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An Investigation of Elementary Mathematics Teachers' Questioning Skills

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Cover Page Footnote

These research results provide important findings. It is a research that will contribute to the field. It is important to investigate the questioning skills of mathematics teachers in the classroom. these research findings reveal these skills.

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Abstract

This study aims to investigate elementary school mathematics teachers' (teaching grades 5–8) questioning skills in class. It also includes observation of the questioning skills of two elementary school mathematics teachers teaching eighth grade. This mixed-methods research study follows an explanatory sequential design. Initially, quantitative data were collected from 265 elementary school mathematics teachers through a questioning survey developed by the researchers. Qualitative data were obtained by observing two teachers who answered this survey and were easily accessible to the researchers for six weeks. One of the researchers was in the role of participant-observer in this observation process, and both teachers were observed for six weeks. Findings from the survey show that mathematics teachers' in-class questioning skills are at a good level. However, the observation results yielded findings that contradicted the survey results. The survey findings indicate that the item on teachers' use of open questions had a higher mean value than the items on closed-ended, rhetorical, and managerial questions; however, the observations showed that teachers used these types of questions more frequently than open questions. Again, while the survey results yielded higher means for teachers' use of real-life and metacognitive questions, these question types were not frequent in the observation findings. The survey also demonstrated longer teacher wait time, also inconsistent with the observational data that showed shorter wait time. Teachers reported high values for in-class discussions on the surveys, yet the observations included very few instances of students participating in these discussions. The findings of the study are discussed with references to the existing literature.

Keywords: Elementary mathematics teachers, questioning skills, mixed research

Introduction

Teacher's questioning in class is defined as instructional clues or stimuli that help convey the content to students to learn and also carry the instructions as to what students can do with the content and how to do it. Questioning is a fundamental element of effective teaching (Hannel, 2009). Teachers ask questions to develop students' interest and motivate them to engage actively in lessons, evaluate students' readiness levels, develop critical thinking and an inquiry approach, review and summarize previous lessons, reveal new relationships about the topic, assess the achievement of instructional goals and objectives, and encourage students to acquire knowledge by themselves (Cotton, 1988). Therefore, both the teachers and the students benefit from teacher questions designed to address these objectives as the students thereby acquire the skills necessary for linking to previous learning and understanding the world around them. The nature of these questions is vital for learning because higher-order questioning requires the students to explore the phenomenon in question more by practice, analysis, evaluation, and synthesis, while lower-order questioning only requires collecting and recalling information. Lower-order questions are easier for teachers, but they do not encourage students' higher-order thinking (Tienken et al., 2010).

When considered in the context of mathematics lessons, it is evident that the types of knowledge built in mathematics lessons may depend on the teacher's questions (Moyer & Milewicz, 2002). The students tend to focus too much on finding the "correct answer" while working on mathematical tasks, so they might fail to step back and see the bigger ideas behind the tasks. It is the teacher's responsibility to bring forward the idea that getting the correct answer is not sufficient by itself and that it is more important to examine the mathematical structure and the ideas behind the tasks (Ng et al., 2011). Therefore, investigating the qualities of questions mathematics teachers use becomes a topic of utmost importance.

Most dialog between the teacher and the students consists of questions and answers (Nappi, 2017). Research on the in-class questioning process of teachers shows that teachers spend about 80% of a school day asking questions (Leven & Long, 1981). The nature and purpose of these questions are quite important; for this reason, the questions used by teachers have been classified in various ways (e.g., Blosser, 2000; Frey & Fisher, 2014; Fusco, 2012; Lowery, 2005).

Blosser (2000) classifies questions into four categories: closed, open, managerial, and rhetorical. Rhetorical questions, to which students are not expected to respond, are often tag questions ending with "right?" or "isn't it?". These questions help students recall information, and they generally elicit a yes/no response. Closed-ended questions have a limited number of acceptable or "correct" answers. Closed questions are useful in checking students' memory and remembering facts. Usually, there is only one "correct" answer (West Lothian Council Educational Psychology Service, 2020). According to Blosser (2000), closed questions should not be thought of as reminders only; they are also used to select and classify similarities and differences and apply the learned information to a new situation. Both levels of thinking are important for students, but it is essential that teachers' questioning moves should not be formed of closed questions only. For instance, teachers' rhetorical questions such as "Does not a square have four sides?" provide an answer to the students without making them think further about it (Ontario Ministry of Education, 2011). Open questions are questions that may have multiple acceptable answers rather than one or two "correct answers." These questions make use of students' past experiences and allow students to explain and justify their ideas, draw or make inferences, form hypotheses, and make judgments based on their own values and standards (Blosser, 2000).

Fusco (2012) categorizes question types into three groups: literal, inferential, and metacognitive. Literal questions are designed for information that is clearly articulated in the lesson or "that is there" in the book, the answers to which are specific, often eliciting remembered information. These questions can also be called closed questions. Inferential questions are the types of questions that expect answers that are not directly found in the texts. These questions are asked to form an appropriate answer by enabling the students to go beyond the text and manipulate the information in different ways. These questions are also called open-ended questions because they do not have a single correct answer; students are free to develop their own reasoning.

The National Council of Teachers of Mathematics (NCTM) (2014) defines four different question types to categorize teacher questions in mathematics classes. These include questions for gathering information, probing thinking, making mathematics visible, and encouraging reflection and justification, namely, Fermi questions (NCTM, 2014). In gathering information questions, students are asked to remember facts, definitions, or procedures. Through probing questions, students are expected to elaborate on and clarify the steps in their solution and explain their thinking. Students are expected to discuss mathematical structures and establish relationships and connections between mathematical ideas in questions that make mathematics visible. In contrast, in questions that encourage reflection and justification, students are expected to demonstrate a deeper understanding of the subject, including reasoning, to ensure the validity of an argument (NCTM, 2014). Questions that make mathematics visible underline the connections between fields of mathematics. Two examples of questions that encourage reflection and justification are "how can you prove that the answer is 51?" and "how do you know that the sum of two odd numbers is always even?" Fermi questions are unexpected questions that encourage multiple approaches, focus on the process, require unconventional solution strategies, and ask for rough quantitative estimates. These questions enable students to create detailed arguments, produce the closest predictions, and focus on the process (NCTM, 2021). As clearly seen above, different types of questions are used for different objectives in the classroom. The types of questions asked determine the level of thinking desired to be developed in students (West Lothian Council Educational Psychology Service, 2020). The questions directed at students are also important in creating ways of learning and shaping student expectations. Therefore, analyzing teachers' questions in teaching contributes to the overall understanding of the broader picture of teaching and learning processes.

Although previous literature demonstrates a consensus on the importance of teacher questioning, several studies indicate that mathematics teachers or teachers of other subjects are not very good at questioning (or at asking good questions) (Aizikovitsh & Star, 2011; McCarthy et al., 2017; Sullivan & Clarke, 1990). For example, Wilen's (1991) research shows that the majority of questions asked by teachers are low-level cognitive questions that require them to focus on memorizing and remembering information. Özkan's (2011) study reports that 94% of the questions asked by teachers in mathematics class are at the remembering, understanding, and application levels, while only 6% of the questions target the assessment of higher-order learning skills, and that the lessons are mostly (95%) based on teacher questions and questions asked by students to each other are not encouraged. On another note, Nystrand (1997) and Döş et al. (2016) also found that teachers ask 12 to 20 questions on average in the class, but about half of the questions are procedural questions for explaining various technicalities. Similarly, Sahin and Kulm's (2008) study shows that 60% of the questions asked by mathematics teachers are about remembering information. In addition to the quality of the questions asked during the in-class questioning process, teachers' awareness of their questioning is also important. For instance, the study conducted by Albergaria-Almeida (2010) revealed that the teachers thought that their questions in class were at high levels, but the recordings and transcripts of the lessons showed inconsistencies with teachers' perceptions. This finding indicates that teachers' awareness of their in-class questioning patterns is low. According to TALIS Turkey 2018, the rate of teachers' self-efficacy in producing good questions for students was 91.9%. However, the rate of presenting problems with no specific solutions to students for cognitive activation was 21.9% (TEDMEM, 2019). According to the report, the rate of presenting problems with no definite solution in cognitive activation practices is lower when compared to Organisation for Economic Co-operation and Development (OECD) countries, and the rate of self-efficacy in questioning is higher when compared to OECD countries; which indicates that teachers lack the competence to ask questions and are not aware of their incompetence. Again, Sahin and Kulm's (2008) study revealed that although teachers ask fewer research or guiding questions in their lessons, they are aware that asking high-level questions is important for students to learn better. That being the case, teachers need to inquire into their own practices honestly. Moreover, such findings also contribute to the knowledge base of teachers, curriculum designers, and educational policymakers.

