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EXAMINING THE TYPE AND QUALITY OF QUESTIONS ASKED BY A SCIENCE TEACHER

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Abstract. *Exploring science teachers' classroom assessment behaviors is a way to understand the professional knowledge competencies underlying effective teaching practices. One of the most important components of in-class assessments is teacher questions. However, studies examining teacher questions that provide support to accurately determine student learning and manage the lesson effectively are quite limited. This research presents a case study of a science teacher in Turkey regarding the question types and questioning proficiency in the teaching of 5th grade "Measurement of Force and Friction" and "Matter and Change". The data have been collected through course observations. The study used an observation evaluation protocol to analyze the video recordings taken from the science teacher's lectures. The results of this study showed that about half of the questions that the science teacher has asked in his class remain at a partially appropriate and inappropriate level, and that the teacher mostly prefers questions that aim to evaluate real information and summarize what is important in his courses. These results point to the need for professional development on a teacher's questioning practices. Therefore, it can be said that those who plan professional development programs for science teachers should consider efforts to improve teacher questioning practices.*

Keywords: *case study, classroom observation, science questions, science teacher questioning*

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Introduction

Questions which accelerate personal development and contribute to the advancement of humanity are an integral part of human life. Therefore, it is not surprising that questions occupy a central place and are a fundamental educational tool in the teaching and learning of all disciplines including science education (Dori & Herscovitz, 1999). Asking questions is a way to teach students by revealing their understanding of a topic and then guiding them to explore a range of logical outcomes instead of lecturing them on what is right and wrong (Vale, 2013). In addition, asking questions is a way of questioning from teacher to student as a way of checking that ideas are indeed correctly communicated and received in full (De Jesus et al., 2003). Teachers who reveal and use students' thinking as the basis of instructional decisions can positively affect students' learning (Ruiz-Primo & Furtak, 2007). The idea that successful teachers can greatly influence student achievement is a central tenet of most educational effective models and is increasingly a powerful driver of education policy internationally (Martínez et al., 2012). In this regard, the Ministry of National Education in Turkey embarked on a major educational reform in science in 2018. In line with this reform, it has been emphasized that the priority in order to ensure the effectiveness of measurement and evaluation practices is expected from teachers, not from curricula. Hence, quality and originality are the main expectations from teachers in terms of measurement and evaluation studies in lessons. It is also emphasized that teachers should turn to formative assessment in their teaching practices (Ministry of Education [ME], 2018). Teachers seize the best possible evidence of what students know through opportunities for formative assessment (Martínez et al., 2012). Ruiz-Primo and Furtak (2007) have emphasized that there is a need for teachers who can interpret the answers of students who have questions that reveal the correct knowledge in the most effective way in the education system in terms of their learning needs and who can use this information to organize their teaching. Teachers' assessment literacy influenced by initial teacher education, in-service teacher training, and ongoing teaching experiences improves over time (Edwards, 2017). Teachers need to be able to apply assessment knowledge and skills in a wide variety of classroom settings as part of their teaching practice (Harlen & Gardner, 2010). The academic development of the student is not measured and evaluated with a single technique (Cagasan et al., 2020). There is a lot of evidence that teachers' classroom assessment practices affect students'

