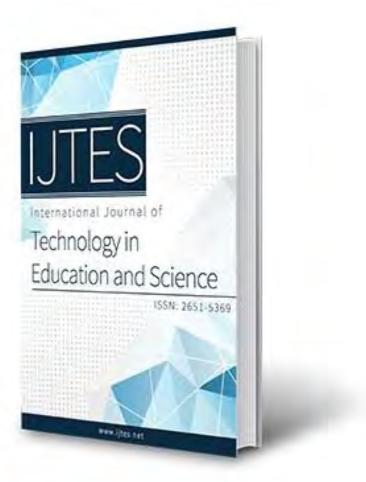

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Abstract

The objective of the present study was to gain a deeper understanding of how middle-grade mathematics teachers implement questions in both technology-supported and nontechnology-supported classrooms. The investigation demonstrated that in-service mathematics teachers teaching in a technology-supported classroom and in a non-technology-supported classroom employed seven questioning channels: teacher-created static nature of drawings, teacher-created dynamic nature of drawings, student-created nature of drawings, student verbal discourse, a ready-to-use educational animation and textbook definition, analogies, and real-life examples. Commonly, both teachers used student-created static nature of drawings on worked examples, teacher-created static nature of drawings on worked examples, and mathematical procedures or concepts in their questioning, as well as students' verbal discourse. The integration of technology introduced three additional questioning channels in technology-supported classrooms: the teacher-created dynamic nature of drawings, a ready-to-use educational animation and textbook definition, and a real-life example. In conclusion, this study indicates that teacher questions can be influenced by the questioning channels employed, and technology might, to some extent, affect teachers' variety of questioning channels. The results are discussed in the light of related literature.

Introduction

Teachers spend most of their class time asking questions (Hattie, 2008). Effective teacher questioning plays a vital role in the classroom, serving as a valuable teaching tool and a means of formative assessment for teachers (Jiang, 2014), as well as a means of guiding students toward desired behaviors (Mason, 2014). Classroom interaction can be facilitated by teacher questioning, which provides instructional scaffolding for students while learning mathematics (Way, 2008). In this sense, in mathematics classrooms, students' zone of proximal development is supported by teachers' questions presented during the instruction, while students interact with their peers and their teacher within the classroom culture (Hufferd-Ackles et al., 2004). Applying Vygotsky's theory to classrooms, it is possible to argue that students and teachers interact with each other, they interact within the culture of the classroom context, and they have individual thinking processes while learning. In this manner, classrooms are claimed to be the environment that provides these social, contextual, and individual factors for interactions, and these interactions should be taken into consideration within the classroom context. When students and teachers interact with each other through questions, knowledge is built in many ways depending on the role of the teachers' questioning in mathematics classrooms. Interaction patterns in mathematics classrooms emerge between student(s) and a teacher while transferring the information among the participants of the conversation related to mathematics.

There is a shared view in the literature that asking well-formulated and appropriate questions in mathematics classes can yield improved student achievement (Redfield & Rousseau, 1981) and better mathematical thinking (Burns, 1985). Although this is a widely acknowledged fact, mathematics teachers still face challenges in providing efficient questions that can get students to the next level of their mathematical thinking (e.g., Franke et al., 2009). Understanding the types of questions that mathematics teachers use is fundamental in comprehending their questioning skills (Franke et al., 2009; Piccolo et al., 2008; Hattie, 2008). Identifying the specific types of questions mathematics teachers use can provide insight into their questioning practices and inform efforts to facilitate improvement in their skills, ultimately leading to enhanced student success (Aizikovitsh-Udi & Star, 2011). A closer look at the questioning behaviors of teachers through question types provides fruitful ground to better understand the role of teacher questioning in classroom practices (Sahin and Kulm, 2008; Ali, 2007; Franke et al., 2009; Shahrill & Clarke, 2014; Piccolo et al., 2008; Hufferd – Ackles et al., 2004; Hunter, 2008; Widjaja, Dolk, & Fauzan, 2010). Question types represent the combination of form and purpose of questions (Orrill, 2013), and researchers interpret this combination in various ways. To illustrate this point, research studies suggest that mathematics teachers may use different types of questions, such as general, specific, probing, and leading questions (Franke et al., 2009); implicit and explicit questions (Parks, 2010); probing, guiding, and factual questions (Sahin & Kulm, 2008); clarification, extension, and guiding questions (Camenga, 2013); student-generated and teacher-generated questions (Harbaugh et al., 2008); starter questions, questions to stimulate mathematical thinking, assessment questions, and final discussion questions (Way, 2008); controlling questions, cloze technique, genuine-enquiry, meta-questions, and open and closed questions (Mason, 2002); or closed-ended questions specifying closed-procedural, closed-routine, closed- complete statement, closed-verification, closed-terminology, and closed-rhetorical (Ali, 2007) to reveal student thinking. Apart from these, teacher questions may involve the use of low or high cognitive capabilities or may take the form of yes/no questions (Shahrill & Clarke, 2014; Piccolo et al., 2008; Sahin & Kulm, 2008). Teacher questioning leads to rich mathematical discourse (Martin et al., 2015), which orchestrates the use of various questioning types, including close-ended, open-ended, or fill-in-the-blanks (Piccolo et al., 2008). There are variations in the types of questions teachers use to make students elaborate on their explanations in primary grades (Franke et al., 2009), although not all primary school teachers have such a purpose (Ali, 2007). For instance, Shahrill and Clarke (2014) emphasized that teachers use yes/no questions to facilitate classroom interaction, which may prompt a chorus response from students. Koizumi (2013) revealed that teacher questions should be tailored to the cognitive abilities of the students, depending on the context (Koizumi, 2013). Researchers such as Hunter (2008) have noted the importance of designing a classroom environment that supports and scaffolds students' reasoning and justification skills by using questions and prompts effectively.

Previous studies have extensively investigated the types of questions asked by mathematics teachers, leading us to understand their questioning methods based on the mathematical content and the structure of their questions that reflect their objectives (Orrill, 2013). However, this approach provides only a limited understanding of how mathematics teachers employ different question types while teaching, particularly in classrooms equipped with technology. Hence, the present study aims to focus on how teachers utilize various question types during teaching with the assistance of technology.

Prior research has examined the question types used by mathematics teachers and their implementation strategies. According to Sahin and Kulm's (2008) investigation on the implementation of question types in various instructional phases, mathematics teachers were observed to use more probing questions during lesson summaries, while the use of factual questions remained consistent, except for the summary part. In another study, Menezes et al. (2013) observed that three mathematics teachers in an inquiry-based classroom employed verification, focusing, and inquiry questions with varying frequencies throughout different stages of the lesson. Verification questions were predominantly used at the introduction and conclusion of the lessons for task introduction and systematization of mathematical learning, respectively, while inquiry questions were integrated within the development and discussion of the task. Focusing questions spread out throughout the lesson, except for the introduction of the task. Both studies revealed that teachers made conscious choices in terms of their use of questions in different phases of the lesson. Martin et al. (2015) presented a different perspective. Their study reveals that when mathematics teachers provide ample opportunities for students to participate in in-class mathematical discussions by prompting questions, students made significant progress toward achieving the intended mathematical knowledge. Similarly, Widjaja et al. (2010) found that Realistic Mathematics Education (RME) provided suitable contexts that supported students' meaningful mathematical learning in a collaborative interaction through teachers' probing questions. According to Sahin and Kulm (2008), the incorporation of concrete materials has the potential to shift the focus of teacher questions. Moreover, probing questions were applied more frequently in mathematics lessons when using concrete materials compared to factual and guiding questions (Sahin & Kulm, 2008).

Previous research on strategies for implementing questioning in mathematics lessons provided a valuable portrayal of the nature of integrating questions into instruction and of how to implement effective questioning. However, understanding this issue in technology-enriched classrooms is also worth attention for several reasons. First, technology is becoming an increasingly prevalent part of education, and more classrooms have access to technology. Second, technology-enhanced classrooms may offer unique opportunities for teacher questioning. Thus, it is crucial to understand how it impacts teaching practices and how teachers use questioning in technology-enhanced classrooms. However, the presence of technology alone does not guarantee that students will engage in rich mathematical inquiries through teacher questions (Monaghan, 2004; Goos et al., 2000). For instance, Cayton et al. (2017) found that teachers had different tendencies in their use of questions during technology-intense lessons and in pivotal teaching moments. Teachers' tendencies to use different question types were shaped according to their responses to pivotal teaching moments.

