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Middle Grades Math with Ice Cream Sundaes: Connecting Math to the Real World

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Abstract: This qualitative case study presents findings related to the experiences of one preservice teacher as they attempted to create student-centered math experiences in their middle school mathematics classroom. The participant was enrolled in a graduate secondary mathematics teacher education program and was student teaching at a middle school. In this research study, I asked, "How does one preservice middle grades mathematics teacher understand ways to connect math to the real world?" The data collected included interviews, classroom artifacts, and researcher memos. The data were analyzed using thematic analysis. The findings suggested that, although the preservice teacher wanted to infuse real world experiences in their lessons, they were unsure of ways to do so; they struggled to infuse a real world context in math at the middle school level. This study draws attention to the importance of ensuring that middle grades mathematics educators receive instruction on ways to help their students make connections to the real world and thus create student-centered mathematics classrooms.

Keywords: preservice teachers; middle school mathematics teachers; real world; active learning; project-based learning

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1. Introduction

When I became an inservice middle school mathematics teacher, I began to realize how important and beneficial it was to my students to make real world connections in their math classroom. I also realized that some of the mathematical standards and practices for secondary mathematics teachers required students to be able to solve and apply math in everyday settings [1]. However, this became a challenge for me as a novice teacher because I did not know how to go about making these connections for my students. My teacher preparation program did not prepare me with these skills. Research suggests that preservice mathematics teachers have difficulty implementing real life examples in their teaching to help students gain a greater understanding of the math context [2]. Therefore, my goal for this research was to understand the experiences of a preservice middle school teacher who was learning about ways to connect math instruction to the real world in a middle school math classroom. The participant's secondary mathematics teacher preparation program required them to take a math methods course focusing on math teaching strategies. Ideally, this course was where a student could learn about different methods of instruction integrating real world context in math [3]. To help understand their experiences, I asked, "How does one preservice middle grades mathematics teacher understand ways to connect math to the real world?"

2. Conceptual Lenses on Learning

Students in the middle grades are trying to make sense of the world around them [4]. Therefore, implementing instructional strategies in a middle school math classroom in ways that help students make sense of that world by making real world connections is important. One of those strategies is active learning. Active learning is a teaching strategy

that emphasizes the processing of knowledge through students' participation in problem solving and inquiry-based learning that promotes students' thinking [5,6]. Teachers who use an active learning pedagogy engage students in critical thinking rather than basic memorization and understanding of the content [4]. Through active learning, middle grades students can learn math by problem solving inquiry-based problems and answering higher-level questions [4]. One form of active learning is project-based learning. Project-based learning is an instructional strategy aligned with active learning. Similar to active learning, project-based learning helps students think critically and develop problem-solving skills [1]. One of the ways project-based learning helps students think critically is that teachers engage students in exploring issues related to the real world [7]. By exploring issues in math that are related to the real world, students can gain a greater understanding of the math topic [8]. Middle grades teachers who use an active learning approach in their classroom also engage students in experiential learning [4] that will empower students beyond the classroom.

Project-Based Learning (PBL), rooted in active learning, is an important middle grades learning method [9]. A project-based lesson is structured in such a way that students are given a challenging problem or question related to the real world. In the PBL classroom, students can engage in inquiry learning by posing and answering meaningful questions that challenge them [9]. Through an active-learning framework, especially one that is nested in PBL, students use and learn different skills such as consistently listening, observing, researching, experimenting, and reflecting [10]. Active learning strategies such as project-based learning help teachers support their students by creating lessons that are connected to their personal interest [11]. Students then engage in inquiry and authenticity to use their voice to reflect, critique, revise, and solve the problem [11]. Studies suggest that students who engaged in project-based learning in math classrooms had significantly higher levels of achievement on standardized tests and better ability to solve conceptual problems [12].