In addition to the quality of teacher questions, it is important to reveal the patterns in teachers' questioning behavior. To illustrate, teachers' wait time, their reaction to students' answers, and the strategies used in questioning all play a vital role. The questions are as good as the answers they produce; for this reason, investigating not only the types of questions but also the process of questioning becomes essential in describing the learning atmosphere in the mathematics classroom. In other words, determining the productivity and efficiency of questions used in class to facilitate learning is a key to illustrating the parameters of effective mathematics teaching. One of the most important parameters in questioning is teachers' wait time. Wait time refers to one of the two periods of silence in an interaction: (a) the pause between a teacher's questions and student response or (b) the pause between a student response and teacher's reaction in the next turn (Rowe, 1987; Hindman et al., 2019). Studies on wait time demonstrate that a typical pause for both situations described above remains under 1 second (Rowe, 1987; Tobin, 1987). In a class, wait time provides a space not only for students but also for teachers to reconsider opportunities, for students to formulate their responses before uttering them, and for contributing to others' responses (Ingram & Elliott, 2014; Ingram & Elliott, 2015; Tobin, 1987). If teachers extend their wait time in such questions, longer wait times can improve the quality and quantity of student responses (Ontario Ministry of Education, 2011). Tobin (1987) revealed in his study that teachers' wait times of over 3 seconds relate positively with increased student success in math and sciences. The amount of waiting time needed depends partly on the level of questions the teacher asks and student characteristics such as familiarity with the content and past experience with the thought process required (Illinois Center for Innovation in Teaching and Learning, 2020). On the other hand, other studies on in-class wait time (Kirton et al., 2007) have also reported boredom when students had to wait while they could have already answered the question. Researchers suggest that extending wait time can be useful only after specific types of questions and that identifying these types of questions might be difficult. On these grounds, the findings of extended classroom observations, as in the present study, could provide a detailed exploration of and implications for question types and wait times, which highlights the significance of this paper's contribution to the literature.

Another important pattern of teacher questioning is the phenomenon of "Redirection/ Probing/Reinforcement." Teachers' facial expressions, gestures, and tone of voice might send signals that prevent students from thinking (Ontario Ministry of Education, 2011). Teachers should avoid providing feedback that discourages students or threatens student's self-respect as well as over-controlling or over-criticizing the student while questioning (Nebraska Academy for Research on Rural Education, 2020). Teachers may also tend to react positively to all responses regardless of their quality, as they are happy to receive any response. As the students begin to realize that not all responses can be perfect and the structure and flow of the lesson might be lost because of this, reinforcement and feedback become useless (Wragg, 2001). Research also shows that redirection/probing/reinforcement not only improves student thinking but also ensures student participation and increases the level of participation (Cotton, 1991; Herbert & Rampersad, 2007). Student collaboration in response to questions, for instance, constructing the responses together and the positive atmosphere this collaboration creates might be another element increasing the participation of all students. The process may thus facilitate students' easier access to connections between ideas and help them create new understandings when they proceed toward a meaningful solution for themselves. In this respect, evaluating teaching from these aspects might provide better insights into the quality of teaching.

Balancing all these processes in class teaching requires a certain level of expertise. There is no single formula for this balance, and this balance changes according to classroom situations. In fact, teachers are aware that the keystone of learning and teaching in the classroom is asking questions (Anderson & Krathwohl, 2001). However, since they use questions very frequently, teachers are clearly not fully aware of the types of questions they use or of the quality of their questions (Crowe & Stanford, 2010). In addition, teachers' failure to sufficiently evaluate questioning procedures leads to inefficiency of investigations on the quality of the process. If teachers analyze their own questioning skills, they can reduce the percentage of questions at the recall level and increase the percentage of questions that necessitate student thinking (Blosser, 2000). Through these questions, mathematics teachers can enable and support students to express their mathematical thinking clearly and accurately (Franke et al., 2009), which in turn might facilitate students' structuring of mathematical thinking. Clearly, examining teachers' questions in class is essential in demonstrating the quality of teaching in mathematics classrooms. The question-and-answer environment in class may reveal more details on how learning occurs. This study can help teachers make a reflective evaluation of the questions they use in their mathematics classrooms. Research shows that teachers specifically trained to ask high-quality questions made significant progress in creating and using such questions in the classroom (Angletti, 1991; Cecil, 1995). In this respect, the findings of this study will provide important insights for both teacher educators and teachers. This study will examine the questioning skills of elementary school mathematics teachers. The following research questions guide the study:

1. How can elementary school mathematics teachers' in-class questioning skills (aims of questioning, types and qualities of their questions, questioning procedures) be described?

2. How can elementary school mathematics teachers’ in-class questioning skills (aims of questioning, types and qualities of their questions, questioning procedures) be described in the process of classroom observations?

Research Method

This study sets out to explore in-service elementary mathematics teachers’ questioning skills in class. The researchers followed a mixed-method study with an explanatory sequential design. First, we gathered quantitative data through an in-class questioning skills survey from elementary school mathematics teachers teaching fifth through eighth graders in İstanbul, Turkey. The main aim was to outline the in-class questioning skills of elementary mathematics teachers. We also used qualitative data to support the findings from the quantitative data. The qualitative dimension of the study followed a case-study design aiming to explore in depth the questioning skills of mathematics teachers in a real classroom context. Two elementary school mathematics teachers, one teaching at a private and one teaching at a state school, were observed. Both teachers volunteered to be observed as part of this study. We used an in-class questioning skills observation form to collect the observation data.

Participants

In this study, 265 elementary school mathematics teachers participated in the survey in the quantitative data collection phase. The demographic profile of participating 265 teachers (teaching fifth to eighth grades) is summarized in Table 1 below. For the classroom observations, we selected two of the participating teachers. Both teachers had 15 years of experience in teaching, one was working at a public school, and one was working at a private school in Istanbul.

Table 1. *Demographics of Survey Participants*

Teaching experience	**Frequency**	**Percent**	**Gender**	**Frequency**	**Percent**
5 years or less	95	35.8	Male	71	26.8
6–10 years	79	29.8	Female	194	73.2
11–15 years	32	12.1	**Education**		
16 years	59	22.3	Bachelor’s	218	82.3
Context of their schools			Master’s	46	17.4
City center	124	46.8	PhD	1	0.4
Town center	118	44.5			

Rural area	23	8.7

Data Collection Tools

In-Class Questioning Skills Survey

We examined data collection tools in the existing literature on questioning skills in class (Fusco, 2012; Ontario Ministry of Education, 2010) and developed a new data collection tool based on these. The in-class questioning skills survey for teachers of mathematics consisted of three parts: (a) goals of questioning in class, (b) types of questions used in class, and (c) the process of questioning in class. The last part, the process of questioning in class, consists of the following sub-dimensions: (a) planning, (b) time, (c) questioning strategies, (d) Redirection/Probing/Reinforcement, and (e) self-evaluation. To validate the data collection tool, we obtained expert opinions from an expert in measurement and evaluation, two experts in curriculum development, and two teachers. Experts stated that the items in the survey were valid to determine the in-class questioning practices of teachers, but some of the items were reworded. We piloted the survey with 60 teachers, and they provided their opinions and suggestions on items that were found problematic (in terms of clarity and meaning, etc.). The researchers evaluated the suggestions by the pilot study participants to form the final version of the data collection tool. Some terms used for concepts such as "rhetorical" or "Fermi" might be unfamiliar to the teachers, or it might be hard for them to categorize questions asked in class. For these reasons, we provided example mathematical questions below each item in sections on questioning aims and types. Some items on questioning aims and types were either put on a Likert-type scale (1: never, 2: sometimes, 3: usually, 4: generally, 5: always) or categorized (e.g., yes/no, 1–3 seconds, 3–5 seconds, etc.) accordingly. Some survey items and given examples are provided in Table 2 below.