Although there are studies relating the use of technology and teacher questioning, there is still limited understanding of how mathematics teachers use questions in technology-integrated lessons. This study, therefore, aimed to examine the use of technology and questions through strategies for the implementation of teacher questioning. In this respect, this study also aimed to contribute to this growing area of research by exploring the use of middle-grade mathematics teachers' questions in technology-supported and nontechnology-supported classrooms covering the same content, the topic of lines and angles. For these purposes, the present research sought answers to the following research question: How do middle-grade mathematics teachers implement questions in both technology-supported and nontechnology-supported classrooms?

Theoretical Framework

This study is based on Vygotsky's sociocultural learning theory (Vygotsky, 1978) and communication theories that encompass the elements of source, message, channel, and receiver. The foundational premise of this study is Vygotsky's idea that learning occurs within a sociocultural context and is facilitated through communication between teachers and students. One effective instructional strategy influenced by Vygotsky's theory is the implementation of questioning in the classroom (Wells, 1999).

Vygotsky's learning theory emphasizes the role of social interaction and cultural context in individual cognitive development. According to Vygotsky, learning is a social process that transpires through interactions among individuals. In this context, teachers and more knowledgeable peers assist students in transcending their current abilities. Vygotsky elucidates this process with the concept of the Zone of Proximal Development (ZPD), which refers to tasks that a student cannot accomplish alone but can achieve with appropriate guidance and support (Vygotsky, 1987). Through asking questions, teachers and knowledgeable peers can uncover potential learning opportunities within the ZPD, thereby fostering cognitive development through social interaction. In this process, communication within the classroom is inevitable. The communication elements of source, channel, message, and receiver are detailed in communication theories (Mathematical Theory of Communication, the Lasswell and Shannon-Weaver communication models etc.). According to these theories, the source (or transmitter) generates and formulates the information into a message. The source is the origin of the information, and the message constitutes the text, sound, image, or other data content that initiates the transmission. The message is conveyed through a channel and is received and interpreted by the receiver (or target). When employed as a tool for activating and directing this communication process, questioning enables the teacher (source) to pose questions that capture the student's (receiver) attention and stimulate the learning process. These questions (messages) are structured in accordance with the lesson content or the student's existing knowledge level and are conveyed through specific channels (e.g., the classroom environment). The student's response to the question indicates that the message has been correctly received and processed. This study will examine how the messages related to questioning are transmitted within the classroom setting, exploring how questions are implemented in the classroom environment.

Method

Design and Participants of the Study

An instrumental case study approach was adopted to investigate middle-grade math teachers' questioning, with a focus on specific features such as active use of technology, active student-teacher engagement, and a shared mathematics topic, which served as instruments to address the research questions. Active student-teacher engagement indicates that the students not only answer questions but also ask questions. In this study, the active use of technology means that mathematics teachers apply a program and smartboard in each of their lessons. Public and private middle-grade schools were chosen for the study because they were purposefully appropriate and included volunteer participants. The topic of lines and angles was selected as one of the representative instructions to make the observations. The cases of the present study were two middle-grade mathematics teachers who were employed in Ankara, Turkey.

Classroom Contexts

The technology-supported classroom environment included individual desks for 20 students, a projector, a smartboard with an internet connection, and a white board. Instruction was typically delivered using the smartboard, but in some instances (e.g., electrical or internet connectivity issues), a regular whiteboard was used, and Geogebra is the program he used for almost all of his teaching. Projector was no longer used. This teacher integrated technology into his lesson during the subject of lines and angles, which is the subject of this study, in the following ways: teaching the lesson through the e-textbook, making drawings about angles through GeoGebra, making drawings on the smartboard, using documents opened on the smartboard for question solutions, and enriching course content using internet connection.

All students had their own desks, and all the desks were facing the board. Teacher Barış (TB) had been teaching in the same school for four years, and he is currently a PhD student in mathematics education. He graduated from the department of middle grade mathematics teacher education and had a master's degree with the thesis examining the effect of using dynamic geometry software on students' geometry achievement and attitudes. He specifically knew how to use GeoGebra. He followed the supplementary book step-by-step in his lecture. While there were problems with the smartboard, he implemented the same lecture benefiting from the printed version of the online supplementary book. The use of a supplementary book compatible with the smartboard was highly structured. The teacher sometimes used the whiteboard where he could show the things he wanted to write freely.

On the other hand, the other classroom compromised 27 students, and all students had their own desks. The desks were arranged to see each other from behind, which was similar to the other class. Several technological tools were available in the classroom, including an interactive screen that has functions similar to those of a smartboard and a projector. It was brought to schools by the Ministry of National Education within the scope of the Fatih project (http://fatihprojesi.meb.gov.tr/). However, as the researchers learned from informal interviews, the teacher did not have adequate technological knowledge to use these devices, as he did not have a chance to receive training about them. Therefore, in the classroom, the instructions were given on the regular whiteboard. Teacher Caner (TC) had been working in the public school for more than five years and had twenty years of experience in teaching. He graduated from the department of mathematics at a public university. In the learning environment, instead of directly answering students' questions, both teachers used student questioning as an opportunity for new questioning dialogs. Although supplementary materials were used in the classroom, what was written on the board was given its final shape by the students' ideas and the teachers' design. Three books were open on the teacher's desk, but it was not clear in what order or in what ways the sources were utilized. The obvious thing was that the worked examples in the classroom to reinforce the topic were the same as the ones available in the books. The teacher performed the lecture, the solutions of worked examples were written on the board, and the students were given some time to write down what was written on the board.

Data Collection Procedures

To collect in-depth information from the participating teachers, classroom video-recordings were utilized as the main data collection tools. Utilizing classroom videos facilitated our understanding of teachers' actions in their natural settings. Thus, lessons of the two participating teachers throughout the 2016 Spring semester were recorded, and the topic of lines and angles was selected as one of the representative instructions to make the observations.The topic of lines and angles included three learning objectives in the teachers' curriculum: to draw equivalent angles to each other, to describe bisector lines separating an angle into two equal angles, and to examine the properties of the opposite, inverse, interior inverse, and exterior inverse angles formed by intersecting lines and a line intersected with the other intersected pairs of the lines (MoNE, 2013, p. XVII). To achieve these objectives, the suggested class hours stated by the curriculum were ten hours. However, the allocated class hours by the teachers for these objectives were comprised of eleven class hours in which four hours were taken in non-technology supported classroom while seven hours belonged to the teacher in the technology-enabled classroom.Data was collected through classroom videos. Following the acquisition of approval from the Middle East Technical University Human Research Ethics Committee (with the designated date of 3.10.2015 and Decision Number: 28620816/397) and acquisition of the written consent forms of middle grade mathematics teachers and written parent consent forms of the middle grade students, classroom videos were recorded and subsequently transcribed.

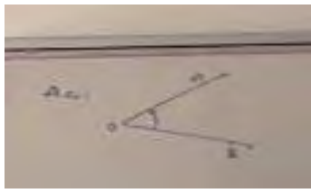
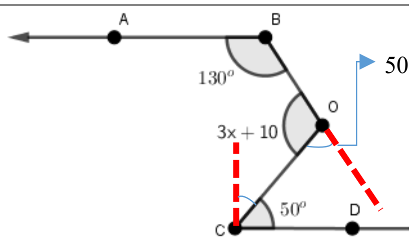
Data Analysis

The analysis of the classroom videos involved multiple stages. In the first stage of the analysis, the researchers made verbatim transcripts, rewatched the videos, and took notes on the transcripts. In the second stage, they separated the instruction into questioning practices. To identify the questioning practices in classroom dialogs, we segmented dialogs into two featuring that were specific to questioning a mathematical concept or procedure, or worked example. Questioning a mathematical concept or procedure and questioning a worked example were separate questioning practices. Examples of this situation are given in Table 1.

After coding worked-out examples, we also examined whether the practices include questioning mathematical concept or procedure in a more general manner as separate from the worked-out example. These practices were coded as questioning a mathematical concept or procedure. The detail was exemplified under the title of teacher-created static nature of drawings or markings for mathematical procedures and/or concepts. As a third stage, we focused on channels within the questioning practice. We think that channels could be understandable by considering it in the communication process in the educational environment.

