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Anticipated and implemented questioning in mathematical discussions by prospective teachers

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Abstract
Teacher questioning is essential in facilitating high-quality mathematics discussions. This study investigated teacher questioning practices anticipated and implemented by three prospective teachers during a field-based elementary school experience. To orchestrate effective discussions, the prospective teachers anticipated questions aligned with student strategies before lessons and implemented various questioning practices during lessons. A case study examined prospective teachers' questioning patterns using an analytic framework to classify and analyze question types and distributions. The results revealed that the prospective teachers prepared diverse types of questions, some of which were effectively used in the classroom. However, there were some instances where anticipated questions were not used, and unexpected questions were posed spontaneously during lessons. By scrutinizing the anticipation and implementation of teacher questioning, this study offers insights and recommendations for developing questioning skills of prospective teachers.

Keywords: teacher questioning, anticipated questions, implemented questions, prospective teacher education

INTRODUCTION

The productive implementation of mathematical discussions supports students' understanding of mathematical concepts and principles (Franke et al., 2009; Stein et al., 2008). Engaging in high-quality interactions with teachers and peers provides students with opportunities to construct mathematical ideas (Hufferd-Ackles et al., 2004; Smith & Stein, 2018). However, not all classroom discursive practices enable students to develop a successful mathematics understanding (Sfard & Kieran, 2001). Several studies have emphasized the teacher's responsibility to elicit students' mathematical thinking through effective discourse (Baxter & Williams, 2010; Heyd-Metzuyanim et al., 2019; Hsu et al., 2023; Huffered-Ackles et al., 2004; Kamii & Warrington, 1999; Wang et al., 2023), Yet, orchestrating productive mathematical discussion is daunting and cognitively demanding for teachers (Boaler & Brodie, 2004; Smith & Stein, 2018).

Teacher-initiated questions are critical for shaping the nature of classroom discourse and engaging student participation (Ciccolini & Stylianides, 2020; Lobato et al., 2005; Purdum-Cassidy et al., 2015). By posing questions suited to students' diverse cognitive levels, teachers can gain insight into students' thinking and guide discussion accordingly. Since questioning is one of the most frequently used teaching practices (Moyer & Milewicz, 2002), developing effective questioning strategies is essential for teachers. However, it is important to note that questioning skills do not develop naturally with teaching experience (Franke et al., 2009; Morales-López et al., 2023). Employing effective and meaningful questions remains one of the most challenging practices, not only for prospective and novice teachers but also for experienced ones (Ju, 2008; Purdum-Cassidy et al., 2015; Recai & Brian, 2010). Research indicates that teachers often struggle to ask effective questions and to determine the timing and relevance of questions during lessons (Gaspard & Gainsburg, 2020; Hiebert & Wearne, 1993). Teachers need to promptly adjust their questions to reflect students' current understanding and mathematical goals, ensuring these questions are relevant in interactions with students (Ong et al., 2010; Purdum-Cassidy et al., 2015).

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Contribution to the literature

- This study establishes a foundation for theoretical development by systematically reviewing previous research on prospective teachers' questioning in mathematics teaching.
- For an in-depth understanding of prospective teachers' questioning practices, this study employs qualitative analysis to scrutinize anticipated and implemented questions by prospective teachers.
- This study provides suggestions for prospective teachers to develop questioning practices.

Anticipating questions that a teacher might ask before lessons can help teachers as it can make discourse more manageable and guide students toward mathematical ideas. As Walsh and Sattes (2011) highlighted, quality questions are challenging to generate spontaneously during instruction, thus, preparing questions in advance enables teachers to engage in timely and effective questioning. By anticipating questions based on possible student responses, teachers gain a deeper understanding of students' thinking, reducing the demands of on-the-spot decision-making during lessons. Smith and Stein (2018) also emphasized that when teachers ask questions they've anticipated before the lesson, it allows students to build on their own thinking without directly telling those who are struggling what to do. Given that prospective teachers have limited experience in teaching mathematics, anticipating questions based on students' thinking can be an effective instructional strategy, providing valuable guidance for questioning practices during lessons.

Effective questioning extends beyond preparing a list of question types. It also requires skill in responding with appropriate, well-matched questions to student answers (Wilen & Clegg, 1986). While teachers may know about different types of questions, including higher-order ones that deepen students' thinking, they may still struggle to ask these questions effectively in actual mathematics lessons, instead relying on lower-order questions that require short, factual responses (Hiebert & Wearne, 1993). Studies reported that prospective teachers revealed concerns that they tended to ask too many yes/no or closed, convergent questions, despite recognizing a wide range of question types (Henning & Lockhart, 2003; Moyer & Milewicz, 2002; Purdum-Cassidy et al., 2015).