Table 2. *In-Class Questioning Skills Survey Items and Example Questions*

Items	Example
1. I ask questions in my classes to stimulate curiosity and interest in a topic.	What can you make in 1000 seconds? (a meal, etc.)
2. I ask questions in my classes to direct my students' attention or focus on a specific topic or concept.	What do you think about the concept of identity?
3. I use my questions in class to promote meaningful student learning.	Can you describe the difference between rational and irrational numbers in your own words?
4. I use my questions in class to deepen students' understanding.	Can a square made up of 10x10 small squares be divided into 3 equal parts? Is dividing 1/2 by 3 the same as dividing it by 1/3?
5. I use my questions in class to improve my students' problem-solving skills.	Some probabilities are not analyzed with the theoretical probability of an event occurring; what could be the differences and reasons for such probabilities?
6. I use my questions in class to encourage my students to question themselves or their peers.	Cemil, would you like to comment on Kerim's ideas/comments? Ayşe, can you answer Veli's question? Can you explain what you mean in a way that Hakan and Fulya could understand?

In-Class Questioning Skills Observation Form

We developed this form to document the mathematics teachers' questioning skills observed in class. The form was parallel to the survey and included such dimensions as the teacher's aim in using questions, the types of questions asked, and teacher moves aiming to exploit questioning processes in class. Some example items from the observation form are as follows: (1) For which purposes does the teacher use questions? Record the questions. (2) What types of questions does the teacher ask? Record the questions. (3) How long does the teacher wait after asking a question? Record the wait time and the question.

Data Collection Procedure

The data collection was carried out in two steps:

Quantitative Data Collection

The quantitative data collection step included the administration of the "In-class questioning skills survey" to 265 elementary mathematics teachers working in various schools. The participants were selected for ease of access and recruited on a voluntary basis. The participating teachers work in various provincial areas, district centers, and rural areas of Istanbul. The fact that Istanbul is the largest city in Turkey provided an advantage for the researchers to reach different types of schools and a large number of teachers.

Qualitative Data Collection

The qualitative data collection step included classroom observations of two elementary school mathematics teachers working in İstanbul, one teaching at a private, one teaching at a state school. Both teachers have 15 years of teaching experience. The purpose behind the selection of teachers from two different types of schools was to investigate the in-class questioning skills of teachers in these settings. Each teacher was observed for six weeks, two hours a week. Both were observed while they were teaching the same topics in their eighth grade classes. In Turkey, elementary mathematics programs are centralized for all schools; both the private and public schools teach for the outcomes listed by the Ministry of National Education. Therefore, the observed teachers were teaching within the same curriculum. The classroom observations were recorded with the teachers' consent so that no questions were missed. The recordings were used to verify the observed questions noted down on observation forms. One of the researchers in this study also had the role of participant-observer; they participated in the classroom observations each week and shared their observations with the other researcher. Both researchers worked together on the categorization of questions. The participant-observer also recorded the teacher-student interactions in class. These interactions are highly valuable for the study in that they ensure thorough investigation of the role of questioning in teaching.

Data Analysis

The qualitative and quantitative data gathered in this study were systematically analyzed and presented following the procedures below.

Quantitative Data

In the analysis of the quantitative data gathered through the in-class questioning skills survey, mean values were calculated and findings were presented in relevant tables.

Qualitative Data

In the analysis of the qualitative data gathered during in-class observations via the observation forms, percentages were used as a form of descriptive statistics. The findings were presented again in tabular form with examples from teacher questions. The public school teacher was assigned the name T1, and T2 is the private school teacher in the analyses presented below. Furthermore, example student-teacher interactions from both classes are provided to illustrate teacher questioning behavior. These interactions were analyzed through descriptive analysis. The dialogues between students and teachers are provided without changes.

Validity and Reliability Measures

1) For the observations to better reflect the classroom realities, we used participatory observations in this study.
2) We solicited expert opinions for the survey forms and observation forms to ensure the reliability and validity of the findings.
3) We utilized multiple data collection techniques to enrich the research process. Different types of data collection instruments were used to increase credibility of findings.
4) The research process was explained in detail.
5) Field experts evaluated the results of the analyses of collected data.
6) The observing researcher and the second researcher held weekly post-observation meetings to validate the observer’s findings and to ensure consistency in the classification of questions. This also contributed to the quality of data collection in the upcoming weeks.

Findings

The findings of this study are based on the analyses of the survey results and observation data on teachers' in-class questioning skills.

In-class questioning skills of elementary school mathematics teachers

In-class questioning aims

Table 3. *The Mean Scores for In-Class Questioning Aims of Mathematics Teachers*

Items	Mean
1. I ask questions in my classes to stimulate curiosity and interest in a topic.	4.00
2. I ask questions in my classes to direct my students' attention or focus on a specific topic or concept.	4.15
3. I use my questions in class to promote meaningful student learning.	4.27
4. I use my questions in class to deepen students' understanding.	3.92
5. I use my questions in class to improve my students' problem-solving skills.	4.26
6. I use my questions in class to encourage my students to question themselves or their peers.	3.56
7. I use my questions in class to determine if there is any challenge that hinders a student's learning.	3.99
8. I use my questions in class to show my interest in students' ideas and feelings.	3.88
9. I use my questions in class to develop my students' mathematical thinking skills.	4.02
10. I use my questions in class to encourage my students to think about their thinking.	4.18
11. I use my questions in class to improve students' imagination.	3.72

As Table 3 reveals, mathematics teachers seem to always use questioning with the aims of promoting meaningful learning for students and improving students' problem-solving skills. While questioning, the teachers generally aim to stimulate student curiosity and interest in a topic, get their attention, deepen student understanding, encourage students to question themselves and their peers, determine the challenges that hinder learning, show their interest in student ideas and interests, develop mathematical thinking, and improve students' imagination.

In-Class Questioning Types

Table 4. *In-Class Questioning Types*

a.	Characteristics of questions in class	Mean
1.	My questions in class are open-ended; that is, my questions generally do not have a unique, exact or one correct answer.	3.35
2.	My questions in class are closed-ended; that is, my questions have a unique, exact and one correct answer.	3.14
3.	My questions in the class are related to real-life and interesting.	3.82
4.	My questions in class initiate a discussion about a topic in mathematics.	3.46
5.	My questions in class are mostly at higher-order thinking levels, such as analysis, inference, evaluation, and prediction. That is, my questions are at a level that cannot be effectively answered through recall (remembering information).	3.08
6.	My questions in class direct students' attention to important, transferable ideas within the discipline (and sometimes interdisciplinary).	3.46
7.	My questions in class raise additional questions and create a desire in students to ask more questions.	3.45
8.	My questions in class allow students to find their own mistakes. In other words, they enable my students to find the correct answer or alternative answers by asking additional questions.	3.81
9.	I make use of "Fermi questions" in class. (Fermi questions do not generally have exact answers, and sometimes there are possible alternative solutions; they are unexpected questions about the real world that ask for rough estimates of quantity.)	2.67
10.	I make use of questions in class for gathering information. (Students remember the facts, definitions, methods and techniques)	3.68
11.	In class, I use questions for explaining thinking. (These questions reveal students' thinking and require students to explain or elaborate on their thinking.)	3.61
12.	In class, I use questions that "make mathematics visible". (Focus on the relationships between mathematics and the other fields of study or the context.)	3.71
13.	In class, I use questions that "encourage reflection and justification". (Students demonstrate a deeper understanding of their reasoning and actions, including building an argument for the validity of their work.)	3.75