To identify the channels of communication of questioning, relevant literature that represents role of manipulative in classroom questioning (Olkun & Toluk, 2004) and analogies (Harrison & Treagust, 2006) guided the researchers at the beginning of the analysis. While determining these channels, the focus was on the strategies by which the teachers made their verbal questions visible, concretized, tangible, or tactile. A sample of questioning channels was represented in Table 1 and Figure 1-a and b.

Table 1. Determining Questioning Channels

Line		Data Excerpt	Questioning practice	Code: Channels of Teacher Questioning
10	TC:	Now, let us draw first what Emel said. We do this to remember. Angle is, she said, what we call the combination of two rays, like this?	Questioning mathematical procedures and/or concepts	 a. Teacher-created static nature of drawings or markings for questioning mathematical procedures and/or concepts Figure 1a
11	Ss:	Angle. *(Students say it altogether.)*		
12	T:	We call it an angle. So here is now an angle for us (pointing to ∠AOB).		
234	S:	Teacher, can I come and show?	Questioning worked example	 b. Student-created static nature of drawings or markings on worked examples in teacher questioning Figure 1b
235	TC:	Come.		
236	S:	Here is 40 degrees. This one should be 50 degrees (represented in blue circle in Figure 8). I stretched it and then created a figure.		
237	TC:	Why is that 50?		
238	S:	Because…		

Therefore, these sentences supported with "*Is that right*" were perceived as questions by the students.

Note: TC: Teacher Caner S: Student Ss: Students

After determining the questioning practice and channels, question statements were specified. The researchers utilized Mason's (2014, p.514) description of questioning, Questioning means here the use of questions and other prompts offered to students so as to help them get unstuck or to direct their attention in a potentially useful way so that they make mathematical progress. The researchers determined questions both with a question mark, e.g., *what do you mean exactly by …?* (Wragg & Brown, 2001, p. 33) and without a question mark which required responses from the students, such as *tell me a bit more about…'* (Wragg & Brown, 2001, p. 33). Some statements with question marks, such as *Did we remember? Do you understand?* or clarification-focused statements, e.g., *Do* *you mean LM ray or LN ray?* were not evaluated as questions because such statements did not address a specific point to question mathematical ideas. In addition, the sentences including “Isn’t it”, “Is that right?” *(e.g., For example, here… Now, here is 116, look at there. Is that right?),* in which the teachers made their students question the mathematical facts they asked by giving them some waiting time, were evaluated within the scope of “question”. Although the wording of these questions is thought to seek students’ approval of the mathematical facts presented by the teachers, there have been situations where the students did not approve the way of teachers.

Validity and Reliability of The Study

In qualitative research, ensuring valid results requires careful interpretation and addressing potential biases (Maxwell, 2009; Yin, 2011). Maxwell (2009) suggests that validity can be maintained by verifying data sources, analyzing data rigorously, and reflecting conclusions through strategies like long-term involvement, rich data, and triangulation. Long-term involvement involves the researcher spending significant time in the research setting. In this study, the researcher observed classrooms for a semester, participating in every math lesson, and conducting informal interviews with teachers to understand their practices and classroom culture. This extensive involvement helped capture routine behaviours and provided deeper insights into the context, making verbatim transcripts more meaningful. Rich data and triangulation involve collecting comprehensive data from multiple sources such as observations and interviews, offering a more accurate depiction of the studied phenomena (Maxwell, 2009).

In this study, data were enriched and triangulated through video transcripts and observational notes, leading to a thorough encoding process focused on lessons about lines and angles. Reliability, which concerns the consistency of study results over time or different settings (Fraenkel et al., 2011), is enhanced by valid research practices. To ensure reliability, peer briefing was used, involving discussions with colleagues to evaluate the data, results, and analysis methods (Fraenkel et al., 2011).

Findings

In this study, teachers' questioning on the topic of lines and angles found two common and five distinct asking styles. This section built on and supported with classroom dialogs, these shared and varied questioning channels in both classrooms.

Similarities of Questioning Channels of Teachers in Nontechnology-Supported and Technology-Supported Mathematics Classrooms

The research findings have demonstrated that the participating mathematics teachers utilized static drawings or markings produced by themselves, in conjunction with ones generated by students and student ideas as instruments for the purpose of posing questions. The subsequent segments of the investigation expounded upon each of these circumstances in great detail, providing explicit examples of the types of inquiries presented by the instructors in these settings.

Using the teacher-created static nature of drawings or markings in teacher questioning

While asking their questions, both teachers utilized either static sketches or added markings to an existing static figure. The fundamental objective behind the teachers' implementation of static drawings or markings was to provide a visual representation of the subject matter under scrutiny within the classroom. Both classrooms employed these two channels to probe mathematical procedures, concepts, and worked examples.

Teacher-created static nature of drawings or markings for mathematical procedures and/or concepts

In a classroom without technological support, Teacher Caner employed visual aids in the form of drawings to facilitate the students' retention of previous knowledge concerning angular regions and to elucidate the concept by utilizing his static drawings. As evidenced by the ensuing dialogue, prior to imparting the objective of drawing an equal angle, he sought to activate the students' background information regarding the representation of an angle. To achieve this, he initially prompted the students to provide definitions of angles, subsequently selecting Emel's definition from among the various definitions offered, and proceeded to scrutinize Emel's definition, culminating in the creation of the drawing depicted in Figure 2, wherein he queried, “she said what we called the combination of two rays, like this?” (Line 10). This guiding question helped the teacher to give students hints that scaffold or lead toward remembering angle concept getting benefit from Emel’s definition. Following to this, the teacher asked a factual question (Line 12) for a specific fact or definition which was angular region. He keeps on asking the same question in Line 12, 14, 16 as well. During the ongoing dialogue, it becomes apparent that the previously depicted figure in Figure 2 served as a catalyst for students to activate their prior knowledge regarding the angular region through questioning. Starting from Line 18, the teacher again used a guiding question by giving clues to the students with the markings he made on the figure he had drawn in Figure 2. As a result of this, he created Figure 3 to address the angular region through the teacher's guiding question (Line 18).

10 TC: Now, let us draw first what Emel said. We do this to remember. Angle is, she said, what we call the combination of two rays, like this?

11 Ss: Angle. *(Students say it altogether.)*

12 TC: We call it an angle. So here is now an angle for us (pointing to ∠AOB). What was the angular region? We are talking about a region now. Yes?

13 S: Teacher, inside or outside of this angle?

14 TC: Yes, you got closer but moved further. What was the angular region?

15 S: Outside the region.

16 TC: Yes?

17 S: The region inside the angle.

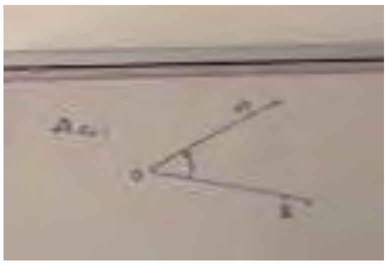


Figure 2. Teacher-created static drawing for the definition of angle

18 TC: Yes. If I shade the arms of the angle and the region, inside that region like this (*marking inside the region*), this area is now a region, a surface, what do I call it?

19 Ss: Angular region *(Students say it altogether.)*

20 TC: Angular region. Do you remember this?

21 S: Yes. We remember.

Figure 3. Using teacher's static drawing for the concept of angular region

In the tech-supported classroom as evidenced in the ensuing dialogue, students posed the questions *Teacher, how can we obtain points? I agree (how can we obtain points?) According to what (we obtain points?) (Line 83, 84, 85)* regarding the mathematical procedures of creating an equal angle when faced with a worked-out example represented in Figure 4. The worked-out example requires students to make the creation of an equal angle to the FLN angle. Although the teacher concluded the lesson on drawing congruent angles by applying the demonstration of the isometric drawing procedure prior to providing the worked-out example, students kept on questioning as to how points may be obtained and the means by which they are obtained with respect to the worked example.

83 S: Teacher, how can we obtain points?

84 S: I agree.

85 S: According to what (we obtain points?)

86 TB: The corner of the square units.

87 S: Okay.

88 TB: Listen to me, why do we *(apply the procedure), because* here it is easier to detect the vertical distance. Right?