Given that few studies have explored the questioning ability of prospective teachers, this study aimed to investigate the mathematical questions anticipated and implemented by prospective teachers during lessons with elementary school students. Accordingly, the current study focused on how prospective teachers anticipated teacher questions before lessons and how these anticipated questions contributed to the implementation of the lessons. It further investigated the possibilities and challenges prospective teachers faced in anticipating and implementing questions. By doing so, this study contributes to the comprehension of prospective teachers' questioning skills and the importance of teacher's questioning practices for orchestrating productive mathematics discussions.

BACKGROUND LITERATURE

Teacher Questioning

Teacher questioning is essential for fostering productive mathematical discussions. National Council of Teachers of Mathematics (NCTM, 2014) highlights the significance of teachers' skill in asking effective questions, which stimulates classroom discourse in mathematics. Such questioning serves various purposes, including helping teachers gauge students' understanding and adapting lessons accordingly. As Martino and Maher (1999) noted, well-timed questions "act as a catalyst, providing the stimulus for further student thinking" (p. 28). Additionally, questions can guide students' attention (Mason, 2002), encourage their active participation, and prompt careful listening.

Not all teacher questioning, however, positively impacts mathematical discussions or student learning. Some questions may disrupt certain students or even have negative effects (Mason, 2002). Effective questions should encourage students to advance their thinking and construct meaning, rather than simply prompting the recall of trivial facts (Kammi & Warrington, 1999; Moyer & Milewicz, 2002). Mason (2020) differentiated between "asking as telling" and "asking as enquiring" (p. 707). "Telling" questions lead students to guess what the teacher wants to hear, whereas "enquiring" questions invite them to articulate their thoughts. Given that teachers tend to use more "telling" than "enquiring" questions (Graesser & Person, 1994), intentional efforts are necessary to enhance questioning techniques in the classroom.

Teacher Question Types

Along with the importance of teachers' questioning during mathematical discussions, it has been demonstrated that various types and levels of questions can offer guidelines for understanding and expanding students' mathematical thinking (Lim et al., 2020). However, asking more questions does not warrant high-order engagement in mathematical thinking (Dahal et al., 2019). Purposeful questioning can enhance the effectiveness of mathematics teaching (NCTM, 2014), and therefore, careful consideration of the intent behind questions is essential for improving their quality (Manouchehri & Lapp, 2003).

For decades, research on teacher questioning has documented a variety of question types (e.g., Boaler & Brodie, 2004; Franke et al., 2009; Herbel-Eisenmann & Breyfogle, 2005; Heyd-Metzuyanim et al., 2019; Lim et al., 2020; Purdum-Cassidy et al., 2015; Sahin & Kulm, 2008; Smith & Stein, 2018). For instance, Smith and Stein (2018) classified questions into two main categories: assessing questions, designed to understand students' thinking, and advancing questions, aimed at guiding students toward lesson objectives. Similarly, Sahin and Kulm (2008) identified three types of questions: probing questions, which require clarification and justification of student strategies; guiding questions, which prompt the next step in solving a problem, particularly when students are stuck; and factual questions, which ask for specific information or definitions.

Some studies have explored teachers' questioning within mathematical discussion contexts (e.g., Dong et al., 2017; Lim et al., 2020; O'Connor & Michaels, 2019). Boaler and Brodie (2004) developed a coding system after observing various teaching examples, categorizing teacher questions into nine types: gathering information, introducing terminology, exploring mathematical meanings, probing students' reasoning, generating discussion, linking and applying concepts, extending thinking, orienting and focusing, and establishing context. O'Connor and Michaels (2019) further categorized teacher questions that promote accountability and student engagement in mathematical discussions, identifying four types of teacher-talk moves: encouraging contributions, fostering attentive listening, probing deeper reasoning, and facilitating collaboration.

Given the objective of this study to examine prospective teachers' questioning strategies, an analytical framework was developed based on prior research on teacher questioning. This study focuses on how prospective teachers use their questions to both assess students' current understanding and enhance their comprehension before and during mathematics lessons.

Prospective Teachers' Questioning in Mathematics Instruction

Previous studies have explored prospective teachers' questioning strategies by analyzing their interactions in mathematics lessons or during interviews with students (Bennett, 2013; Gaspard & Gainsburg, 2020; Henning & Lockhart, 2003; Moyer & Milewicz, 2002; Nilssen et al., 1995). These studies consistently indicated that prospective teachers faced challenges in posing appropriate questions to students. Analyses of teachers' questions in whole-class discussions revealed that prospective teachers often focused their questions on eliciting factual information from students (Bennett, 2013). Blanton et al. (2001) also noted that prospective teachers tended to rely on questions that prompt students to perform simple computations or recall information. According to Moyer and Milewicz (2002), some prospective teachers struggled to fully engage with student responses, resulting in a lack of suitable follow-up questions that adapt to students' thinking.