14. I use "managerial questions" in class.	3.59
15. I use rhetorical questions in class. (These are mostly tag questions ending with "right?" or "isn't it?" that help in recalling information and generally eliciting a yes/no response.)	3.60
16. In class, I use questions that emphasize metacognitive skills in class.	3.53
17. In class, I use "comparison questions" that require the student to determine whether the ideas/objects are similar, different, unrelated, or contradictory.	3.58
18. I use questions that require students to explain their feelings or express emotion in class.	3.34

Table 4 shows that the Fermi questions have the lowest mean value and are occasionally used by the teachers in class. The types of questions that teachers sometimes ask in the classroom are open-ended questions, closed-ended questions, higher-order thinking questions, and questions that require explaining feelings or emotions. The questions teachers used generally include interesting questions related to real life; questions that initiate a discussion about a topic in mathematics, evoke disciplinary and interdisciplinary associations, create a desire in students to ask more questions, or enable students to discover their own mistakes; questions for gathering information, explaining thinking, making mathematics visible, or encouraging reflection and justification; managerial questions; rhetorical questions, questions that emphasize metacognitive skills; and comparison questions. The types of teacher questions with the highest means were questions related to real life and questions that enable students to discover their own mistakes. These results demonstrate that teachers who use different types of questions prefer to use some question types more frequently than others. The analysis of the types of questions used in class reveals significant details regarding the quality of teaching.

The Process of Questioning in Class

Table 5. *The Process of Questioning in Class*

	a) Planning	Mean
1.	Before I ask the question, I plan the skills that I want my students to know, understand and practice.	3.81
2.	I predict the possible responses I might receive from the students in class before I ask the question.	3.90
	b) Questioning strategies	
3.	I use KWL (What I know—want to know—learned) charts that help the students determine what they know, ask questions about what they want to know, and record what they learn.	2.47

4. I use the "Think-pair-share" strategy (cooperative learning through group work).	2.72
5. I use one-to-one question and response patterns such as Teacher-Student A, Teacher-Student B..., asking my question to a student, and after I get my answer, I ask another student a different question and get a response.	3.29
6. I use the Teacher-Student A-Student B-Student C- Teacher pattern, in which I address a question to several students and get their responses.	3.33
7. I ask questions addressing the whole class. (Not only a few, but all students can put forward ideas to respond to the question)	4.10
c) Redirection/Probing/Reinforcement	
8. I refrain from criticizing student responses in class.	4.20
9. When students provide incomplete or incorrect answers in class, I immediately intervene and help them.	3.18
10. I use praise carefully for the student responses. (I do not offer verbal rewards such as "yes", "very good", or "well done" for every response.)	3.52
11. When students provide incomplete or incorrect answers in class, I ask additional questions (use probing) to help them correct their answers.	4.09
12. When a student is confused or cannot answer a question, I do not let them feel inadequate. Instead, I tell them that I will turn to them later and re-direct my question to other students.	4.06
13. During a discussion in class, I encourage students to question the contributions made by other students.	3.83
14. I ask additional/probing questions that do not contain the answer but help a student find the correct answer to their own question.	3.92
Self-evaluation	
15. I video/audio-record my teaching in class and later evaluate my teaching. a) Teachers who said yes: 26 b) Teachers who said no: 239	
16. If I do not know the answer to a student question, I behave as if I knew it and let it pass.	1.54
17. If I do not know the answer to a student question, I do not feel uncomfortable. I recommend resources to help the student find the answer.	3.82

	d) Time	
18.	I wait for a while before I provide feedback to a student response after a student responds to my question.	3.91
19.	I allocate time to answer my students' questions if they have questions related to the class.	4.35
20.	If the student's question is not related to the class topic, I delay responding to the question until a more suitable time comes.	3.45
21.	I allocate time for students to think after I pose a question.	**Frequency**
	a. 1–3 seconds	4
	b. 3–5 seconds	24
	c. 10 15 seconds	4
	d. 30 seconds	3
	e. About 1 minute	177
	f. 1–3 minutes	14
	g. More than 3 minutes	34
	h. Other responses:	
	• It would change depending on the topic, the question, and the class atmosphere	1
	• It would change depending on the length and complexity of the question.	1
	• It would change depending on the question; less than 1 minute, more than 3.	1
	• It would change depending on the question but between 30 seconds and 1 minute.	1

Table 5 summarizes the mathematics teachers' process of questioning in class. In the planning phase for in-class questioning, the teachers generally plan their questions in advance and predict the possible student responses. With regard to questioning strategies, the teachers sometimes use KWL charts and "think-pair-share" strategies that support group. Other strategies that teachers sometimes utilize are question-answer exchanges between the teacher and a student and directing a question to several students simultaneously. Although teachers do not direct their questions to several students frequently, the mean value for directing questions to the whole class is higher.

Examining the redirection/probing/reinforcement processes reveals that the move teachers sometimes make is to help students through immediate intervention when students provide incorrect answers. The mean score for this item is considerably high, although it was the lowest in the category. Teachers generally prefer using verbal rewards such as "yes," "very good," or "well done" carefully, asking additional questions to help the student correct their answer, redirecting the question to other students without causing the student to feel inadequate when they cannot answer a question, encouraging students to ask questions to each other during discussions, and asking probing questions that help students to respond.

In the area of teachers' self-evaluation practices on their questioning processes, 10% of teachers record their lessons and evaluate their teaching afterward, while 90% do not. When teachers cannot respond to student questions, they occasionally let them pass while they generally recommend extra resources to help answer the question.

We examined teachers' practices concerning time in the process of in-class questioning at two levels: teachers first responded to survey items on a 5-point Likert scale and then to a multiple-choice item that measured their wait time. Teachers report that they generally wait before providing feedback on a student's response and that they delay dealing with student questions that are off topic. The move that they always prefer to do is to allocate time for on-topic student questions. However, the amount of time allocated for questions varies: 177 teachers report that they wait for about 1 minute, 34 teachers wait for 3–4 minutes, 14 teachers for 1–3 minutes, 24 teachers for 3–5 seconds, 4 teachers for 10–15 seconds, and 3 teachers wait for 30 seconds. Some teachers report that teacher's wait time depends on the difficulty of the question or the class atmosphere.

Findings of Classroom Observations

The findings of the classroom observations are summarized in the tables below. Table 6 presents a categorization of the two observed elementary teachers' questions according to their aims. The types of questions and questioning behaviors/practices will be presented later.

Table 6. *Findings of Classroom Observations-Aims*

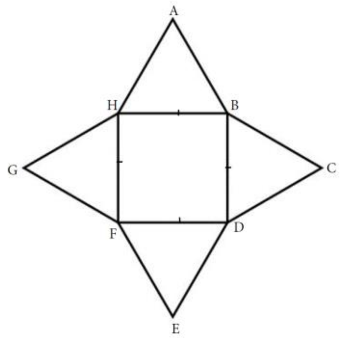
Aims	T1 (%)	T1- Question examples	T2 (%)	T2- Question examples
To stimulate curiosity and interest in a topic.	9.5	1) Have you ever heard the word "Pikola"? 2) In music shows, there is a person playing a steel triangle. It needs to sound at the right time. Have you ever seen it? 3) We will talk about it more in the future… the Pythagorean	14.2	1) We use integral to calculate the volumes of cut-off pieces. Have you heard it before? 2) What is the use of knowing the coordinate system, you ask?

		theorem came into being with the rhythm of the music.		
To focus attention on a specific topic or concept.	19.04	1) What do ≤ and ≥ mean? Shall we focus on them? 2) Do you remember the number line?	18.59	1) Does it say half or whole? What would I do for similar questions? 2) What is surface area?
To create an opportunity for students to think about and internalize knowledge.	14.2	1) Can I show the exact place of $\sqrt{5}$ on the number line? 2) If I asked for the possible values of 2x in 2x<16, would you need to divide both sides by 2?	14.2	1) If it is a square pyramid, how many lateral faces, as a square has four …, would it have? 2) Show me the edges. Weren't these all equal?
To deepen student understanding.	14.2	1) Can we say the possibility of drawing a triangle depends on the length of its sides?	12.24	1) The arc length is equal to what?
To encourage solving complex problems.	-		-	
To promote opportunities for students to learn indirectly through discussions.	-		4.08	1) Do I have to find the surface area of the cylinder here?
To encourage students to ask questions about themselves and others	-		-	
To diagnose challenges that hinder students' learning.	14.2	1) Any questions until now? 2) T1 points to the inequality examples on the board and asks the students: Can you read these for me?	8.16	1) Anyone who could not understand?