89 If you want, you can choose from here or from there *(showing any points on the line*). However, if you select this point, is it possible to determine the distance as integers? 1,2,3, … Do you know what the exact coordinates of the point are?

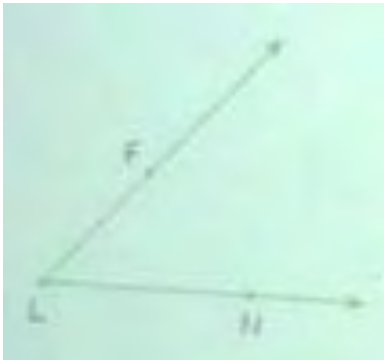


Figure 4. The worked-out example

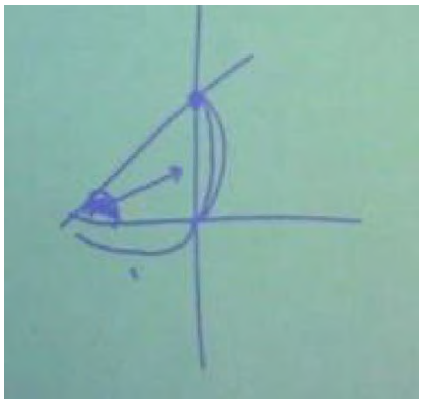


Figure 5. Teacher-created static drawing for the procedure of creating equal angle

The teacher directly addressed the student's question (Line 86). Although the question was answered, the teacher probed the student's question further by elucidating the reasoning behind the process of creating an equal angle (Line 88-89) by means of a drawing featured in Figure 5 supporting the channel with the guiding questions in a leading manner such as "*why do we (apply the procedure), because here it is easier to detect the vertical distance. Right?* (Line 88)*, is it possible to determine the distance as integers? 1,2,3, …", "Do you know what the exact coordinates of the points are*?" (Line 89). The important thing to note here is that the teacher does not solve the question, but draws himself a figure for questioning a mathematical procedure, creating equal angle, separately from the worked-out example.

The teacher employed a visual aid in the form of a drawing to facilitate student comprehension. Given that this illustration was integral to resolving the aforementioned worked example and neither the instructor nor the pupils had yet resolved it, it was crucial for the students to fully comprehend the static drawing presented by the teacher. The teacher skillfully incorporated the non-existent static drawing on the board as an intermediary between student question and the teacher pertaining to the creation of equal angles.

Teacher-created static nature of drawings/markings on worked examples

Both teachers posed questions pertaining to the worked examples, which subsequently evolved into a channel that served as a contextual basis for the instructors to pose specific questions concerning the worked example itself. As is evident in the following dialogue, the instructor presented a worked-out example (Figure 6) necessitating that the pupils create an angle of measurement equivalent to FLN.

74	TB:	(The worked example) set the point (F) there. This one is a ray LM. This is a combination of both rays, a point (L) is common. They are the rays whose common point is L. You can choose this one (the red bubble in the figure below), it has a corner. You can choose that one as well *(pointing to other possible points on the LF ray).* Which one you like.
75	S:	F.
77	TB:	You choose F. Okay, what is the vertical distance of F?
78	S:	2.
79	TB:	2? Okay, 2 units, vertical. (What is) horizontal?
80	S:	That is also 2.
81	TB:	2 units, horizontal (distance). We say 2 units, horizontal (distance), right? Therefore, when I choose two-two, three-three, five-five, one hundred-one hundred, and one thousand-one thousand, do I get an angle equal to that angle?
82	S:	Yes.
		Teacher Barış, 2nd lesson, Line 74 – 83

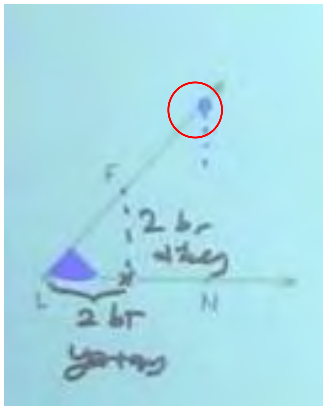


Figure 6. The use of teacher's static drawing on the worked example

Despite the worked-out example appearing to solicit a solution through consideration of the F point, the instructor inquired as to which point the pupils preferred by asking *Which one you like* allowing the pupils to freely select either F or another point during the solution phase (Line 74). With this guiding question, he supported the students to think about or recall the strategy of creating equal angle procedure from a wider perspective by leaving them free to think about the strategy. The teacher asked the students the horizontal and vertical lengths of the F point they chose in the coordinate plane (Line 77 and 79) by factual questions that requires students to provide the next step in a procedure and simultaneously indicated them on the Figure 6 with his drawings or markings. Finally, by showing them in the figure, the teacher asked the guiding question in a leading way (Line 81) to determine whether choosing the points ensured that a one-to-one ratio would create equal angles.

Using student-created static nature of drawings on worked examples in teacher questioning

The students produced drawings illustrating the solutions to the worked examples, providing the teachers with evidence to question about the students' comprehension of the worked examples. By questioning the students' drawings, the teachers successfully resolved any confusion surrounding the worked examples and the students took an active role by sharing their ideas through teacher questioning during the worked examples. The teachers facilitated the students' ability to articulate their ideas by having them work on their drawings. The aim was to eliminate any confusion the students may have had with the worked examples by examining their drawings and to understand what they intend to say.

As is apparent in Figure 7, the classroom dialog displayed a worked example related to two parallel lines intersected by a third line. The student made drawings including creating a line whose starting point was O (therefore transferring 50º to COD) and creating a right line whose starting point was C (therefore finding an 40º angle) on the worked example as represented in Figure 8. In response to this approach of the student, Teacher Caner, in non-technology supported classroom, posed the probing questions (Line 237, 239, 241).

234	S:	Teacher, can I come and show?
235	TC:	Come.
236	S:	Here is 40 degrees. This one should be 50 degrees (represented in blue circle in Figure 8). I stretched it and then created a figure.
237	TC:	**Why is that 50?**
238	S:	Because…
239	TC:	Hey, you need to use parallelism in order to make opposite angles. **Which ones are parallel?**
240	A.S:	No one is parallel (to each other) because not 90 degrees, but that is 180 degrees.

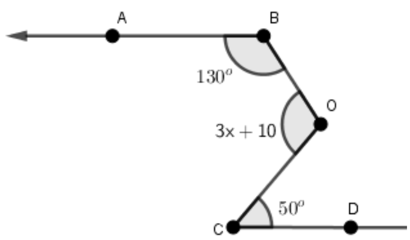


Figure 7. The worked example

241	TC:	Okay, wait a minute, you drew a right line (*represented as yellow line*) here. Okay. 40 degrees. **What are you going to do (with that 40 degrees)?**

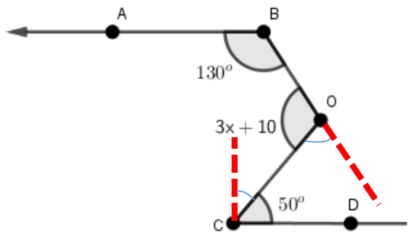


Figure 8. Student's drawing on the worked example

242	S:	(no answer)
243	TC:	Well, if the line was parallel to that line (represented as green lines), you can say that they are interior angles. However, there is not such a situation here.

Teacher Caner, 3rd lesson, Line 234-243

Note. A.S: Another student

Thanks to the student's drawings, the teacher asked a probing question *Why is that 50?* to justify the reason why he put the angle of measurement (50°) in that place (Line 237). Following to this, the teacher asked another two probing questions (Line 239 and Line 124) to elaborate on his thinking about parallelism (Line 239) and make explanation about the description of the usefulness of 40° angle (Line 241) that he found (Line 241). Through the student's drawing for the solution of the worked example, the teacher attempted to mediate a solution to the student conflict with the probing questions.

Using student verbal discourse in teacher questioning

In such cases, in response to the student's ideas, teachers pose questions to students. Here, the teachers respond to the student ideas with a question depending on the nature of the student ideas. In other words, in the teaching environment, teacher questions hang in the air, cannot hold onto anything like a student or teacher drawing, real life example, a textbook definition, or an animation. As seen in the following dialogue, Teacher Barış followed up student's comment by saying *what did you not understand?* (Line 45). The probing question provided the student to make explanation or elaborate about his opinion. In the other classroom, Teacher Caner asked a factual question *What did you find?* (Line 101) to learn the answer of the exercise from many students.