However, prospective teachers have also demonstrated a degree of diversity in their questioning techniques, particularly during one-on-one student interviews or classroom instruction. In their investigation of questioning strategies by 48 prospective teachers during diagnostic mathematics interviews with elementary students, Moyer and Milewicz (2002) identified three main strategies: check-listing, instructing rather than assessing, and probing with follow-up. While prospective teachers often employ check-listing techniques, some also exhibit utilization of competent questions.

It has also been studied that prospective teachers' questioning skills can vary depending on several factors. Some studies have demonstrated that prospective teachers questioning skills can be improved (Ju, 2008; Purdum-Cassidy et al., 2015). For example, Ju (2008) found that, within a collaborative inquiry community, prospective teachers increased their use of questions requiring student justification, compared to questions focused on simple facts or definitions. Conversely, other studies have observed declines in questioning skills over time (Gaspard & Gainsburg, 2020; Nilssen et al., 1995). Gaspard and Gainsburg (2020) investigated the questioning strategies of prospective mathematics teachers during a 10-week student teaching experience. At first, teachers valued open-ended questions that encouraged explanation and reasoning; however, as they encountered unexpected student responses, they began asking fewer questions overall, with a noticeable decline in unpredictable ones.

Taken together, prospective teachers engage in questioning practices during mathematics lessons while navigating challenges and adjusting their questioning strategies based on lesson contexts and student responses. Building on this background, the current study aims to examine how prospective teachers anticipate questions before lessons and implement questioning strategies during instruction to foster mathematical discussions.

METHOD

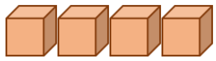
Participants and Setting

This study was conducted as part of an elementary teacher preparation program at a university in Korea. In the previous semester of their junior year, the prospective teachers completed a one-week field

Table 1. Main activities and exploration focus

Main activity	Exploration focus	Period
Exploring questioning practices theoretically	Understanding the practice of questioning	Six weeks (before student-teaching internship)
	Comprehending different types of questions and their examples	
Anticipating teacher's questions	Anticipating questions the teacher might ask based on students' strategies before implementing a mathematics lesson	
	Planning when to ask questions and what questions to ask	
Implementing teacher's questions	Understanding students' strategies and posing appropriate questions during the lesson	Four weeks (during the internship)
Reflecting questioning practices	Assessing the anticipated questions in terms of their effectiveness during the lessons	Four weeks
	Identifying teacher questions that were not asked but could have been helpful for students	

Table 2. Information about the mathematics lessons

PT	Grade	Topic	Goal	Mathematical task
PT1	1	Subtract a whole number from 10	Students can perform subtraction using basic facts instead of subtracting by one each time.	If four are taken away from 10, how many are left?
PT2	4	Calculate fractional part of a whole	Students can understand the procedures for calculating fractional parts of discrete quantities.	If I get 4/9 of 27 marbles, how many marbles will I have?
PT3	6	Make figures using wooden blocks	Students can explore different ways to create figures using 4 wooden blocks.	Make as many different figures as possible using 4 wooden blocks with the AlgeoMath program. 

experience, during which they observed lessons taught by expert teachers. In the current semester, 37 prospective elementary teachers participated in a 15-week course on elementary mathematics education methodology. As part of this course, the prospective teachers completed a 4-week student-teaching internship at elementary schools. During the internship, they spent the entire day at their assigned schools, planning and teaching classes. Lessons were typically conducted by prospective teachers independently, with minimal assistance or intervention from their cooperating teachers. In this study, the focus was on analyzing mathematics lessons by prospective teachers during this internship.

To enhance the professional competence of prospective teachers in mathematics instruction, the methodology course required them to study theories related to elementary mathematics education. Emphasis was placed on the importance of teacher questioning and related strategies as essential teaching skills. Throughout the sessions, prospective teachers worked collaboratively with peers to anticipate teacher questions, guided and coached by the instructor. This practice continued weekly for six weeks. Following this period, the prospective teachers participated in a four-week student-teaching internship, which they had the opportunity to apply questioning practices in real mathematics lessons with elementary students. After completing their field experience, they reflected on and analyzed their teaching practices, with a focus on their use of questioning strategies. **Table 1** provides a summary of the main activities and focus of exploration.

Of the 37 prospective teachers enrolled in the course, three (PT1, PT2, and PT3) were selected for closer analysis in this case study due to their strong understanding of the questioning process and their efforts to integrate these techniques into their mathematics lessons during the student-teaching experience.