To show a genuine interest in student ideas and feelings	-		-	
To improve students' thinking	19.04	1) Does a triangle have only one height from a vertex?	14.28	1) Why do you think these shapes are similar? 2) You do not always need to memorize a formula for a mathematics question, OK?
To encourage students to think about their thinking	-		8.16	1) Why do you think you solved it wrong?
To improve students' imagination	9.52	1) What would this net of a 3D shape look like when it is folded up? 2) Think of this eraser as a line. Join these two markers. Can I connect this side to this one? I could not, no matter what I did, right? Can I connect them when I narrow the angle?	4.08	1) Let's draw two lines intersecting perpendicularly, OK? (0,0) will be the middle point.

As Table 6shows, Teacher 1 and Teacher 2 use questions mostly with the aims of "focusing attention on a specific topic or concept," "creating an opportunity for students to think about and internalize knowledge," "deepening student understanding," and "improving students' thinking." Teacher 1 uses relatively more questions "to diagnose challenges that hinder students' learning" than Teacher 2. It is possible that T2's statement, "You do not always need to memorize a formula for a mathematics question, OK?" might lead to mathematical misconceptions. This is because the most important reasons for misconceptions in mathematics include "overgeneralization" (thinking that a rule that belongs to only one field or subject of mathematics is valid for all mathematical subjects) or "over-specialization" (considering only one dimension or application of a rule that can be interpreted and used in a wider scope) (Özmantar et al., 2008). Teachers' use of such statements indicates that they do not pay attention to the possibility of misconceptions.

A student-teacher interaction to illustrate how T2 uses questioning to internalize knowledge and to deepen student understanding can be seen below in a dialogue about the image below:



S: (showing the points A, C, E, and G) These overlap when folded.

T2: So, is it the vertex?

S: All four, A, C, E, and G, are equal.

T2: OK, what is equal to what?

S: A=E.

T2: Give me the pencil. You don't say that; look (pointing to the sides AB and BC), would this side come together with this side?

S: Yes, A and C are equal, then.

T2: $|AB|$=$|BC|$ (writes all the equal sides down). All of these are equal to each other, OK?

S: I don't understand anything.

T2: Didn't I say so?

In this dialogue above, the student cannot visualize the three-dimensional solid shape of the plane shape. Rather than solidifying the figure, the teacher asks the student to imagine it, which causes the student more confusion. Moreover, at the end of the dialogue, we see T1 ignoring that the student could not understand it.

Similarly, in the example below, T1 engages in a dialogue with a student on the area of a triangle:

T1: If the side lengths are different, then the heights belonging to those sides are different.

S: Then, we would find different values for the area, no?

T1: What was the area formula? All the sides can be a base.

S: Then, is there proportionality between the side and the height?

T1: I can say this; I don't know if it answers your question, two triangles with the same area are inversely proportional, of course. Height and edge in a certain ratio.

The response provided by the teacher is not sufficient for the student. The student has a misconception about the area and cannot comprehend what the area is about. However, the teacher attempts to explain it based on the formula only and does not guide the student about how the area is calculated on different sides or suggest applying the calculations together. This dialogue emerges as an important example of how students become convinced that mathematics is a subject to be learned based on the rules and formulas. Another such example can be observed in the dialogue below:

T1: This perpendicular line that I draw from Vertex A to Side BC, I call it the height of Side BC.

S: All the heights are equal, aren't they?

T1: No.

S: How does it happen?

Another S: Does it always have to be perpendicular?

T1: Height is always perpendicular.

S: If the angles are equal, then all the heights are equal, right?

T1: Then I tell you this. In an equilateral triangle, the angles are equal and 60 degrees each, right? (Draws a triangle) All the heights are equal.

In this dialogue, the student is unable to understand the concept of height, T1 does not explain it and draws attention to some other topic, and memorized learning occurs again.

On a similar example about triangle inequality, T1 again comments, "Why is there no equality in triangle inequality? Then a triangle would not form, but a direct line would. So, there should be a certain inequality." In T1's question and own answer, it was unclear what forming a direct line means. Furthermore, T1 unfortunately directs students to misunderstand and generalize misconceptions that inequalities form triangles, and when there is no inequality, lines are formed.

The frequent questions asked by both teachers are similar to the question, "Is there anyone who could not understand?" When a student could not understand the topic, T1 asks more questions to understand the challenge and the difficulty the student is experiencing. What is also important is the nature of these questions. For instance, in a dialogue with a student about pyramids, T1 says, "How will it be, not on the ground but in the air? A flying pyramid? I'm not a technical drafter. How can I draw in 3D? Give shading from left, right, from the top," in response to a student. This is odd because the teacher, who cannot draw the shape but claims only a technical drafter can, expects the students to display the skill. Moreover, suggestions such as "shading from the right, left, or the top" are not very clear for students. When asking questions such as "is it on the ground or in the air," the teacher does not provide sufficient explanation as to how it should be drawn.

T1 does not use any questions to encourage students to think about their thinking, and T2's questions addressing this aim are also very few. Teacher 2 again asks very few questions "to promote opportunities for students to learn indirectly through discussions"; however, T1 never used such questions during the observations. To exemplify, in a similar interaction in T2's class, a student asks, "Why don't they make it intersect at (1,1) on the coordinate system?" and T2 answers, "(0,0) is reasonable. They wanted it to start there," which is confusing and targets memorization. As the teacher is not able to explain the reasoning, they give a confusing answer. A dialogue between T2 and a student about the coordinate system might better illustrate this situation:

T2: What is the ordinate?

S1: x,y

T2: Look, I ask you so that you learn it. If it is Y, it is ordinate; if (x,y), it is coordinate.

> *S2: Teacher, wouldn't we understand the signs of the quadrants easier if we use translational movement (Left -, right +, up +, down -)*
>
> *T2: I am not talking about translation.*
>
> *S2: Teacher, won't we understand better if we used that technique?*
>
> *T2: No, why would you understand better?*
>
> *S2: You did not understand me.*
>
> *T2: I understand you, but I do not do translational movement now. We are studying the ordinary coordinate system. Forget about translation.*

As seen in the interaction above, the teacher could not provide an adequate answer to the student who attempted to memorize the signs without trying to understand the reasoning in the coordinate system. T2's other exchange with a student is:

> *S: Can I swap x and y?*
>
> *T2: No. The first one is x; the second one is y. I cannot change them as I like. Then it goes to a different point, OK?*

The example above shows that the teacher's response is not clear, that it does not clarify what a different point means, and that the teacher provides a confusing answer.

Similarly, T2 asks more questions to stimulate curiosity and interest in class relative to T1. Both teachers were observed to be using questions that aim "to improve students' imagination" rarely. For instance, T1 asks more questions than T2. But questions selected by T1 to stimulate curiosity and interest in class are not very familiar to students, despite being related to real life. Instead of these, more familiar examples can be given. Again, the question that T2 is trying to ask to stimulate curiosity includes the concept of integral; however, considering the fact that the students have never heard of this concept and that they will not hear it until high school, this question is actually unnecessary. It is also noteworthy that T1 says, "The Pythagorean theorem came into being with the rhythm of the music" (the teacher had a lack of knowledge) but does not give any explanation of this. We would also like to share T2's question again: "You ask, what is the use of knowing the coordinate system?" and their own answer is exactly as follows: "Meridian-parallel, coordinate system has been developed in order to make these regions smaller and larger and easier to understand. The plane moves in the sky according to the given codes, right? They thought of it as a projection." In addition to being insufficient, T2's answer is not even comprehensible. Especially in similar questions, T2 might be using confusing questions to prevent students from asking more questions. To illustrate, T2's use of "You say why do we need mathematics. To embody abstract concepts. Software, for instance" to make mathematics visible or to establish the importance of mathematics is again confusing because T2 does not provide any further explanation or a specific answer. Instead, T2 tries to prevent the students from asking questions again by drawing their attention to a subject whose background is not very familiar to the students.