44	S:	Teacher, I did not understand anything in terms of angles (content).
45	TB:	What is it that you did not understand?
		7th lesson, Teacher Barış
100	TC:	The problem is like this […] We need to find x.
101	TC:	What did you find?
102	S:	270.
		Teacher Caner, 3rd lesson

Similarities of the questioning channels showed that using teacher-created static nature of drawings or markings, using student-created static nature of drawings on worked examples, and using student verbal discourse in teacher questioning were common in both technology-supported and non-technology supported classrooms and those strategies were non-technology related question strategies.

Differences Identified in Teacher Questioning Channels in Favor of the Technology-Supported Classroom

The investigation revealed that the integration of technology in the classroom had a positive impact on the questioning channels employed by the teacher teaching in tech-supported classroom. Specifically, the study identified five distinct questioning channels that were unique to the tech-supported mathematics classroom. These included (1) the use of student-created static drawings to illustrate mathematical concepts and procedures to be questioned, (2) teacher-created dynamic drawings to facilitate questioning of mathematical procedures or concepts, (3) readily available educational animations to illustrate mathematical concepts and procedures to be questioned, (4) analogies to enhance questioning of mathematical procedures and/or concepts, and (5) real-life examples to further questioning of mathematical procedures and/or concepts. Notably, these channels were not observed in nontechnology-supported classrooms. Although these channels have been identified in the tech-supported classroom, not all of these channels are technology-based questioning channels. The subsequent section provides a detailed explanation and examples of these identified channels.

Using the student-created static nature of drawings for mathematical procedures or concepts in teacher questioning

In addition to the other use of students' drawings in teacher questioning on worked examples in teacher questioning, students' drawings have also been utilized for questioning mathematical procedures or concepts. This utilization of drawings has been observed in instances where the teacher aims to question the textbook explanation of congruent angles through a student's drawing. The ensuing discourse exemplifies how the teacher endeavors to interrogate the concept of 'congruent angle' and the process of relocating congruent angles in appropriate positions, utilizing the static drawing of the student as depicted in Figure 9a-c.

15 TB: I am reading (the text about a definition). Aylin will draw what she understood. A thing is parallel between two lines, (while) the other thing is not between two parallel lines, but they both face the same direction. What do you understand from that?

16 S: That is what I understood (from the text). Well, for example, the angle here (referring to red circle in Figure 9a).

17 TB: That is one of them. That is between (the lines), right? That is between the two parallel lines. Where is 'not between the two parallel lines?'

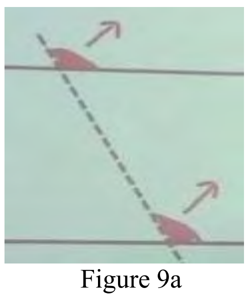


Figure 9a

17 S: 'not' is here. Can be (that one)? (referring to

yellow circle in Figure 9a)

18 TB: Can't be the other one? (Referring to orange circle in Figure 9b)?

19 S: It can be that one (pointing the purple circle in Figure 9b).

20 TB: What are they, which ones are corresponding angles?

21 S: Corresponding angles are this one and that one (the student was marking the blue angles and black angles in Figure 9c)

22 TB: Why are they corresponding angles?

23 S: Because they face the same direction.

24 TB Did you understand?

25 Ss: Yes.

Teacher Barış, 7th lesson, Line 7 – 18

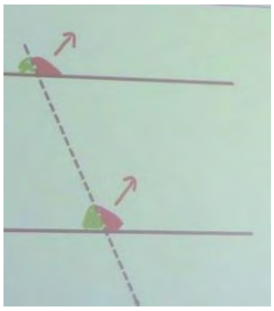


Figure 9b

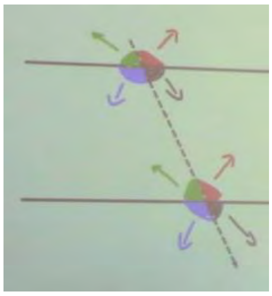


Figure 9c

As demonstrated in the preceding conversation, the teacher instructed the student to visually represent her comprehension of the textbook definition. This definition, rephrased by the teacher as " a thing is parallel between two lines, (while) the other thing is not between two parallel lines, but they both face the same direction" (Line 15), served as the basis for the drawing. While the student was dealing with creating her drawings, the teacher employed questioning techniques to uncover the student's thoughts concerning the concept of congruent angles. These questions (i.e., *That is between the (lines), right?, Where is 'not between the two parallel lines?, Can't be the other one?, Why are they corresponding angles?)* not only facilitated the teacher's understanding of the student's interpretation of the related angles but also prompted her to articulate her ideas more comprehensively. As reflected in Lines 8, 10, 12, 14, and 16, the student initially indicated one feasible instance of a congruent angle. The teacher, employing strategic questioning, guided her to recognize alternative methods of positioning angles. Additionally, the teacher provided explanations for why the highlighted angles qualified as congruent angles.

Using teacher-created dynamic drawing for mathematical procedures or concepts in teacher questioning

In the context of the technologically enriched classroom, the teacher employed the dynamic visualization tool GeoGebra to generate illustrative dynamic drawings during instructional sessions. These visual representations served as instrumental aids of teacher questioning in the facilitation of conflict resolution pertaining to mathematical procedures or conceptual ambiguities experienced by the students.

As seen in the following dialogue, a questioning episode was initiated with a student question as to whether an equal angle was created using additive reasoning on the segments of angle as well as using multiplicative reasoning on the segments.

216 S: Teacher, do we have to increase [the length of the line segments] one by one? Don't we do that by adding [numbers to the length of the line segments] (see Figure 10)

217 T: Hımm, she says, for instance, that is five, let's increase by one. Let's increase here by one as well, and six. That is impossible. Let's try if you want (see Figure 11).

218 S: Let's try.

219 T: Yes. We are going to test Damla's idea. Yes, I am drawing an angle. What are the coordinates, two and two [the distance of point C to the point B], what are the coordinates, let's do two and three [the distance of point A to the point C] (see Figure 12). I am doing like that. Check me if I am measuring [the angle] correctly. The distance... three… is there any problem? All right. How many [units] to increase?

220 S: Two.

221 T: Let's increase by two. Would that be four, and would that be six?

222 S: Teacher, in that case, they will be congruent [to each other].

223 T: Let's increase by three. I am increasing by three. That [distance of a point to the axis of ordinate] would be five, and that [distance of a point to the axis of abscissa] would be six. That was five and six? What I did is, I increased that one by three and that one by three as well. We are checking if they are equal [to each other] in the measurement of the angle. I am selecting the points. The measurement of the angle is $50,19^0$ and the measurement of the angle is $50,31^0$ (see Figure 12). Let's see. Is there something like that? Is the rate important?

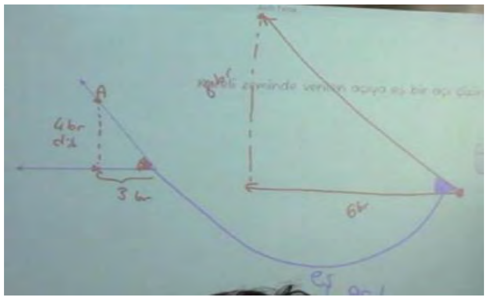


Figure 10. Creating a Congruent Angle by Multiplicative Reasoning

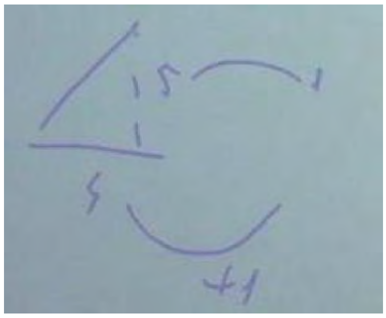


Figure 11. Creating a Congruent Angle by Additive Reasoning

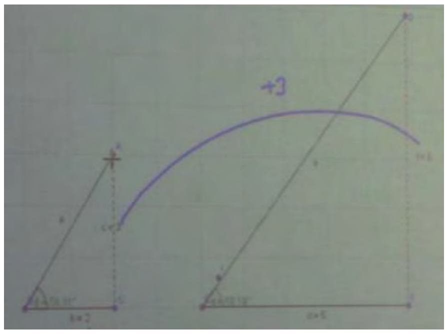


Figure 12. Creating an Incongruent Measurement of Angles by Additive Reasoning

Corresponding to the student question, the teacher created static nature of drawings to to visualize what the student intend to say and to question that congruent angle can not be created by additive reasoning (Figure 10-11). Following this, he responded to her question explicitly, saying that "That's impossible" (Line 217, see Figure 10-11), but he gave another opportunity to her to test her idea. As the student agreed on testing her idea, the teacher started to create a dynamic figure (Figure 12).

