenological qualitative investigation of mathematics teacher candidates' (TCs) experiences using simulation technology. The simulation took place in a secondary mathematics education course typically taken during the second year of the teacher preparation program. Six TCs participated in the study, including two males and four females. Of these, five were White, and one was non-White. The participants were in their second or third year of a teacher education program at a university in the Midwest. They were enrolled in a course that focused on deepening content knowledge in geometry and probability, as well as exploring connections between mathematics standards and inquiry-based instructional strategies.

In December 2023, all participants engaged in a mathematics task called the CarpetMart task (Dietiker & Kassarjian, 2022), in which participants worked to determine the perimeter of any size rug, using both an algebraic equation and a geometric representation (see Figure 1). After participants came back from winter break, they began to think about that same task, this time through the eyes of a teacher. Participants were introduced to the simulation technology used throughout this research study (Mursion). The Mursion environment consists of a classroom with 5 different student avatars (see Figure 2). Each avatar has its own learner profile and represents a student in a classroom. The simulation took place over two class sessions. During the first session, participants had the opportunity to ask the avatars questions to get to know the students. These questions were focused on two domains: (1) rapport-building questions to get to know the students and (2) questions to understand students' mathematical knowledge related to the CarpetMart task. Participants then completed an assignment about anticipating student solutions for the CarpetMart task. We began our instruction with a discussion of the context of the task.

CarpetMart Task

Your friend Alonzo needs help with his family's rug manufacturing business, known for its unique designs. One of their best-selling designs is shown below, available in various sizes, all maintaining the same shape.

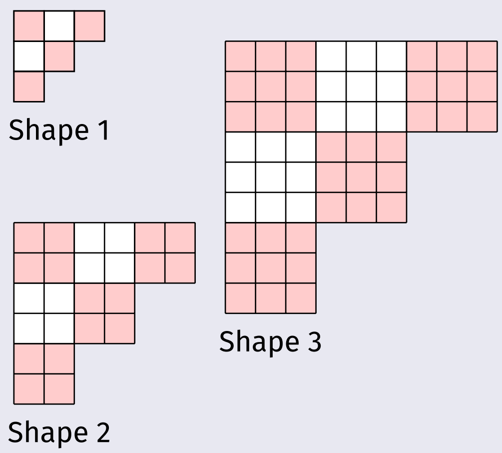
Alonzo is thrilled because the king of a distant land wants to order a very large rug for his massive banquet hall. However, the king is indecisive and won't select the exact rug or its size until the day before the event. Since the palace is enormous, the rug will be huge!

To prepare, Alonzo must quickly calculate the perimeter of the chosen rug to order the correct amount of fringe for its edges.

Figure 1: CarpetMart task (Adapted from *Core Connections Geometry* (Dietiker & Kassarjian (2022)).

Investigate the rug design to the right. The "original" rug is shown in Figure 1, while Figures 2 and 3 are the next enlarged rugs of the series. With your team, create an equation for the perimeter of your rug design that relates back to the image of the rug. Be ready to share your analysis with the rest of the class. Your work must include the following:

1. A description of the next figure in the sequence. What will it look like? What is its perimeter?
2. A general equation that represents the perimeter of your rug design.



The second session of the simulation was the teaching day. It began with the avatars sharing initial mathematical solutions to the CarpetMart task, based on work completed by actual 9th-grade students. In teams of four, the TCs collaborated to create probing questions designed to elicit the avatars' mathematical thinking on the task. One TC was randomly chosen to lead their team's questioning strategy for the CarpetMart task. This TC facilitated the session by engaging with the avatars and drawing out their ideas related to the task. Meanwhile, the other participants observed the lesson, taking notes on the student solutions, ideas, and responses. After the simulation, all participants took part in a small group reflection with their peers.

Figure 2: Simulation classroom.

After the simulation, semi-structured interviews were conducted with each mathematics TC. Each participant responded to nine main questions (see Appendix), with additional probing questions used to delve deeper into their answers. The interviews were audio recorded and transcribed for textual analysis. Inductive thematic analysis (Hatch, 2002) was then carried out by the first author to code the data. The steps for the inductive analysis process are outlined below.