This research was centered around the idea that integrating real-world connections in a middle school math classroom through both active learning and project-based learning is important. Integrating inquiry-based learning practices in teacher preparation programs can help support preservice teachers' transition to effective inservice teaching [8]. What follows is a discussion of the benefits of using real world context when teaching mathematics to help further inform this study.

3. Literature Review

3.1. Middle Grades Math

Middle grades students learn best when they are taught in diverse ways [9]. Teaching students through problem solving helps deepen their mathematical understanding [13]. Teachers can facilitate a deeper understanding of math through inquiry strategies and using real world problems [13]. Using real world math problems in a middle school classroom refers to math problems that contain familiar and interesting daily life contexts [14]. These might include math problems that are connected to or close to students' everyday real-life situations [14] that are relevant to them. When teachers embedded real-world connections into their math curriculum studies found a significant improvement in student collaboration, achievement, and engagement [1]. Therefore, it is important for mathematics teachers not only to have strong mathematical content knowledge [15] but also to get to know their students so that they can adapt their lessons to their interests.

Middle school is a time during which students need to engage in learning that broadens their view of the world [9]. For this reason, it is important that students are first taught math with situations connected to the real world. Once they gain comprehension of these connections, they can then be introduced to the mathematical procedures [16]. When learning math, it is important for students to see themselves in the context of the problems and the problems' relevance to their lives [17]. A positive relationship with math in the middle grades can have a lasting impact [16].

3.2. Real-World Math

Some appropriate real world math problems that can be connected to the everyday lives of middle school students are topics such as taking a trip to the grocery store or a restaurant, planning a birthday party, or going to the park [13]. Drawing real world problems from students' daily lives helps represent the diverse cultures of students and works to build on their culture knowledge [9]. Real world connections in mathematics instruction are beneficial to middle school students because it helps students not only to comprehend the context better but also to improve their ability to problem solve [18]. The Program for International Student Assessment (PISA) also suggests that mathematical real-world problems can connect to students' personal lives and occupational, scientific, and societal contexts. In this way, students can learn how mathematics can be applied to their environment [14]. When students are not able to understand how the mathematics they are learning is connected to their real-life, it can cause students to struggle with the subject and even cause them to develop a dislike for it [19]. Both struggling with a subject and disliking can lead to a lack of motivation to learn [16].

3.3. Preservice Mathematics Teacher

When mathematics teachers teach math in a meaningful way, it can have a positive impact on their students. Students are more likely to perform better and enjoy learning math, when taught mathematics by teachers who are confident and passionate. One of the ways a teacher can show their passion in the classroom is by connecting the math context to their interest and their students' interests [20]. However, preservice mathematics teachers are not taught in their teacher preparation programs how to teach mathematics in a meaningful way. The required math methods course that preservice teachers take does not provide them with opportunities to engage in inquiry-based solving tasks that they can use in their future practice [21]. Teachers are more likely to teach middle school students with inquiry-based tasks if they have experienced it themselves in math methods courses [22]. Exposing preservice mathematics teachers to inquiry-based learning strategies such as project-based learning helps them construct knowledge they can transfer to their professional growth. Additionally, preservice mathematics teachers believe that they will be able to teach effectively if they can keep their students' interest, not by being strong in their mathematical content knowledge [23].

4. Method

4.1. Participant

The participant for this qualitative case study [24] was purposely selected because the participant was a preservice secondary mathematics teacher who was currently student teaching at a middle school. Furthermore, the participant had already taken the math methods course. The participant's pronouns were they/their. They were one of the two participants from the larger study, which included a total of three participants: two preservice mathematics teachers and the professor from the math methods course. The participant was a preservice secondary mathematics teacher enrolled in a 7th–12th grade graduate teacher education preparation program at a private university located in a large, urban city in the northeast part of the United States. The participant had an undergraduate degree in mathematics. As a requirement of the program, they had taken the math methods course the previous semester, and they were currently student teaching at a middle school.