On a final note, the observations showed that teachers tended to answer their own questions. For instance, T1 responded to their own question "What would this net of 3D shape look like when it is folded up?" immediately. Again, T2 asked the following question to help students visualize: "Think of this eraser as a line. Join these two markers. Can I connect this side to this one? I could not, no matter what I did, right? Can I connect them when I narrow the angle?" However, the teacher was observed to answer their own rhetorical questions. The observation findings indicate that most teacher questions were answered this way. Neither of the observed teachers used questions that aimed "to encourage students to ask questions about themselves and others," "to show a genuine interest in student ideas and feelings," or "to encourage solving complex problems."

Table 7. *Findings of Classroom Observations—Types of Questions*

	T1 (%)	T1 Question examples	T2 (%)	T2 Question examples
Open-ended (i.e., does not have a unique, exact and one correct answer)	11.2	1) If the weight of apples is less than 2kg, what could it be? 2)What is height?	8.33	1) If it has a distance of two units from the origin, what might be the coordinates of a point on the x-axis?
Closed-ended (i.e., has a unique, exact and one correct answer)	17.2	1) What is the circumference of a cylinder with a base circumference of 150 cm and a height of 16 cm? 2) Is the expression -4<8 true? Does the sign flip when divided by (-3)? 3) That's 6 there; is that the hypotenuse 10?	25.64	1) What is the value of π? 2) How do we find the surface area of a cylinder? 3) Is it 60 when I multiply it? As it did not ask for the whole, do I take only the half of it? What is the half of it? What do I write where I see Pi?
Questions that require higher-order thinking skills	3.44	1) How can we find the hypotenuse if it is a decimal number?	1.28	1) What kind of area is formed inside the cylinder when a piece is cut?
Questions that trigger a discussion	4.31	1) If it is greater than 2, does it start from 2.1? 2) When any number is added or subtracted from both sides of an inequality, does the inequality symbol flip? What if we multiply?	3.84	1) Effects such as gravity and friction cause objects of the same weight not to fall at the same time. Is the surface area among these effects? 2) If there are 4 choices in 20 questions, the probability of getting them all correct is 4^{20}, right? But when we roll the dice,

				it is always different, right? How does it happen? 3) Can I draw the slant height from any side of the cone?
Questions related to real life	2.58	1) When you watch a film on TV, what does +7 mean? 2) Those under 18 cannot buy a SIM card, can they? 3) People under and over which ages could not go out during the pandemic?	2.56	1) The phones we use in daily life, for instance, what is their surface area like? 2) Sewer pipes, plastic pipes have a thickness, right? 3) When we talk about cones, we all know that party hats are actually cones.
Questions that require reasoning and justification	3.44	1) Can I show the exact place of $\sqrt{5}$ on the number line? 2) How do we solve it? 3) How did you find this??	1.92	1) Why did you multiply it by 6? 2) Tell us what you understand.
Questions that raise additional questions and create a desire in students to ask more questions.	2.58	1) Is $\sqrt{5}$ greater than 2? 2) When the pyramid is folded up, which of these options would not be possible? What if I look at it differently from below?	1.28	1) If I pay the VAT tax of the SCT tax, do I not pay the tax of the tax?

Table 8. *Findings of Classroom Observations—Types of Questions*

Types of questions		T1 (%)		T2 (%)
Fermi questions	-	0	-	0
Gathering information questions	1) Where do we locate the numbers greater than +2 on the number line? 2) 12–16-… does this triangle reminds you of something?	5.17	1) What is the formula for the circumference of a circle? 2) What is the base formula of the square pyramid?	5.12

	3) Do you remember how to draw the height, bisector and median from the previous years?		3) What do we call the geometric figure whose base is a circle, formed by connecting all points on the circumference of this circle with a point outside the base?	
Questions for explaining thinking	1) When it says 'after travelling 12 miles', it should travel 12 miles after travelling 12 miles, right?	6.02	1) What did you do here? Can you tell me the steps of the solution? 2) What is meant by the question?	3.20
Rhetorical questions	1) Numbers greater than -3 are to the right, right? 2) In a 12-gon pyramid, the edge of the base belongs to the 12-gon, doesn't it? 3) If I add -5 to one side of the equality, I have to add it to the other side, right?	21.55	1) Area of a circle is $A = \pi r^2$, isn't it? 2) Surface area of a cylinder is …. Right? 3) If I draw a line from the apex of the cone, isn't it perpendicular to the base?	19.2
Managerial questions	Let's look at the following problems, shall we? Shall we move to the next page? Can you be a little quiet? How many minutes are left? Did the bell ring? Do not open the textbook	21.55	Can you be quiet? Can you open your book? Will you stop talking? Would you take your seats?	27.56

Table 7 and Table 8 illustrate that both teachers use closed-ended questions the most. The frequency of use for these two types of questions is considerably higher than the others. Following this, both teachers' most frequently used questions were rhetorical and managerial questions. Both teachers use gathering information questions at similar rates. The other types of questions—questions that require higher-order thinking skills, that trigger a discussion, that are related to real life and interesting, that require reasoning and justification, for which a single answer would not suffice, and that create a desire in students to ask more questions—have very low percentages. T1 uses questions related to real life and that create a desire in students to ask more questions the least. T2 uses questions that require reasoning and justification and that are related to real life and interesting the least. Another finding of the observations is that the teachers never ask Fermi questions. The interactions above also show that teachers tended to ask closed-ended or rhetorical questions more.

Teachers' Questioning Behavior/Practices

Table 9. *Findings of Classroom Observation—Teacher's Practices*

Teacher's practices	T1	T2
Wait time after the teacher asks a question to the students, and Whether the teacher gives enough time for all students to think about the question.	1) The teacher answers their own question without giving enough time. 2) As soon as they receive an answer from a single student, they repeat it if it is correct and correct it if it is wrong.	1) The teacher answers their own question without giving enough time. 2) As soon as they receive an answer from a single student, they repeat it if it is correct and correct it if it is wrong. (avg. 2 seconds)
The students that are usually addressed by the teacher when asking questions	6 or 4 active students 8 silent students, and 5 active students Certain students are active	4–5 students Volunteers
Small-group work while solving a problem or task	-	-
Teacher reactions to student answers	Positive to correct answers (well done, nice) No reaction to wrong answers	Well, we made a gifted girl like you solve such questions. Have you suddenly lost all your intelligence? You're super, you're a genius.
Feedback provided by the teacher when they see a mistake or an error in a student response.	Immediate correction by the teacher	Correction by the teacher
Teacher's response to student questions	Immediate response	Immediate response
When the teacher does not know the answer to a student question	Pretends to know and gives evasive answers Asks for some time to think about it	Pretends to know and gives evasive answers Asks for some time to think about it.
Video/audio-recording while teaching the lesson (or a part of it) and later self-evaluating and re-organizing the practice.	-	-

Table 9 classifies and examines the teachers' behavior/practices/moves. Both teachers tend to answer their own questions without giving the students enough time, and when they get an answer, both repeat the student answer if the answer is correct and immediately correct when the student answer is incorrect. The observation notes highlighted that this questioning behavior was frequently repeated. Teachers were not observed to redirect the same question to other students when they got incorrect answers. Both teachers ask their questions to the whole class but do not allow other students to share their responses once they get the first answer. Besides, both teachers tend to interact with a limited number of students throughout the lesson, and the same students respond to all questions. Neither of the two observed teachers uses KWL charts or "think-pair-share" strategies that facilitate group work. The teachers are inclined to immediately correct student errors. Concerning their reactions to student responses, T1 positively reacts with verbal rewards such as "well done" or "nice" to correct answers while remaining silent when students provide wrong answers. On the other hand, T2 uses awkward remarks during lessons, such as "Well, we made a gifted girl like you solve such questions" or "Have you suddenly lost all your intelligence?" Again, T2 also uses hollow statements like "You're super, you're a genius" to motivate students. In addition, both teachers are observed to pretend to know the answer when they actually do not and provide evasive answers. Both teachers note that they did not record their lessons for reflection and reorganizing their teaching practices. The teachers generally try to elicit responses immediately when they ask a question. This increases their tendency to provide the correct answer to their own question when the student responses are incorrect or insufficient.