1. Each transcript was read in its entirety. The frame of analysis was evidence of professional growth and understanding of lesson study from each interview.
2. Each transcript was reread, and memos of salient domains were created.
3. All of the salient domains were given a code. These codes consisted of types of professional growth and attitudes and knowledge on lesson study. The codes that emerged were as follows: open-mindedness; rapport-building skills; improved confidence; and teacher-view.
4. The transcripts were reread. Salient domains were refined and revised.
5. Domains were analyzed, searching for examples that fit with or run against the domains identified.
6. An outline was created discussing relationships within and between domains.

Interrater reliability was not a concern for this study as there was only one researcher that engaged in analyzing the data.

4 Findings

This study investigates how secondary mathematics TCs perceive the use of simulation technology with respect to their professional growth. Themes developed from inductive analysis included cultivating openness to students and solutions, improved rapport building skills, enhanced confidence and teacher-view.

Cultivating Openness to Students and Solutions

As TCs reflected upon the mathematics teaching simulation, every individual noted that they felt as though the experience helped them become more open-minded. TC 1 noted that the simulation taught them that as a future teacher, they need to be open-minded in regards to students beliefs, thoughts, and ideas and how those would affect students interactions with mathematics. They continued on, stating that "This experience was a good eye opener that we should be more open-minded and not judge students until we know the full story." Other preservice teachers found themselves becoming more open-minded in regards to thinking about how students learn mathematics and the types of mathematical solutions that they produce on tasks. TC 2 noted that “No students’ brain is completely the same, students are going to think of things in different ways. That is why it is important that we stay open-minded to all different types of student mathematical solutions.” This TC specifically thought about the different backgrounds that students bring into the classroom, and how this may affect their mathematical thought processes. Overall, the TCs perceived several ways in which this simulation helped them to be more open to students mathematical ways of being.

Improved Rapport-Building Skills

The mathematics TCs shared that the experience helped improved their ability to build rapport with students. Several of the TCs noted that this was because we spent a class session meeting the avatars and getting to build rapport with them. TC 1 noted that “We were better able to predict how students would react to the task, because we had time to build rapport with them. This experience helped me discover effective questions to ask students to build rapport.” TC 1 noted both the effects of building rapport with students, as well as improved abilities to build rapport with students in the future. Additionally, TC1 is a good example of the way the participants felt about the connection between building rapport and being able to anticipate students mathematical engagement and possible solution pathways. TCs also described how they might go about rapport building with students, and related those ideas back to the simulation and what they had learned by engaging with the avatars. TC 3 discussed this by stating: One thing that I would do before launching a task would be to ask each of my students how they like to learn, what causes distractions to them, and also what helps them learn? I would also ask them who they like to work with, and who they do not like to work with. Overall, the TCs perceived that the mathematics simulation helped improve their rapport-building skills and connected rapport with better anticipation of students’ mathematical thinking.

Enhanced Confidence and Teacher-View

Mathematics TCs discussed how the simulation improved their confidence in regards to future mathematics teaching opportunities. They mentioned becoming more comfortable with specific aspects of teaching as a result of engaging with the avatars during the simulation, such as, improved confidence in facilitating mathematical discussion of a task, including both selecting and sequencing student ideas, and more confidence being in front of students. TC 6 also described the idea of gaining confidence through a simulation, stating that “It was nice to be able to experience teaching in front of my peers without teaching an entire class. Also, it’s not like it’s a recording and you have to watch yourself mess up teaching in front of everyone.” TCs also noted that a benefit of the simulation was that they got to see the task from two different perspectives, first as the student and then as the teacher. When the simulation asked them to step into the role of the teacher this widened their view of the task and inspired their confidence because “we got to see the behind the scenes of it, and like, we got to choose what to pick from and why. I think that it was important to see” (TC 4). Overall, simulation helped TCs gain confidence for future teaching opportunities that they will have.

Simulation Benefits and Limitations

The TCs reiterated that since the mathematics teaching simulation didn’t involve real children it was a safe space to practice mathematics teaching. In their interview, TC 2 stated that “It was good to experience the simulation, which is a way to learn that is a no stakes sort of thing.” TC 5 elaborated on the low stakes learning environment, as they noted “I feel like being in front of students can be intimidating, but the simulation made the experience not very intimidating. The simulations made being in front of students less intimidating and lower risk. It made it a better environment to learn about teaching and lesson study." TCs also believed that the simulation provided a realistic classroom environment that represented what it would actually be like to facilitate the task in a high school mathematics classroom. TC 2 stated that "I was trying to make all of my interactions with the avatars as realistic as I possibly could. For the most part, I think the simulation was rather realistic with how students would respond to us." The realism enabled the TCs to gain practical classroom experience through the mathematics teaching simulation. TC 5 also agreed that Mursion provided a realistic simulation as they said "I think the simulation was helpful, because we did not know exactly how students would react. That made it feel realistic, like how a real student might act." Overall, the mathematics TCs indicated that simulation technology can provide a realistic and low-risk learning environment for practicing the teaching of mathematics.