4.2. Data Collection

The participant engaged in one semi-structured interview and one focus group interview and provided two sample lesson plans. As the researcher, I wrote reflective memos after each interview. The semi-structured and focus group interviews were each conducted via Zoom. Each interview took between 30 and 40 minutes. The interviews were recorded, transcribed, and coded via a word document. The two sample lesson plans collected were also coded.

4.3. Data Analysis

To transcribe the interviews, the recordings from Zoom were used alongside Microsoft Word. I used In Vivo coding to describe the narrative of my participant [24]. Through this coding, I was able to utilize my participant's own words [24] to help give an in-depth understanding of the findings. To ensure the credibility and trustworthiness of the data [24], I performed three rounds of coding for the individual semi-structured interview and five rounds of coding for the focus group interview. Throughout each round of coding, I highlighted key phrases and sentences related to my research question. While I was coding the focus group interview, it became challenging for me to only focus on data from the middle school participant. As I coded the focus group interview, I had to make sure to focus only on what the middle school preservice teacher shared rather than on what my other participant, a high school preservice math teacher, was sharing. I decided to do two more rounds of coding to help ensure I was analyzing only data from the middle school preservice teacher.

The participant's lesson plans were coded using the same processes. As I analyzed the lesson plans, I looked for evidence of math problems that were connected to the real world and/or any project-based learning assignments. After generating codes from the interviews and lesson plans, I began to group the codes together to generate themes that would answer the research question guiding my study: "How does one preservice middle grades mathematics teacher understand ways to connect math to the real world?" Conducting multiple rounds of coding helped me narrow down my themes to three. Additionally, to help triangulate my data, I included rich description in my reflective memos detailing where the interview took place—for example, I noted the participant's body language throughout the interview as well important details that took place while conducting the interview with them (e.g., long pauses before answering a question). These details helped support the findings of this study.

5. Findings

The participant of this study provided rich information regarding their understanding of how to connect math to the real world. Following the data analysis of the individual interview, lesson plan, and focus group, three themes emerged: (1) limited exposure to methods, (2) experiences with real world math, and (3) struggles to actualize real world math in lessons, which I describe with examples from the participant's quotes.

5.1. No Real World Contexts in Education Courses

The first theme reflects the participant's understandings of what they learned in their education courses, particularly their math methods courses: They discussed how they were required to write lesson plans and create unit lesson plans. The participant explained,

> In my classes, I've had like projects I have to write a lesson plan and I've also had projects where I have to write like a unit of lesson plans and those are kind of like I would spend a long time on that because I was doing both before I actually started teaching and I think it was kind of unrealistic because I would be spending so much time on just like a one lesson, but it was new it would be like a 40 min lesson and I would be planning for weeks.

A lot of time was spent on the lesson planning process rather than on gaining exposure to PBL with real world contexts, the participant continued to explain:

> We learned a lot of visual literacy in math, he showed us a lot of things with algebra tiles um he showed us a lot of visual representations in math.

Throughout the interviews, focus groups, and lesson plan descriptions, it was clear that the ideas of real world contexts were not reflected in the math teaching strategies embedded in the math methods course. Exposure to such methods was limited throughout their teacher preparation courses. They said,

> For one of my classes, it was like teaching middle grades class we had a project to make it, like to create an interdisciplinary unit and it was project based and that was good, but I never got to like apply it and like you know have real students try it out.

The participant explained having experience creating a project-based lesson in one of their courses; however, they never had the opportunity to teach the lesson. This alludes to the gap that exists for the preservice teacher—not being able to make connections between the theory learned and their practice. Additionally, the participant shared the following during the focus group interview:

> ...like the old-fashioned teaching styles I've noticed from my cooperating teachers are only doing direct instruction and just having like a lesson displayed on like the projector and then the students just kind of take notes and answer questions and there's no like activities or there's really not even much practice either, which is not good.

This gives the understanding that the preservice teacher did not learn about PBL or real world context in their courses nor were they able to learn about it from a more experienced teacher.