Research Design and Data Collection

A case study was conducted to investigate the detailed characteristics of prospective teachers' questioning. According to Cousin (2005), a case study can be used "to explore and depict a setting, and to advance understanding" (p. 421). Therefore, this methodology was chosen to examine how prospective teachers anticipated and implemented questioning during mathematics discussions in their student-teaching experience. Each prospective teacher's planning and implementation of mathematics lessons was treated as a single case.

Table 2 provides information on the grade level, topic, goals, and mathematical tasks for each prospective teacher. Generally, prospective teachers set their lesson goals and tasks based on students' interests and the cognitive demands of the tasks, rather than strictly following the goals and tasks outlined in the mathematics textbooks. For example, for the topic "subtract a whole number from 10," the goal in the textbook was "students will be able to subtract a whole number from 10 and express it as a subtraction equation." However, PT1 newly set the goal as "students

Table 3. Analytic framework for types of teacher questions

Type	Description	Example
FQ	Questions to elicit previously learned knowledge or information related to a task	What is the fraction? What are the unknowns?
GQ	Questions to focus on key elements of a task, especially when a student is off the right track	Do you remember how we solved 1/4 of 8 last time? Is there enough information to solve the problem?
PQ	Questions to describe, elaborate, or justify strategies	How did you solve this problem? Why did you divide the number by 9?
EQ	Questions to apply or extend ideas being discussed to different situations	Will this pattern work for five blocks? Does this method work for other fraction problems?
CQ	Questions to connect with other mathematical ideas or students' strategies	Do you see a pattern in this task? Compare the strategies to each other.
TQ	Questions to check students' understanding or to monitor their problem-solving processes	Can you understand what the problem is asking? Check your answer. Is it correct?

Note. FQ: Factual Question; GQ: Guiding Question; PQ: Probing Question; EQ: Extending Question; CQ: Connecting Question; TQ: Tracking Question

can perform subtraction using basic facts instead of subtracting by one each time."

For each prospective teacher, three types of data were collected: reports on lesson planning, implementation, and reflection; video-recorded lessons with verbatim transcripts; and teaching materials and copies of student worksheets. The reports written by each prospective teacher included detailed descriptions of their lesson planning, implementation, and reflection, as well as an analysis of the lesson by the individual prospective teacher, along with feedback from the instructor and peers. Each video and transcript provided insights into the implemented lessons, showcasing the overall lesson flow, teacher-student interactions, and student participation.

Data Analysis

This study examined how prospective teachers anticipated and implemented questioning practices during the lesson phases of launching a mathematical task, students' exploration of the task, and related discussion and summarization. Questions unrelated to mathematical tasks, such as those about students' personal lives or attention, were excluded from the analysis. Additionally, not all statements in the form of a question were considered teacher questions; only those aimed at eliciting student responses related to mathematical content were counted as questions.

To examine the types of teacher questioning, previous research on analyzing teacher question types–particularly Boaler and Brodie (2004), Sahin and Kulm (2008), and Smith and Stein (2018)–informed the development of a coding system. Some categories of teacher questions were adopted from these studies, while others were revised to reflect the specific characteristics of the prospective teachers' questioning practices in this study. An initial framework was developed based on relevant research, and subsequent analyses of the data led to adjustments and alignment of the subcategories in the framework. Table 3 presents the analytic framework used for coding teacher questions, along with descriptions and examples drawn from the lessons in this study.

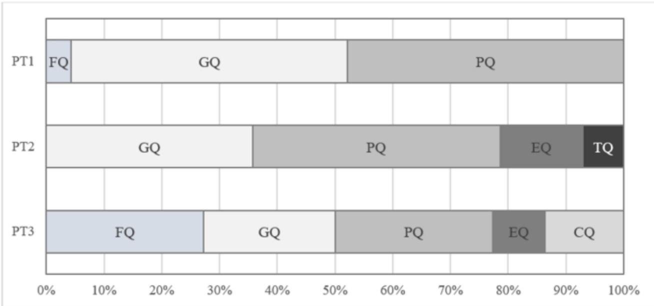


Figure 1. Distribution of the types and proportions of anticipated questions (Source: Author's own elaboration)

To analyze the distribution of question types and better understand the prospective teachers' questioning practices, one lesson was selected for detailed examination. Three coders, including the author, independently coded the types of questions asked by prospective teachers to ensure reliability. Consistency was achieved through discussions and comparisons among the coders, and the codes were finalized once a consensus was reached. Additionally, a qualitative comparison between the anticipated and implemented questions was conducted (see Appendix A for an example), allowing for an analysis of how anticipated questions were utilized, why some were not included in the lessons, and which unanticipated questions were implemented. Nvivo 12, a qualitative data analysis software, was used to code the teachers' questions, categorize the various types, and gain insight into the flow of questioning throughout the lessons.