To do this, the teacher created horizontal and vertical line segments proportional to each other and then benefited from the measurement quality of the GeoGebra. He found the measurement of the angles in both figures ($50,19^0$ and $50,31^0$) and proved that the angles would not be equal if the students applied additive reasoning while constructing a congruent angle (see Figure 12). The following classroom dialog exemplified how GeoGebra assisted the teacher's questioning concerning the student's question:

Using a ready-to-use educational animation and textbook definition in supplementary textbook for questioning mathematical procedures or concepts

In the technology-enhanced classroom, the teacher asked the students some questions about educational animation in the supplementary book running with the help of a smartboard. The educational animation was represented on the title of a page of the supplementary book as a flash icon and run by flash player. The animation is represented in Figure 13.

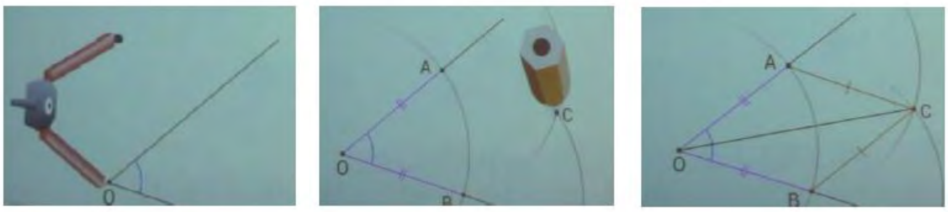


Figure 13. Educational Animation that Represents the Procedure About How to Draw A Bisector with Compasses

This educational animation included the procedure about how to draw a bisector with a compass. The teacher watched the animation with the class. During the session of playing, the teacher asked the students about the procedure of drawing a bisector in a leading manner, stating "*It drew a ray with one of the legs of the compasses. It drew the other ray with the leg of the compasses. There is an angle there, right? It opened the legs of the compasses; put the corner of the angle, and it drew an arc, didn't it?"* After the end of the playing, the teacher imitated the construction using DGS on the smart board as well.

In the other example, the same teacher wanted students to question about corresponding angles via textbook definition. As demonstrated in the following conversation, the teacher instructed the student to visually represent her comprehension of the textbook definition.

15 TB: I am reading (the text about a definition). Aylin will draw what she understood. A thing is parallel between two lines, (while) the other thing is not between two parallel lines, but they both face the same direction. What do you understand from that?

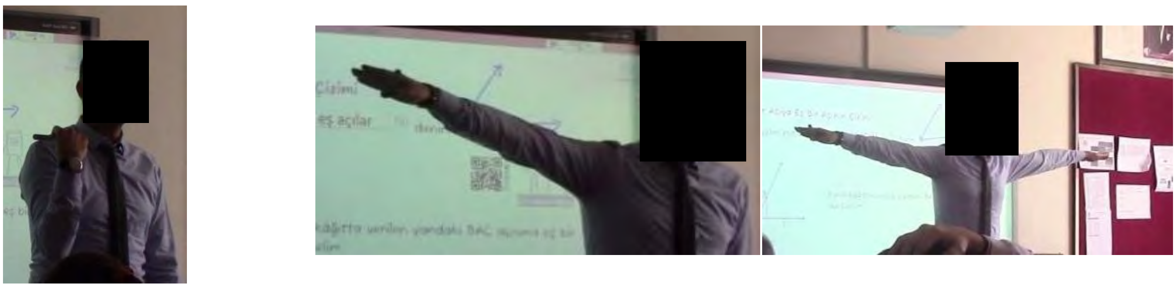
Texbook definition, rephrased by the teacher as "a thing is parallel between two lines, (while) the other thing is not between two parallel lines, but they both face the same direction", which served as the basis for asking *What do you understand from that?* (Line 15).

Using Analogies in teacher questioning

Analogies were employed as an instrument in two ways to facilitate teacher questioning: dynamic-based analogies for questioning mathematical concepts and static drawing-based analogies for questioning about worked examples. This questioning strategy was only utilized in tech-supported classroom. In the ensuing discourses, both applications of analogies were expounded upon.

Dynamic-based analogies for questioning mathematical concepts.

In this kind of use, the teacher asked questions about mathematical concepts through analogies. At the beginning of the instruction, the teacher used an analogy that required students to give meaning to mathematical concepts including point, ray, and line (Figure 14a, 14b, 14c).



a. Point as a shoulder b. Ray as an arm c. Line as opening both of the arms

Figure 14. Body analogy

The analogy was dynamic in nature while the teacher questioned the link between the analogy and mathematics on his own body:

41 TB: Okay, tell me what I am doing now? Assume these (showing the shoulder and the part between the shoulders) as two points. What is this?
42 S: Line segment.
43 S: A ray.
44 TB: (Opening the arms) These are the points. Is that a ray? What is this?
45 S: Line segment.
46 TB: Just a second. What is this?

47 S: Line segment.

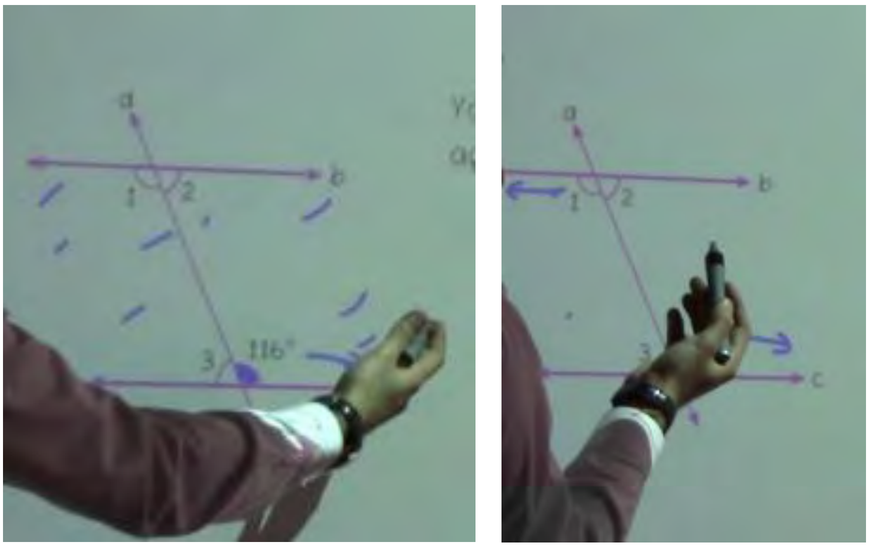
48 TB: That one? You mean the line between the two points. These are the points [that the shape passes] My shoulders. (The teacher opens both of the arms).

49 S: That is a line in that case.

Accordingly, the teacher instructed the students to consider the tips of their shoulders as points and asked, "What is this?" (Line 41), referring to the actual line segment in Figure 14a. Next, by extending one arm to the side, the teacher questioned, "Is that a ray? What is this?" (Line 44), referring to the shape in Figure 14b, prompting inquiry. In response to a student's identification as a line segment, the teacher continued to use analogy, once again prompting the students to identify the actual line segment (Line 46 and Line 48). Subsequently, the teacher reminded the students that the tips of their shoulders represented a point and, this time, with both arms extended (Figure 14c), asked the students to verbally express the concept of a line segment without posing the question explicitly.

Static drawing-based analogies on worked examples

In the other use of analogy we see that the teacher referred to an analogy by drawing while corresponding angles on the worked example representing in Figure 15.