Discussion and Conclusion

The quantitative analysis of the surveys indicates that mathematics teachers always use questioning to promote meaningful student learning and improve students' problem-solving skills. The aims that the teachers generally target are stimulating curiosity and interest in a topic, getting students' attention, deepening understanding, encouraging students to question themselves or their peers, determining challenges that hinder learning, showing interest in students' ideas and feelings, developing students' mathematical thinking skills, and improving students' imaginations. On the other hand, the observation findings show that the teachers' actual classroom questioning practices do not match the survey results. For instance, the aims most targeted by Teacher 1 and Teacher 2 in their questioning in class are "focusing attention on a specific topic or concept," "creating an opportunity for students to think about and internalize knowledge," "deepening student understanding," and "improving students' thinking." Specifically, the questions the teachers used to deepen student understanding are not sufficient, as seen in the dialogue examples we presented. When students do not display mathematical thinking in response to questions aiming to improve students' thinking, teachers tend to provide knowledge to be memorized directly. Similarly, our analysis revealed that teachers might give up on questions directed at deepening student understanding and instead provide more explanations to teach the concepts.

Teacher 1 uses relatively more questions "to diagnose challenges that hinder students' learning" than Teacher 2, but these are still insufficient. A frequent question both teachers ask is, "Is there anyone who could not understand?" This question, directed to the whole class, sometimes receives the response "I don't understand" from a few students, and the teacher repeats the explanation. One error the teachers committed is "retelling what is already told" to a student who could not understand it. Teachers are generally unaware that the students ask for a different way to solve the problem. As the provided dialogue examples show, asking rhetorical questions to diagnose the problem might make it more challenging to see the real problem. Teacher 1 does not use any questions with the aim of encouraging students to think about their thinking, and Teacher 2's questions addressing this aim are very few. Teacher 2 again asks very few questions "to promote opportunities for students to learn indirectly through discussions"; however, Teacher 1 never used such questions during the observations. Furthermore, the questions asked to promote learning through discussions lose their value when the teacher provides the answer for the students. Both teachers were observed to be using questions that aim "to improve students' imagination" rarely. Although Teacher 1 uses more questions than Teacher 2, the example dialogues show that the insufficiency of teacher knowledge and providing generic answers to student questions might drift the questioning away from its original purpose of improving students' imagination. In addition, neither of the participating teachers were observed to use questions to "encourage students to ask questions about themselves and others," to "show a genuine interest in student ideas and feelings," or to "encourage solving complex problems." These findings show that the quality of teaching is questionable. The main aims of an effective mathematics teacher should be to evaluate students' understanding, develop critical thinking skills, and facilitate reasoning and making sense of mathematical ideas (NCTM, 2014). Therefore, teachers should be able to ask questions that assess students' various levels of understanding and support students to ask their own questions (NCTM, 2014).

While the results of the survey indicate that teachers use questions effectively in the mathematics teaching process, the results of the observations demonstrate the opposite. The observation results show that teachers make efforts to be interactive in the questioning process, but they also try to manage this interaction (Mortimer & Scott, 2003). That is, teachers adopt a teaching process that asks students for answers but ignores students' opinions as they focus only on the scientific idea, typically guiding students through a series of questions and answers in order to reach a certain point of view. In other words, teachers have attitudes that ignore students' views, even when they are quite different from scientific ones. Similar studies in the existing literature that observed mathematics teachers in their classrooms (Parker and Hurry, 2007) also confirm these findings. We concluded that 70% of the questions asked in the lesson were asked by the teacher and that the teachers did not encourage students to produce their own questions. Drageset (2015) also found that teachers control the teaching process with guiding questions and students only respond to basic tasks in the form of control questions.

The questions used by T1 to stimulate curiosity and interest in the lesson are examples from daily life but ones that students do not encounter very frequently. Instead of these, teachers should give more obvious examples. When the teacher carefully asks questions about real problems, concerns, relationships, and interests, students want to explore these problems and be more actively involved in the lesson (Fusco, 2012). Doing mathematics in the classroom should closely model the act of doing mathematics in daily life (Walle, 2005). These modeling acts are "thought-revealing activities" that provide rich learning environments to teachers by enabling them to see the students' real thinking styles and conceptualizations (Lesh & Sriraman, 2005). Many studies in the literature indicate the importance of these effective mathematics teaching processes (Fennema et al., 1993; Aydoğan Yenmez et al., 2018). However, observation results showed that this process was not effective, as T2 answered their own question, and the answer was not understood by the students. In addition, it is apparent from T1's self-answered questions that there is a lack of knowledge. Occasionally, T2 is observed to be providing confusing answers, and sometimes, it is not clear what the answer intends to convey. Especially in similar questions, T2 might be asking confusing questions to prevent students from asking more questions. Similarly, T2's questioning attempt to make mathematics visible or to establish the importance of mathematics is again confusing because T2 does not provide any further explanation or a specific answer but tries to prevent the students from asking questions again by drawing the attention to a subject whose background is not very familiar to the students. If the aims of questioning are not properly predetermined in the teaching process, it may result in chaos, disorganization, and eventual failure to learn. The relevance of a question depends on the extent to which predetermined goals have been achieved (Crespo, 2002). For example, questions involving complex mathematical skills (divergent) are primarily used for answers at the application, analysis, and synthesis levels. Using these kinds of questions requires a good preparation process (Epstein, 2003). The answers the teachers give to the questions they ask may cause various problems, such as (1) creating misconceptions; (2) causing the students to perceive mathematics as a lesson with rules and formulas that need to be memorized by giving complex answers; (3) as a result of the teacher's reaction to a student who wants to make connections between different subjects, the student thinking that mathematical knowledge should not be transferred even within mathematics itself; and (4) the inability to construct mathematical knowledge due to insufficient examples or explanations on a concept that needs to be embodied. Teachers' in-class questioning practices are crucial for avoiding such problems. Teacher questions need to be open-ended, thought provoking, and intellectually engaging, and they should generate further inquiry, point to important transferable ideas within and between disciplines, be accountable over time, and lead to discussion (McTighe & Wiggins, 2013). Nevertheless, the questions asked in the observed classes were seen to lack these qualities.

According to the survey responses, teachers rarely use Fermi questions. This finding is consistent with the findings of the observation. The questions that teachers sometimes use in class are open-ended questions, closed-ended questions, higher-order questions, and questions that require explaining feelings and emotions. The questions teachers generally used include questions that are interesting and related to real life, initiate a discussion about a topic in mathematics, evoke disciplinary and interdisciplinary associations, create a desire in students to ask more questions, or enable students to discover their own mistakes; questions for gathering information, explaining thinking, making mathematics visible, or encouraging reflection and justification; and managerial questions, rhetorical questions, questions that emphasize metacognitive skills, and comparison questions. The types of teacher questions with the highest means were questions related to real life and questions that enable students to discover their own mistakes. Findings from the observations again do not confirm some of the survey findings. Both teachers used closed-ended questions more than others in their lessons. Following this, the most frequent questions both teachers used were rhetorical and managerial questions. In fact, most of the class proceeds with such questions. For instance, questions such as "In the same triangle, the height of the longest side is smaller, isn't it?"; "If I draw a line from the apex of the cone, isn't it perpendicular to the base?"; and "Numbers greater than -3 are to the right, right?" are rhetorical yes-or-no questions that make the students repeat the teacher. The teacher could reach higher goals in mathematical thinking and knowledge by reformulating these questions as follows: "How, do you think, would the height change when the length of its side changes?"; "If I were to draw lines from the apex of the cone to its base, which of these lines would be the shortest?" or "Where do we locate the numbers greater than -3 on the number line?" Piccolo et al.'s (2008) study observing mathematics teachers also shares similar results. The study concludes that closed teacher questions limited the interaction and did not prove student understanding. Again, the study revealed that probing and guiding questions were much more likely to produce interactions that showed proofs of student understanding.