RESULTS

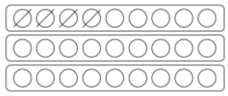
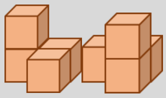
Characteristics of Anticipating Questions by Prospective Teachers

Figure 1 shows the distribution of questions anticipated by prospective teachers at the lesson design

Table 4. Examples of anticipated student strategies and corresponding teacher questions by PT1

Strategy	Description	Teacher question [Question type]
Subtracting 4 from 10 one by one using fingers	Stretch out ten fingers and fold one finger at a time, repeating this four times and confirming that the answer is 6, as six fingers remain.	How many fingers did you fold? [Factual] Why did you fold your fingers one by one instead of all at once? [Probing]
Representing only the result of 10-4, without the process	Draw a bar and label it as 6.	What does the bar mean? [Factual] How can you represent subtracting 4 from 10 in your diagram? [Guiding]

Table 5. Examples of student's incorrect strategies and corresponding teacher questions

Strategy (PT)	Anticipated student's strategy	Teacher question [Question type]
Misinterpreting the numerator and denominator of the fraction (PT2)	 Forming a bundle of nine and crossing four with diagonal lines.	What does fraction $\frac{1}{9}$ mean? [Factual] Can you remember how you figured out $\frac{1}{4}$ of 8? [Guiding]
Failing to correctly recognize the figures after rotation (PT3)	 Recognizing both figures as identical	What shape would be formed if you rotated the left shape by 180 degrees? [Guiding] Compare the two shapes based on the wooden block on the second floor. [Guiding]

stage. The prospective teachers anticipated three to five types of questions, commonly GQs and PQs. Following are characteristics of the prospective teachers' practices of anticipating questions.

First, the prospective teachers anticipated questions not only to assess students' thinking but also to guide them toward the lesson's goals. **Table 4** provides examples of questions anticipated by PT1 based on expected student strategies. The question types presented in [ ] were added by the author. PT1's questions, such as "How many fingers did you fold?" and "What does the bar mean?" were designed to prompt students to explain their strategies. Additionally, follow-up questions were planned to help students progress toward the lesson's mathematical objectives. For instance, the question, "Can you fold all four of your fingers at once?" was intended to lead students to subtract 4 from 10 simultaneously by decomposing 10 into 4 and 6. In this way, the prospective teachers prepared specific student responses and teacher questions to support progress toward the mathematical goals.

Second, the prospective teachers anticipated questions for students who were expected to encounter difficulties or make mistakes. PT2 foresaw that some students might struggle to grasp the meaning of $\frac{4}{9}$ of 27, as they were not familiar with discrete quantities in fraction problems, and 27 can be a relatively large number for them. Therefore, anticipating that students might incorrectly approach the task as outlined in **Table 5**, PT2 prepared teacher questions aimed at guiding students to refocus on the task's essential aspects or prompting them to recall previously learned ideas. PT3 also anticipated students' incorrect strategies and prepared corresponding teacher responses, such as "What shape would be formed if you rotated the left shape by 180 degrees?" or "Compare the two shapes based on the wooden block on the second floor." This illustrates the prospective teachers' intention to employ teachers' questions for students to identify their misconceptions or errors and move forward to mathematical ideas, rather than simply pointing out their mistakes or directly explaining ideas.

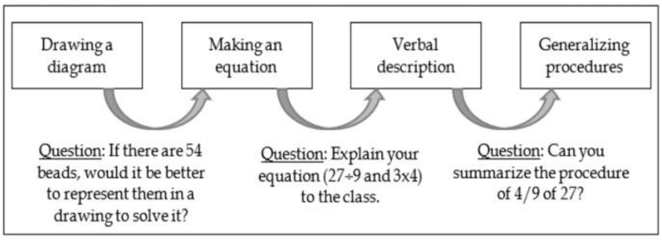


Figure 2. PT2's lesson plan about sequencing students' strategies and teacher's key questions (Source: Author's own elaboration)

Finally, the prospective teachers anticipated the sequence of teacher questions for whole-class discussions during the planning stage. **Figure 2** shows part of PT2's lesson plan, outlining the anticipated strategies and the key questions that a teacher will ask accordingly. PT2 aimed to progress from specific strategies to generalization through purposeful questioning by a teacher. For instance, the question about using a drawing to solve the problem involving 54 beads was designed to prompt students to recognize the inefficiency of the drawing method and to consider more efficient strategies. By sequencing the series of questions, PT2 intended to encourage students to explore efficient strategies independently and to generalize calculation principles.