(a) (b)

Figure 15. River analogy on worked examples

107 TB: For example, here… Now, here is 116, look at there. Is that right? Here, 116 is looking at the right side (Figure 15a) and it is on the same side with the river. Right?

108 S: Yes.

109 T: We are thinking it [the parallel two lines] as a river, right? (Figure 15-b)

110 S: Yes

Teacher Barış, 4th lesson, Line 107-111

The worked example requires students to find angles of measurement numbered 1, 2, and 3. According to the teacher, angles numbered as 1 and 2 were located in different rivers where the river flows in different sides. The meaning of different side was marked with short blue segments in Figure 15a and Figure 15b indicated by arrows pointing to the right and left.

Using real-life examples in teacher questioning for questioning mathematical procedures or concepts

Real-life examples were used as a tool for teacher questioning when the teacher wanted to establish a relationship between alternate interior angles concept and spirit level and to question the procedure of finding the appropriate locations on spirit level. As seen in the following dialog, Teacher Barış opened the picture of spirit level from smartboard and used the picture in his questioning:

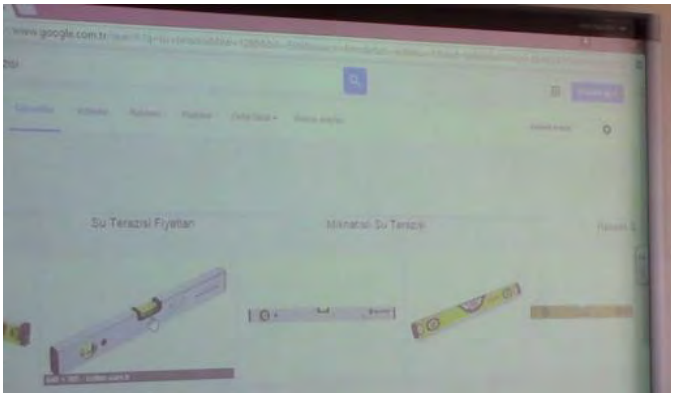


Figure 16. Real life example for questioning mathematical procedures or concepts

111	TB:	Where do we use spirit level?
112	S:	To balance.
113	TB:	Which balance?
114	S:	Balance of a base.
115	TB:	Let's say we make a shelf. One of them is like this, the other one is like that, right?
116	S:	However, they are not parallel.
117	TB:	Not parallel. In that case, if I intersect that line like this, z rule is applicable?
118	S:	No.

Teacher Barış, 7th lesson, Line 111-118

As can be observed in this example, the teacher asked the question *one of them is like this, the other one is like that, right?* (Line 115) and *In that case, if I intersect that line like this, z rule is applicable?* (Line 117) to emphasize the parallel lines and to associate balance and interior angles.

Differences of questioning strategies in both of the classrooms showed that some of those questioning strategies could be technology driven whereas some of them are not related to technology. Among them, using student-created drawings, teacher-created drawings, and static or dynamic drawing-based analogies in teacher questioning can also be implemented in non-technological settings. However, teacher-created dynamic drawings, ready-to-use educational animations, and real-life examples presented on the smartboard via the internet have been strategies that contributed to teacher questioning with the support of technology.

Discussion and Conclusion

The objective of the present study was to gain a deeper understanding of how middle-grade mathematics teachers implement questions in both technology-supported and nontechnology-supported classrooms. The investigation demonstrated that in-service mathematics teachers teaching in technology supported classroom and in non-technology supported classroom employed seven questioning channels: teacher-created static nature of drawings, teacher-created dynamic nature of drawings, student-created nature of drawings, student verbal discourse, a ready-to-use educational animation and textbook definition, analogies, and real-life examples. Commonly both teachers used student-created static nature of drawings on worked examples, teacher-created static nature of drawings on worked examples or mathematical procedures or concepts in their questioning, and using students' verbal discourse. The integration of technology introduced three additional questioning channels in technology-supported classrooms: the teacher-created dynamic nature of drawings, a ready-to-use educational animation and textbook definition, and real-life example. Hence, the utilization of technology has aided the teachers in fostering communication and collaborative efforts with their students via questioning. This finding confirms that the relationship between the teacher's questioning techniques and different media can influence the approach to these techniques (Akkoç, 2013) and the utilization of contemporary technological settings facilitates novel forms of engagement between mathematics teachers and pupils, as posited by Hollebrands and Lee (2016). Notably, the channel of employing analogies which is the remaining channel, was not tied to technology but instead to the teacher's own approach. Therefore, we can say that in addition that teacher questioning is a content and context dependent discourse (Carlsen, 1991; Koizumi, 2013; Nisa & Khan, 2012), there could be basically technology-dependent or teacher-dependent questioning channels.

There may be different reasons for the emergence of these channels. While the use of static drawings created by teachers seemed influenced by instructional content, such as teaching lines and angles that necessitated drawing, the channels involving real-life examples and analogies were more independent of specific content. The use of ready-made educational animations and textbook definition to question mathematical processes or concepts was adopted based on the teacher's systematic use of an e-book as a guide and therefore quite likely stemmed from the teacher following step-by-step instructions in an e-book. Considering that analogies can also be used in different mathematical subjects and that the analogies that emerged in this study were used independently of technology and the supplementary book, we can easily say that these uses do not originate from technology but rather analogies represented the teacher's own approach of questioning. Taking all these elements into account, the act of teacher questioning can be contextualized in the following manner: the questioning by mathematics teachers in classroom settings could be influenced by technology, reliant on specific textbooks, influenced by content, and molded by the teacher's individual choices.

Moreover, the study disclosed that students' drawings were not only used to question worked examples but also by teachers to inquire about mathematical procedures or concepts in technology-supported classrooms. However, the teacher in the non-tech supported classroom has a tendency of making questioning only on worked examples using student-created static nature of drawings. He did not involve student's questioning mathematical procedures or concepts using student-created static nature of drawings. The variation among the teachers suggests that teachers can play different roles in determining on which questioning channels will be used in teacher questioning. In line with this, the results supported the idea that questioning is a personal action (Mitchell, 1994; Fox, 1983). In addition to this, the questioning channel held the potential to significantly convey to students the value of their thinking processes. This indicated that strategies linked to students' drawings could form part of classroom norms (Cobb & Yackel, 1996) specific to teacher questioning, demanding students to share the responsibility for learning. In conclusion, this study indicates that teacher questions can be influenced by questioning channels employed and technology might in some extend affect on teachers' variety of questioning channels. Moreover, a teacher may have different preferences about which questioning channels they will carry out the questioning.

Implications

In order to support a roadmap of teacher training about questioning, we as mathematics educators should improve perspectives about meaning of using the questioning channels in an effective way for student thinking. Related with this study, now we have an idea that teacher questioning can be applied through visual forms (static or dynamic drawings, animation, picture of real life example, analogies), verbal forms (student verbal discourse), or textual forms (textbook definition). To improve in-service teachers questioning, we may need to think about these questioning channels in detail and as separate cases from each other. We mean that how student-created drawings and teacher-created drawings contribute to classroom learning through teacher questioning are different cases to examine. Because teacher-created drawings may represent a more teacher-oriented questioning environment whereas student involvement with student-created drawings/markings may invite students to represent their ideas. These examples may be not available when teacher-created drawings and student-created drawings/markings are questioned by teachers with chorus yes-no answers in a leading rather than probing manner. Therefore, these channels remind mathematics educators that teacher questioning is a complex behavior but address that varied classroom settings would open the ways for improving teachers' questioning in practice.

Examining the ways in which questioning strategies serve as a means of both teaching and reaching students, in addition to considering the type of question posed, provides insight into the intricate nature of the act of questioning for further studies. Considering the mentioned questioning channels as an initial step, this process can be repeated with getting larger number of teachers and increasing the number of mathematical topics to understand the nature of teacher questioning. Different mathematical topics may have a potential to support using different questioning channels.

Limitations

This study was important in terms of revealing the way that two middle grade teachers use the questions in this specific topic, lines and angles, and the types of the questions while applying their instructions. Therefore, the findings of the study might be explained within the limitation of the content and the participants.

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References

Akkoç, H (2013). Pre-service mathematics teachers' practice of questioning in computer learning environments. In B. Ubuz, Ç. Haser, & M.A. Mariotti (Eds.), Proceedings of the Eight Congress of the European Society for Research in Mathematics Education (pp. 2514–2523). Antalya, Turkey: Middle East Technical University and ERME.