5 Discussion

This study builds on previous research on simulation technology by offering a mathematics-focused perspective with secondary TCs. Earlier studies have demonstrated that simulation technology provides a realistic and low-risk learning environment (Epps et al., 2020; González-Martínez et al., 2019). The responses from the mathematics TCs in this study align with these findings, as they highlighted how the simulation realistically represented a high school classroom while offering a safe space to practice their teaching skills. Additionally, past research has shown that simulation technology enables students to develop their skills outside of practicum experiences (Epps et al., 2020). The findings of this study support that idea, as the mathematics TCs reported enhancing their rapport-building skills and gaining valuable experience in teaching mathematics that they could apply to future teaching situations. This study also reinforces previous research on teaching habits in mathematics classrooms, which has shown that presenting multiple mathematical solutions enhances discourse and student learning (Bingobali, 2011). The mathematics TCs discussed how the simulation helped them grasp this critical aspect of effective teaching. Furthermore, research on student-teacher relationships has linked strong rapport-building to increased student achievement (Olsen & Green, 2024). The findings of this study support that conclusion, as the mathematics TCs described how the simulation improved their rapport-building skills, ultimately enhancing their teaching practices.

6 Implications on Teaching Practice

This study has important implications for initial mathematics teacher preparation. The findings suggest that simulation technology can be a valuable tool in the context of mathematics teaching with TCs. Through the simulation, the secondary mathematics TCs in this study reflected on their growth in becoming more receptive to students' diverse mathematical approaches. This is crucial, as pre-service teachers need to learn how to work effectively with students who may have different ways of thinking about mathematics. The simulation intentionally provided this diversity through a range of student profiles and varied mathematical solutions to challenge the TCs. Additionally, the study showed that the TCs improved their rapport-building skills as a result of participating in the simulation. Rapport-building is a foundational component of teaching and essential for every TC to develop. By engaging with a diverse set of students, building rapport, thinking like mathematics teachers, and devising strategies to elicit students' mathematical thinking, the TCs reported increased confidence in their teaching abilities. Mathematics teacher education programs aim to provide relevant and effective teaching experiences, and simulation technology can play a crucial role in achieving that goal.

7 Limitations of this Study

This study has two main limitations that affected its methodology and results. These are sample size and the data analysis procedure used. By only interviewing six participants, there could have been a variety of other themes that were apparent throughout the class, but the findings only managed to catch a limited amount within the six participants that were interviewed. One contributing factor to sample size is that chosen TCs were selected from one course section. TCs that engaged in a LS simulation in a different course section likely had a different experience. Thus, it could have been beneficial to choose participants from multiple course sections to gauge perceptions from a wider variety of people. Time was a contributing factor to this limitation. Using a coding procedure to analyze the data could have led to the loss of broader context within participant responses. By coding a statement made by a participant, it may seem like it was intended to fit one particular code. When put back into the context of a participants response, the true meaning of what they were trying to say may have been lost or misinterpreted within the coding. This could lead to confirmation bias while analyzing the data.

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Appendix

Below are a list of the interview questions that were asked in each interview.

1. Can you tell me about your overall experience with the CarpetMart Task and the Mursion simulation? You can discuss or reflect on anything you'd like.
2. (FOR OBSERVERS) What did you look for in students while observing during the Mursion lesson? What were you watching for? (FOR TEACHER) What did you look for in students while teaching?
3. What student responses did your team successfully anticipate? What responses did your team not anticipate?
4. How has working with Mursion impacted your understanding of anticipating student responses?
5. How has working with Mursion impacted your understanding of selecting and sequencing student solutions?
6. Was this a worthwhile experience towards your professional growth? Why or why not?
7. Is there anything that wasn't a part of this experience that you wish had been a part of it? If so, what is it?