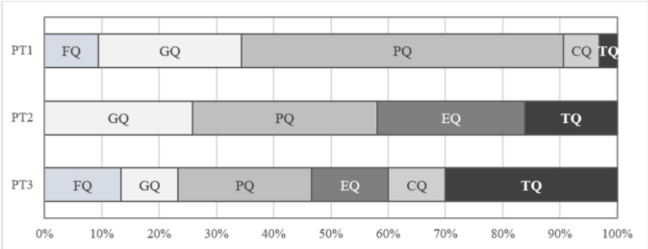


Figure 3. Distribution of the types and proportions of implemented questions (Source: Author's own elaboration)

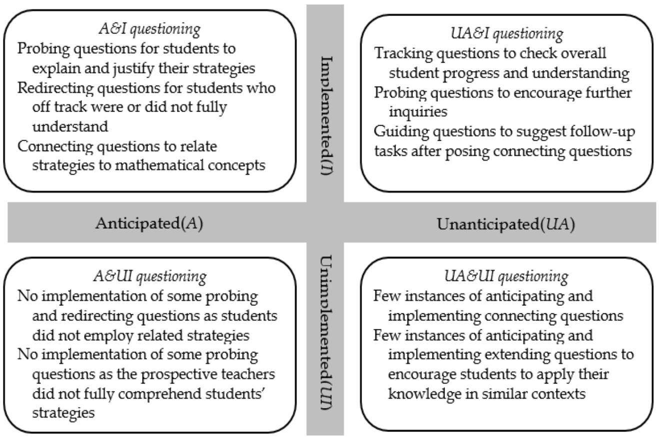


Figure 4. Four quadrants of teacher questioning practices (Source: Author's own elaboration)

Characteristics of Implementing Questions by Prospective Teachers

Figure 3 illustrates the distribution of question types implemented by prospective teachers, revealing a wider range than initially anticipated ones. The findings indicate that all prospective teachers frequently used questions to prompt strategy explanations (PQ), redirect responses (GQ), and assess the student's understanding (TQ). Some prospective teachers employed questions to elicit prior knowledge (FQ), expand student ideas (EQ), and foster connections between mathematical concepts (CQ).

In examining questions teachers posed compared to those they had anticipated, we categorized these questions based on whether they were anticipated and whether they were implemented. For instance, the prospective teachers sometimes used questions they had anticipated in the actual lessons, but they also created and posed spontaneous questions they had not anticipated. In this study, as shown in **Figure 4**, teachers' questioning practices were classified into four quadrants to highlight the diverse aspects of questioning practices. To provide deeper insight into these practices within lesson contexts, the study presents key episodes from each of the four categories.

First, within the category of anticipated and implemented questions, certain questions effectively promoted students' understanding and problem-solving. For instance, while monitoring student work, PT2 noticed that one student was struggling to figure out what $\frac{4}{9}$ out of 27 means. PT2 used questions anticipated before the lesson to help address the student's difficulties and steered them toward a correct approach to the problem. The following is the interaction between PT2 and a student, including the types of questions posed by the PT2 in square brackets.

> PT2: How did you solve the task? [Probing]
>
> S: I bundled 27 into 3 sets of 9 each (presenting the diagram that the student drew). What should I do next?
>
> PT2: To get 4/9 of 27, firstly, divide 27 into 9 groups. Do you think that you can get 9 groups if each group contains 9? [Guiding]
>
> S: No ...?
>
> PT2: To divide 27 into 9 groups, how many will be in each group? [Guiding]
>
> S: Um ...
>
> PT2: I see. Then, how about this? If there are 8 marbles, how many marbles are 1/4 of 8? [Guiding]
>
> S: 2? As 4 multiplied 2 makes 8.
>
> PT2: Now, can you figure out how to calculate 1/9 of 27? [Probing]

In the interaction above, PT2 initially guided the student to focus on the meaning of finding $\frac{1}{9}$ of 27. However, when the student struggled to understand and respond to the teacher's question, PT2 adjusted the task by changing the numbers 27 to 8 and $\frac{4}{9}$ to $\frac{1}{9}$ to simplify the meaning. By posing the questions that had been anticipated in advance, the students understood that 27 needed to be divided by the value of the denominator of the fraction, enabling them to proceed with the initial task. Reflecting on their questioning practices, PT2 stated, "With limited time to monitor students' strategies, preparing questions in advance made it easier to support students with anticipated challenges. Through this process, I felt a sense of accomplishment."

Second, in the category of unanticipated but implemented questions, the prospective teachers spontaneously asked questions during lessons to gauge students' understanding, invite further comments, or guide them in approaching tasks. For instance, PT2 selected a student who had developed a unique strategy but was hesitant to present it to the class. To share the student's strategy with the whole class, PT2 obtained the student's permission to share the strategy on their behalf, then posed questions such as, "Who would like to re-explain this strategy?" and "Do you all agree with this?" Although the student who created the strategy did not present it, PT2's spontaneous questioning allowed the strategy to be shared with the entire class and encouraged additional responses from other students.