Ali, R. M. (2007). Teacher talk in mathematics classrooms: Questioning to establish procedural competence. In Proceedings of the Second International Conference on Science and Mathematics Education (pp. 342-352). Penang, Malaysia: SEAMEO Regional Centre for Education in Science and Mathematics.

Aizikovitsh-Udi, E., & Star, J. (2011). The skill of asking good questions in mathematics teaching. *Procedia - Social and Behavioral Sciences*, *15*, 1354–1358.

Burns, M. (1985). The role of questioning. *The Arithmetic Teacher, 32*(6), 14-17.

Camenga, K. A. (2013). Developing Independence in a Capstone Course: Helping Students Ask and Answer Their Own Questions. *PRIMUS: Problems, Resources, and Issues in Mathematics Undergraduate Studies*, *23*(4), 304–314. https://doi.org/10.1080/10511970.2013.764363

Carlsen, W. S. (1991). Questioning in Classrooms: A Sociolinguistic Perspective. Review of type Educational Research, 61(2), 157–178.

Cayton, C., Hollebrands, K., Okumuş, S., & Boehm, E. (2017). Pivotal teaching moments in technology-intensive secondary geometry classrooms. *Journal of Mathematics Teacher Education*, 20, 75-100.

Cobb, P., & Yackel, E. (1996). Constructivist, emergent, and sociocultural perspective in the context of developmental research. *Educational Psychology, 31*(3/4), 175–190.

Fox, D. (1983) Personal theories of teaching, *Studies in Higher Education, 8*(2), 151-163.

Fraenkel, J.R, Wallen, N.E., Hyun, H. (2011). *How to Design and Evaluate Research in Education* (New York: McGraw-Hill).

Franke, M. L., Webb, N. M., Chan, a. G., Ing, M., Freund, D., & Battey, D. (2009). Teacher Questioning to Elicit Students' Mathematical Thinking in Elementary School Classrooms. *Journal of Teacher Education*, *60*(4), 380–392.

Goos, M. E., Galbraith, P. L., Renshaw, P. and Geiger, V. (2000). *Classroom voices: Technology enriched interactions in a community of mathematical practice.* Paper presented at the International Congress on Mathematical Education, ICME 9, Tokyo.

Harbaugh, A. P., Carter, T. A., & Capraro, R. M. (2008). Quality of Instruction: Examining Discourse in Middle School Mathematics Instruction, *Journal of Advanced Academics, 19,* 376–410.

Harrison, A. G., & Treagust, D. F. (2006). Teaching and learning with analogies friend or foe? P. J. Aubusson et al. (eds.), Metaphor and Analogy in Science Education, pp. 11-24.

Hattie, J. (2008). *Visible Learning, A Synthesis of Over 800 Meta-Analyses Relating to Achievement.* NY: Routledge.

Hollebrands, K. F., & Lee, H. L. (2016). Characterizing questions and their focus when teachers implement dynamic geometry tasks. Journal of Mathematical Behavior, 43, 148–164.

Hufferd-Ackles, K., Fuson, K. C., & Sherin, M. G. (2004). Describing Levels and Components of a Math-Talk Learning Community. *Journal for Research in Mathematics Education, 35*(2), 81–116.

Hunter, R. (2008). Do they know what to ask and why? Teachers shifting student questioning from explaining to justifying and generalizing reasoning. In Figueras, O., Cortina, J.L., Alatorre, S., Rojano, T., & Sepúlveda, A. (Eds.). *Proceedings of the Joint Meeting of PME 32 and PME-NA XXX.* Vol. 3. México: Cinvestav-UMSNH.

Jiang, Y. (2014). Exploring teacher questioning as a formative assessment strategy. *RELC Journal*, *45*(3), 287–304.

Koizumi, Y. (2013). Similarities and differences in teachers' questioning in German and Japanese mathematics classrooms. *ZDM*, *45*(1), 47–59.

Martin,C., Polly, D., McGee, J., Wang, C., Lambert, R., & Pugalee, D. (2015). Exploring the Relationship between Questioning, Enacted Mathematical Tasks, and Mathematical Discourse in Elementary School Mathematics. *The Mathematics Educator, 24* (2), 3–27.

Mason J. (2014). *Questioning in mathematics education.* In: Lerman S, editor. Encyclopedia of mathematics education. Mahwah (NJ): Springer; p. 513–519.

Mason, J. (2002). Minding your Qs and Rs: effective questioning and responding in the mathematics classroom, in L. Haggerty (Ed.) *Aspects of Teaching Secondary Mathematics: perspectives on practice*, RoutledgeFalmer, London, 248–258.

Maxwell, J. A. (2009). *Designing a qualitative study.* In: Bickman, L., Rog, D.J. (Eds.), The SAGE Handbook of Applied Social Research Methods, second ed. SAGE Publications, Thousand Oaks, CA, pp. 214–253.

Menezes, L., Guerreiro, A., Martinho, M. H., & Ferreira, R. A. T. (2013). Essay on the role of teacher's questioning in inquiry-based mathematics teaching. Sisyphus Journal of Education, 1 (3), 44-75.

Mitchell, J. (1994). Teachers' Implicit Theories concerning Questioning, *British Educational Research Journal, 20*(1), 69-83.

Monaghan, J. (2004). International Journal of Computers for Mathematical Learning, (9), 327–357.

MoNE (2013). *Ortaokul matematik dersi öğretim programı (5, 6, 7 ve 8. Sınıflar).* T.C. Milli Eğitim Bakanlığı, Ankara.

Nisa, S., & Khan, A. A. (2012). Questioning Practices in A Social Studies Classroom : A Case Study from Pakistan. *International J. Soc. Sci. & Education, 2*(3), 474–482.

Orrill, C. H. (2013). *The SimCalc Vision and Contributions.* In Hegedus, S., & Roschelle, J. (Eds). The SimCalc Vision and Contributions (pp. 285-298). Netherlands: Springer.

Olkun, S. & Toluk, Z. (2004). Teacher Questioning with an Appropriate Manipulative May Make a Big Difference, *Issues in the Undergraduate Mathematics Preparation of School Teachers, 2,* 1 – 10.

Parks, a. N. (2010). Explicit Versus Implicit Questioning: Inviting All Children to Think Mathematically. *Teachers College Record, 112*(7), 1871–1896.

Piccolo, D. L., Harbaugh, A. P., Carter, T. A., & Capraro, M. M., & Capraro, R. M. (2008). Quality of Instruction: Examining Discourse in Middle School Mathematics Instruction, *RMLE Online, 19*(3), 376–410.

Redfield, D. L., & Rousseau, E. W. (1981). A Meta-Analysis of Experimental Research on Teacher Questioning Behavior. *Review of Educational Research, 51*(2), 237–245.

Sahin, A., & Kulm, G. (2008). Sixth grade mathematics teachers' intentions and use of probing, guiding, and factual questions. *Journal of Mathematics Teacher Education*, *11*(3), 221–241.

Shahrill, M., & Clarke, D. J. (2014). Brunei Teachers' Perspectives on Questioning: Investigating the Opportunities to "Talk" in Mathematics Lessons. *International Education Studies*, *7*(7), 1-18.

Widjaja, W., Dolk, M., & Fauzan, A. (2010). The role of contexts and teacher's questioning to enhance students' thinking. *Journal of science and mathematics education in Southeast Asia, 33*(2), 168-186.

Way, J. (2008). Using questioning mathematical to stimulate mathematical thinking, *APMC, 13* (3), 22–27.

Wells, G. (1999). *Dialogic Inquiry: Towards a Sociocultural Practice and Theory of Education.* Cambridge University Press.

Wragg, E. C., & Brown, G. (2001). *Questioning in the Secondary School*. *Successful Teaching Series*. Taylor & Francis Group.

Vygotsky, L. S. (1978). *Mind in Society: The Development of Higher Psychological Processes.* Harvard University Press.

Vygotsky, L. S. (1987). *The collected works of L. S. Vygotsky, Vol. 1. Problems of general psychology.* (R. W. Rieber & A. S. Carton, Eds.). Plenum Press.

Yin, R. K. (2011). *Qualitative Research from Start to Finish* (First Edition). Guilford Press.

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