The observations led to the finding that other types of questions, such as questions that require higher-order thinking skills, that trigger a discussion in class, that are related to real life, that require reasoning and justification, and that create a desire in students to ask more questions, have very low percentages of use. Both teachers use gathering information questions at similar rates. Neither of the two teachers used Fermi questions during the observations. This finding is similar to the argument by Brualdi (1998), who noted that teachers use lower-order questioning more often than higher-order questioning. The reasons for these include maintaining control over the class, the obligation to follow the program, and the relative ease of getting student attention. In the last three decades, studies have found that teachers still continue to ask questions at the lowest level of Bloom's taxonomy (Hickman, 2006), that teachers ask simple questions directed at remembering information and revision (Akyol et al., 2013; Ateş, 2011; Döş, 2016; Wimer et al., 2001). Existing literature reveals that using Fermi questions in mathematics teaching improves students' critical thinking skills (Ärlebäck, 2009; Sriraman & Knott, 2009; Sriraman & Lesh, 2006) and that these question types provide a good opportunity to discuss problem-solving strategies (Albarracín & Gorgorió, 2014). Therefore, using these question types in the classroom will lead to positive learning outcomes.

The survey results show that the teachers generally plan their questions in advance and that they predict the possible student responses. Teachers also stated that they generally do not use questioning strategies in the classroom, or they use strategies rarely. Although teachers occasionally ask a single question to more than one student at the same time, they are more inclined to direct their questions to the whole class.

Regarding the redirection/probing/reinforcement processes, the surveys revealed that the move that teachers sometimes make is to help students through immediate intervention when students provide incorrect answers. The moves that teachers generally make are using verbal rewards such as "yes," "very good," or "well done" carefully; asking additional questions to help the student correct their answer; and redirecting the question to other students without causing the student to feel inadequate when they cannot answer a question, encouraging students to ask questions to each other during discussions, and asking probing questions that help students to respond. Results regarding teachers' self-evaluation practices on their questioning processes reveal that 10% of teachers record their lessons and evaluate their teaching afterwards, while 90% do not. According to the survey findings, when teachers cannot respond to student questions, they occasionally let it pass while they generally recommend extra resources to help answer the question.

Teachers' moves concerning time in the process of in-class questioning were inspected at two levels. Teachers report that they generally wait before providing feedback to student responses and that they delay dealing with student questions that are off topic. The move that they always prefer is to allocate time for student questions on the topic. In addition, teachers often report that they wait for about 1 minute. A few teachers also state that wait time changes with respect to the difficulty of the question or the level of the class.

However, the findings from the observations do not confirm what teachers reported in the surveys. Both teachers occasionally answer their own questions without giving the students enough time, and when they get an answer, both repeat the student's answer when the answer is correct and immediately correct when the student's answer is incorrect. On average, both teachers have a wait time of 2 seconds after asking their questions. Heinze and Erhard (2006) also found that the average wait time between a teacher question and a student response is about 2.5 seconds and that the length of this wait time does not change with respect to the lesson stage (e.g., comparing homework, repetition of content or working on new content). One of the mistakes that teachers often make in questioning is that they do not give the students enough time to think (Ün Açıkgöz, 2014). Teachers' wait times for questions that necessitate higher-order thinking skills should be longer (Borrich, 2014). Short wait times also reflect the tendency to ask the same question to other students when the responses are incorrect. Yıldızlı (2020) also reported similar findings in a study that observed a mathematics teacher. Both of the observed teachers in our study ask their questions to the whole class, but once they get the first answer, they do not invite other students' contributions. The teachers fail to create a classroom atmosphere in which different ideas and reasonings about mathematics are discussed. In addition, both teachers are observed to be conducting their lessons only with a few students, and only those students answer the teacher's questions. Tainio and Laine (2015) demonstrate that incorrect answers by students should not be avoided; communicating the message that incorrect answers are acceptable and appropriate student contributions is important, and this message might help students approach solving problems more positively. Therefore, it is important to consider incorrect student answers as appropriate contributions.

One of the best ways to see the different strategies that students use in solving a problem in a mathematics class is to make students talk about their thinking with their peers. However, ignoring other student contributions once the correct answer is received reduced the quality of learning in the observed classes. Mueller et al. (2014) found that mathematics lessons in which students question and reflect on their own thinking and in which multiple approaches to reach the solution are encouraged help students gain self-confidence in sharing their multiple ways of reasoning, own their solutions and trust their reasoning, and therefore increase their mathematical autonomy. Guihun (2006) argues that teachers need to diversify their questions so that they address all the students, voluntary or not; that they need to encourage students to comment on their peers' contributions; that teachers should avoid such questions as "who can answer this" or "does anyone know the answer"; and that teachers should give students enough time to think and wait until five or six students volunteer to answer.

Both teachers usually immediately correct student errors. With regard to their reactions to student responses, T1 uses "well done" or "nice" for correct answers while remaining silent when students provide wrong answers. On the other hand, T2 uses awkward remarks during her lessons, such as "Well, we made a gifted girl like you solve such questions" or "Have you suddenly lost all your intelligence?" Again, T2 also uses hollow statements like "You're super, you're a genius" to motivate students. Teachers should construct feedback procedures effectively in class because with effective feedback, the student should be able to answer the questions “where am I going,” “how do I go,” and “where will I go” (Hattie & Timperley, 2007; Orsmond & Merry, 2011). For these reasons, the teacher should adopt a role that is direct and clear, highlighting the positive sides of student performance and avoiding the use of criticizing language (Mandhane, 2015; Yıldızlı, 2020). In addition, both teachers were observed to be pretending to know the answer to student questions when in fact they do not and providing evasive answers. Students might have various questions in class, and the teacher may not know the answer to all. Instead of giving a confusing or evasive answer, the teacher could say, “I do not know about that, but let’s research and learn it together,” which would not discourage the student from asking questions and would motivate the student through a positive learning experience.

Both teachers note that they did not record their lessons to later evaluate and reorganize their teaching practices. The survey results also show that most teachers do not record themselves in any way (video, audio recording, etc.) and do not engage in self-reflection. The literature emphasizes that teachers should use recordings such as videos to evaluate themselves (Clarke et al., 2006; Hollingsworth & Clarke, 2017; Kaur et al., 2013). As the literature presented in the Introduction reveals, teachers’ awareness of their questioning practices is rather low. A teacher who does not reflect on their own teaching will not be aware of their mistakes and will not display an attitude open to development. This argument is also supported by the findings of a research study by Di Teodoro et al. (2012), who had teachers record their in-class questions to later reflect on them through analysis and reordering procedures. In their study, the teachers report asking deeper questions, internalizing the awareness of the quality of questions, and becoming more conscious about the questions they ask in class after they engaged in reflection. In another study, Almeida (2010) demonstrates that after participating in a continuous professional development course designed to increase teachers’ awareness about questioning in class, the teachers were more aware of their practices. That is, teachers changed their in-class questioning behavior by reducing the number of questions they ask and therefore maximizing the time for student questions.

In this study, one of the observed teachers works at a public school while the other teacher teaches at a private school. It is noteworthy that both teachers’ lesson and questioning procedures are very similar. These commonalities in the teaching procedures of teachers working in schools with different resources and facilities and teaching students with different socioeconomic backgrounds prove that the teacher is the most important resource shaping the learning no matter how rich learning environments might be. This study clearly reveals that it is the teacher who will or will not integrate the possible resources in the learning process. This study also showed that teachers’ self-evaluation and their practices in the real classroom environment might be contradictory. Future studies might be conducted to raise teachers’ awareness of and improve their skills in in-class questioning practices. In addition, the positive and negative effects of teacher questioning on student learning might be explored further.

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