Third, regarding the anticipated but not implemented questions category, the prospective teachers were unable to use certain anticipated questions in class as students did not display the expected reactions. For example, PT3 had prepared questions like, "What patterns would you find?" and "Could you find another pattern?", expecting students to create figures with specific patterns in mind. However, contrary to PT3's anticipation, students found the activity challenging and often created figures without following the intended rules, thus preventing PT3 from using these questions.

Furthermore, the prospective teachers missed opportunities to employ anticipated questions because they struggled to fully understand students' responses. For instance, in PT3's lesson, some students argued that two distinct figures were identical because they faced each other, referring to this as "mirror mode." Although PT3 had anticipated this misunderstanding and prepared appropriate responses in advance (see **Table 4**), PT3 was unable to ask the prepared questions due to difficulty in grasping the students' terminology and reasoning. Consequently, PT3 resorted to direct explanations to correct the students' mistakes. In PT3's reflection report, PT3 expressed disappointment in being unable to respond effectively to the expected misunderstanding during the lesson.

Finally, certain types of questions, such as those involving requests or connections to mathematical ideas, turned out to be neither anticipated nor implemented. The following example illustrates how PT1 generated questions during the lesson in response to unexpected student reactions.

PT1: How did you solve the task? [Probing]

S1: I solved it with my thoughts. I thought that subtracting 4 from 10 gave 6, because adding 4 to 6 makes 10, and adding 6 to 4 also makes 10.

PT1: S1 explained that subtracting 4 from 10 resulted in 6 because adding 4 to 6 makes 10. Does that make sense to everyone? [Tracking]

S2: What's the relevance of that?

PT1: Shall we take a closer look at what this means? What do you get when you add 4 to 6? [Factual]

Ss: Ten.

PT1: That's a composition of 10. It seemed like S1 was discussing the composition of 10. Now, if we think about it the other way around, we could consider the decomposition of 10, right? How would you decompose 10 into 6 and what other number? [Factual]

Ss: Four.

Although S1 shared a strategy demonstrating the relationship between addition and subtraction, PT1 was unable to further explore the mathematical ideas within the student's strategy. Instead, PT1 relied on explanations and FQs, to which students responded with only closed and convergent answers. Consequently, while students answered PT1's questions, it remained uncertain whether they truly understood the underlying mathematical concepts. Anticipating and implementing CQs, such as "Why is subtracting 4 from 10 related to adding 4 to 6 to make 10?" could have enhanced the teacher's questioning practices and supported the students' understanding.

Examining questions in this category does not imply that prospective teachers should anticipate and use every question type. Instead, teachers' awareness and thoughtful application of diverse questions can more effectively facilitate mathematical discussions. In this study, the prospective teachers primarily used questions for probing, inviting, and redirecting during whole-class discussions. While this approach may have helped prospective teachers understand students' various strategies, incorporating other question types, such as reflecting or connecting, could have elevated the discussion beyond simply sharing strategies, allowing students to connect mathematical ideas more deeply.

DISCUSSION

This study demonstrates that anticipating and implementing questions positively impacts both the professional development of prospective teachers and student learning. The results indicated that the prospective teachers anticipated a variety of student strategies and prepared appropriate questions accordingly. Notably, they developed questions in advance to support students who might encounter difficulties in understanding or solving a task during lessons. Given that the prospective teachers in this study had prior training in questioning practices before their student-teaching experience, such preparation likely developed their competence to employ effective questioning strategies. This aligns with Moyer and Milewicz (2002) assertion that "different types of questions are more appropriate for different mathematical situations" (p. 310), suggesting that incorporating a variety of questions could enhance students' understanding. On the other hand, certain questions also revealed gaps in the prospective teachers' understanding of both mathematics and student thinking. Given the documented challenges prospective teachers face with questioning practices (Henning & Lockhart, 2003; Purdum-Cassidy et al., 2015; Wilen, 2001), it is essential to provide opportunities for them to develop and refine their questioning skills.

Additionally, the results revealed that the practice of posing questions during mathematics lessons differs from simply anticipating questions beforehand. In this study, the prospective teachers used both anticipated and unanticipated questions, enabling students to engage in mathematical discussions aligned with lesson goals. Yet, some questions did not foster meaningful interactions between teachers and students. For example, when students struggled to figure out probing or expanding questions, and did not provide the anticipated responses, the prospective teachers modified their approach, asking simpler and step-by-step questions, or providing direct explanations of key mathematical ideas without further questioning.