5.2. No Real World Math Experiences

The lack of opportunities to practice, or implement, a PBL unit that was interdisciplinary was felt as a missed experience by the participant:

> I mean, I've never really had like a real world math experience in K-12, but I would think of maybe something that is applicable to real life like doing work with solar panels or something like that. I really haven't seen that though.

This lack of experience with the application of real world knowledge is further explained by the participant in a pointed question that asked them to try to think of specific ways that they incorporate real world, real-life experiences in their instruction. They explained,

> I'm trying to think of what ideas I have, I think the closest thing I can think of is telling them and showing them what the Math is used for with calculus. Let's say you can use that for like you know acceleration and motion and all that and I know and like in algebra one with quadratics you can use that to like answer questions about trajectory like motion flying through the air, but I don't know if I am able imagine anything like bigger and beyond that.

The participant's frank understanding of their limitations with connecting math to the real world is evident; however, they did make an effort to give examples of how to possibly make those connections in different math topics such as algebra I and calculus. The participant did not perceive any opportunity to build on or actualize these ideas. They also acknowledged that making real-life connections for students would have made the math more relevant for their students. As the participant explained,

> I think it would be more relevant for the students if they could see how the math was used in real-life and it might be something that they could relate to and so maybe they could be making those connects too.

5.3. Real World Data

The participant's lesson plans provided evidence of struggles to connect real-world math and/or PBL into their pedagogy. For example, the central focus of one lesson stated the following: "The central focus of this lesson is for students to learn how to construct a scatter plot and to apply this knowledge by graphing real world data onto a scatter plot." The "real-world" data in the lesson referred to "changes in a species population over time. The participant also created a unit objective phrased as follows: "Students will learn about

mathematical limits, which can be represented graphically. One way this knowledge can be applied to real world situations is through logistic growth of a species population." While this topic might appeal to some learners, it does not reflect the cultural experiences of students in their student teaching classroom. Additionally, there was a word problem in the lesson with a table that had data labeled "Number of Ice Cream Sundaes Purchased" and "Amount of Money Spent." The instructions of the word problem were as follows: "Mikaela owns an ice cream shop. To organize her finances, she is tracking how the number of ice cream sundaes purchased by a customer relates to the amount of money the customer spent on their order. Graph a scatter plot with Mikaela's findings." The participant also made a note of their rationale in the lesson for choosing this specific problem: "This example was chosen because ice cream is relatable to students." This problem, while attempting to perhaps build on students' experiences with ice cream, remains at a superficial level. While the preservice teacher did use in their lessons the term "real-world," and had a problem related to the real world such as buying ice cream and the actual population data of a few countries, there were no discussion of PBL and no wider context for the "real-world" nature of the math problems. Perhaps even more problematic was the absence of culturally relevant examples of math problems.

6. Discussion

The findings of this study indicate that the preservice middle school teacher had limited exposure to ways to connect math instruction to the real world in their teacher preparation courses and no experiences actualizing any of their ideas. Even in the one course, though they were required to work on a project-based learning lesson, they never had the chance to teach it in a middle school math classroom. Additionally, the preservice middle school teacher had limited opportunities to discuss ways of actualizing their ideas in a real middle grades math classroom. The preservice teacher expressed witnessing a lot of "old-fashioned" teaching styles and direct teaching during their student teaching. Their cooperating teacher did not implement activities or practice for their students. Unfortunately, they did not gain experience applying effective middle school teaching methods during student teaching.

The teacher preparation program the preservice teacher was in did not provide sufficient teaching on various mathematics teaching methods grounded in making real-world connections for students. Despite this, the analysis of one of their lesson plans did show evidence of real world context in the central focus of the lesson and in the unit lesson plan objective. The problems chosen for that lesson also involved real world topics such as ice cream and money, which can be relevant to the lives of middle school students. Nevertheless, the preservice teacher expressed not being able to explain how they would go about teaching a lesson in math connected to the real world. In spite of this, they did feel it would be beneficial to be able to connect math lessons to the real world for their students sometimes. The participant stated,

> . . . I think it would be good sometimes, but I don't think it would be something I can do all the time.