This finding supports Mason's (2020) assertion that "when students get stuck in solving tasks, it is a natural tendency for teachers to simplify the questions so that their students can succeed" (p. 706). Similarly, Moyer and Milewicz (2002) found that some pre-service teachers prioritized instruction over assessing students' mathematical knowledge, often resorting to guiding questions or abandoning questioning altogether. Since the purpose of questioning in mathematical discussions is to explore mathematical concepts and deepen students' reasoning (Ciccolini & Stylianides, 2020; Hufferd-Ackles et al., 2004; Labato et al., 2005), some of the questions observed in this study may not effectively foster students' conceptual understanding of mathematics and result in limited insight into students' understanding.

As Lim et al. (2020) stated, "teachers facilitate the discussion using student mathematical thinking as the seed of discourse" (p. 393), emphasizing that teacher questioning should prioritize student thinking (Weiland et al., 2014). Given the prospective teachers' limited experience with students and their evolving content knowledge, engaging in a learning community can allow prospective teachers to reflect on their questioning practices through collaborative inquiries (Ju, 2008). Additionally, conducting mathematics interviews with students offers prospective teachers valuable experiences, enabling them to observe students' strategies, interpret their understanding, and decide how to respond in real-time (Kabar & Taşdan, 2020; Moyer & Milewicz, 2002). Weiland et al. (2014) suggested that experiential field opportunities for prospective teachers support the development of questioning as a core instructional practice. Therefore, intensive efforts need to be made to enhance the professional development of questioning practices among prospective teachers in actual mathematics lessons for elementary school students.

CONCLUSIONS

Recognizing the importance of teacher questioning in facilitating mathematical discussions, this study explored how three prospective teachers anticipated and implemented questioning practices during their field-based teaching experiences. The findings revealed that while the prospective teachers were able to anticipate and use various types of questions to elicit students' thinking and guide them toward lesson objectives, some anticipated questions were not aligned with the student's cognitive levels. Additionally, unanticipated situations hindered the prospective teachers from formulating appropriate questions. This underscores teachers' knowledge of mathematics and their understanding of students are essential for effective questioning practices and professional growth.

Given that focusing on the entire questioning process–from anticipation to implementation and reflection–could enhance teachers' awareness of their questioning practices, further research on prospective teachers' questioning strategies across diverse contexts could provide deeper insights into their competencies and challenges. Additionally, comparing questioning practices between prospective and experienced teachers could offer valuable insights for improving questioning skills in teacher preparation programs.

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Declaration of interest: No conflict of interest is declared by the author.

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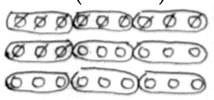
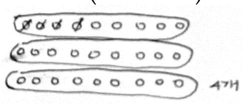
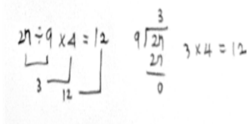
APPENDIX A

Table A1. Example of questioning practices anticipated and implemented by PT2

Anticipated			Implemented		
Student strategy	Teacher question *[Question type]*	I/UI	Student strategy	Teacher question *[Question type]*	A/UA
Picture (correct) 	Why did you group 27 into bundles of 3? [*Probing*]	I	Picture (correct) 	Can you explain how you solved the task? [*Probing*]	UA
	Figure out how many marbles are $\frac{4}{9}$ of 54 by drawing a picture. [*Extending*]	I		What does grouping 27 circles into 9 sets represent? [*Probing*] (Writing 5/9 of 54 on the board)	UA
				How can we represent this with a drawing? [*Extending*]	A
Picture (incorrect) 	Why did you group 27 into bundles of 9? [*Probing*]	I	Picture (incorrect) *I grouped 27 into sets of 9, resulting in 3 sets (showing a drawing of this). What should I do next?*	If you divide 27 into 9 sets, will each set contain 9 items? [*Guiding*]	A
	When there are 8 marbles, how do you calculate $\frac{1}{4}$ of 8? How many marbles are in each bundle? [*Guiding*]	I		If you have 8 marbles and want to figure out 1/4 of 8, how many items should be in each group? [*Guiding*]	A
				If you divide 27 into 9 groups, how many items should be in each group? [*Guiding*]	A
Equation (correct) 	Why did you divide 27 by 9? [*Probing*]	UI	Equation (correct) $27 \div 9 = 3$, $3 \times 4 = 12$ *I divided 27 by 9 and then multiplied by 4, which resulted in 12.*	How would you explain this solution to your friends? [*Probing*]	UA
	Why did you multiply by 4 afterward? [*Probing*]	UI		Why did you choose to divide by 9? [*Probing*]	A
	Explain your equation in a way that the class can easily understand. [*Probing*]	UI		If you have four parts of 1/9, does that equal 4/9? [*Factual*]	UA

Note. I: Implemented; UI: Unimplemented; A: Anticipated; and UA: Unanticipated