If preservice middle grades teachers are not learning and understanding ways to connect math instruction to the real world, then they are not creating the kinds of lessons that might encourage and motivate middle grades students to engage in active learning. Instead, as seen in this example, they tend to rely more on using teaching strategies that promote memorization and basic understanding. Findings suggests that, when this preservice teacher transitions to inservice, they may not be able to engage students in math problems that are explicitly relevant and related to real world issues, problems, and contexts. When students are taught through lessons that promote their inquiry, they are able to conceptualize their learning and perhaps engage in higher levels of achievement [12]. Without explicit instruction on ways to engage students in active learning inspired by real world context, new inservice teachers may struggle to implement project-based learning, to help their students develop problem-solving skills, and most importantly, to help their

students gain an understanding of how the math they are learning is relevant to their real life. Therefore, it is important that preservice middle school math teachers take courses focused on inquiry-based learning approaches.

Research suggests that, for a mathematics teacher to be effective in the classroom, they need mathematical and pedagogical content knowledge [25]. Most teacher preparation programs have indicated that preservice teachers have the mathematical and pedagogical content knowledge to teach traditional mathematics but lack the ability to teach mathematics aligned with the mathematical standards [26]. One of those mathematical standards happens to be being able to make those real-world connections in math. Studies have reported that mathematics teachers are often proficient in teaching mathematical procedures but are not able to make connections with the mathematics they are teaching [26]. For mathematics teachers to be effective, they need to have knowledge that goes beyond mathematics content knowledge [26].

Teacher preparation programs for middle school mathematics teachers are often structured to focus on mathematics courses such as algebra, statistics, number theory, and many more advanced math topics. Few courses are dedicated to focusing on mathematics education for teaching middle school math to students [26]. This study supports the literature that suggests we need more math and math methods courses focused on ways to build PBL and connect the real world to classroom concepts.

7. Conclusions

The experience of one preservice middle school mathematics teacher gives us insight into their struggles with implementing learning strategies that promote active learning through real-world problems. Preservice middle grades mathematics teachers need to learn not only about how to do the math but also about how to teach it effectively to students so that students see and understand how and why math matters to them. Teacher preparation programs can begin by looking at the mathematics education courses they are offering to determine whether they are geared toward helping middle school students understand how to apply the mathematics they are learning to real life [14]. However, this study only took place at one university and with one preservice teacher, so this is a limitation. Future research should focus on the experiences of other preservice middle grades mathematics teachers in other university contexts. It is clear, however, that preservice middle grades mathematics teachers need more support in their teacher preparation program with different teaching methods that help connect math instruction to the real world.

Teacher preparation programs need to also focus on the student teaching experiences of preservice middle grades mathematics teachers. There should be careful consideration of the school placements of preservice middle grades mathematics teachers as well as the cooperating teachers chosen to support them. Ensuring that the cooperating teachers who are selected are using teaching strategies other than direct instruction from textbooks and memorization of problem-solving methods can help the preservice teachers gain important insights and experiences, as well as firsthand knowledge of how to be creative, culturally responsive, and student centered. It is important that the cooperating teachers are well versed in their practice with significant teaching experience to be able to be models for the preservice middle grades mathematics teachers. This can help preservice middle grade teachers transfer what they are learning in their courses into the classroom. Additionally, it is important that preservice middle grades mathematics teachers receive more mentorship and observation throughout their program, especially during student teaching, so that they experience ways to connect plans to practice.

The experience and preparation of preservice middle grades mathematics teachers are important so that they do not have any disconnect in their practice. As we have seen, preservice teachers need exposure to a myriad of different effective mathematical teaching strategies for middle school students. Such exposure may help inculcate the confidence and readiness that preservice middle grades mathematics teachers need when they become inservice middle grades mathematics teachers.

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