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learning and learning environment (Coombs et al., 2018). A teacher's assessment approach consists of both conceptual insights and practical information about student assessment in the context of classroom instruction (DeLuca et al., 2018). However, the questions used in the courses are the most guiding quality for practitioners and students in terms of measurement tools in the teaching process. Questioning behavior in the formative assessment process is the most important technique that teachers should use. Behaviors include questions that will encourage students to reveal more and different types of knowledge to discover students' knowledge (Black & Wiliam, 1998; Shavelson & Ruiz-Primo, 1999). Oral assessment made by the teacher using questions during the lesson is an important element of any effective teaching and learning strategy (Akimov & Malin, 2020). Oral assessment is defined as an assessment that evaluates communication and language skills, examines problem solving, critical thinking, and students' skills in demonstrating their mastery of content and concepts (Borin et al., 2008). Teacher questioning serves many learning purposes such as initiating, reviewing, summarizing, arousing students' interest, guiding students' thinking, mediating students' knowledge construction, and evaluating the achievement of set goals in science (Kayima & Jakobsen, 2020; Kawalkar & Vijapurkar, 2013). It seems particularly promising that students in science classrooms from the early years answer questions to explore their scientific reasoning, evaluate misconceptions, and enable their conceptual development (Bell & Cowie, 2001; Hondrich et al., 2016). The teacher creates opportunities to reveal evidence of students' scientific knowledge thoroughly. Students actively participate in their learning as they become aware of the inconsistencies in their knowledge through the evidence obtained (Ateh, 2015). Teachers ask questions for both formative and summative purposes throughout a class period. The questions asked by the teacher reveal prior knowledge and control the students' evolving understanding (Reiser et al., 2017). Teachers' questioning particularly influences students' subsequent cognitive learning (Kayima & Jakobsen, 2020). Teachers usually use questions as a pedagogical tool to frame students' scientific activities and research (Tanak & Hanuscin, 2021). The questions that science teachers will ask students in their lesson planning or pre-lesson discourse often become different due to the diversity of interactions in the classroom. Sometimes a question is used as a tool to start the thought process; sometimes questions guide the process (Hus & Kordigel Aberšek, 2011). Understanding a classroom context is about understanding the teaching and learning processes and their outcomes (Kayima & Jakobsen, 2020). The context of classroom questioning includes a relationship between cognitive, affective, social, and motivational aspects of learning, and these aspects need to be explored in relation to each other in order to comprehensively understand a teacher questioning (Ho, 2005). Teacher questioning is a prominent feature of class speech (Chin, 2006). Therefore, it is necessary to examine the lessons in their natural environment in order to capture the quality of the questions in the lessons of science teachers and to make comprehensive inferences about their questioning competencies. It can be said that studies addressing teacher questions and emphasizing the importance of these questions are limited in years of research on the teaching processes of science teachers in their classrooms. When the literature is examined, it has come to the fore that the studies on the quality of science teacher questions and which learning features are limited, comprise of only a few studies (Eshach et al., 2014; Hus & Kordigel Aberšek, 2011; Kayima & Jakobsen, 2020; Soysal & Soysal, 2022). Determining questions through classroom observations, which are an important component of teachers' current formative assessment practices, is very important for the accurate determination of the aspects that are disrupted in their teaching since the determination of the situation of science teachers about asking questions can make an important contribution to understanding their inadequacies in their interaction with their students. In addition, it is thought that the study can contribute to the research on the development of science teachers' professional knowledge about classroom assessment and evaluation.

Considering the relevant literature, it is clear that more research is needed on how science teachers practice asking questions. In order to describe this situation through a specific example, in this study, it was aimed to obtain detailed information about the questioning practices of a science teacher.

Related Literature

Science begins and ends with questions (Popper, 1973). The basis of science is to ask questions about the natural world and then look for answers. Asking questions helps bring the true spirit of science to our education system, and the art of asking good questions is an important skill (Vale, 2013). Teachers have used questions to encourage thinking in the classroom since Socrates and probably before him (Arslan, 2006). The intention to understand the student's knowledge is the essence of the assessment (Ateh, 2015). This view is intended to support teachers' "a culture of classroom inquiry and deep reflection in which students learn from discussions

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shared with teachers and peers" (Black & Williams, 1998). Education researchers studying teacher questioning have emphasized the importance of characterizing the context in which a teacher's question arises (Kayima & Jakobsen, 2020). Roth (1996) defined teacher questioning as a case study designed to reveal student knowledge, channeling students' discursive activities into independent explanations and student-centered discussions. A teacher mediates the learning situation by drawing the child's attention to cognitive phenomena. The most common form of this type of teacher mediation at school is teacher questions. Different processes in students' minds are revealed with different types of questions (Hus & Kordigel Aberšek, 2011). Almost all educators agree that science teaching should include more question-based learning and less fact-based memorization (National Research Council [NRC], 2012). One way that science teachers can meet the expectation of building deeper understanding during classroom discussions is to develop the questions they ask their students (Lee & Kinzie, 2012; Resnick et al., 2010). Science educators typically adopt a cognitive functional perspective in verbal questioning and view teacher questions as essential communicative tools to foster higher levels of scientific thinking among students (Oliveira, 2010). There are many reasons why science teachers view asking questions as an important aspect of their teaching practice: questions can be used to assess children's ideas and progress, encourage scientific thinking, encourage both dialogue and curiosity, and support learning (Forster & Penny, 2020). "The questioning process can open new windows by creating opportunities to see thoughts and experiences from new perspectives" (Cooper & London McNab, 2009, p. 204; Olsher & Kantor, 2012). Teacher questioning can help reveal ideas that students take for granted. It can also make students realize that their current explanation is not yet sufficient. In this way, teacher questioning can help students create new questions to further their research (Reiser et al., 2017). Although such cognitive perspectives are consistent with the problem-solving or knowledge-building orientation of question-based science classes, teachers report that they neglect the fact that their questions serve both social and cognitive functions simultaneously (Oliveira, 2009). Chin (2007) argued that productive teacher questioning serves to strengthen and advance student thinking, primarily focusing on revealing appropriate scientific terminology and key phrases students need to express their ideas in a scientific way. Asking questions is an integral part of the scientific inquiry and learning process, and asking good questions encourages interaction between teachers and students (Arslan, 2006). Although scientific questions are used in many ways, not all questions used in science classes are "scientific questions" (De Jesus et al., 2003). Specifically, teachers mostly rely on low-level questions that require students to remember separate pieces of information (Benedict-Chambers et al., 2017). Although the act of asking questions has the potential to greatly facilitate the learning process, it also has the capacity to silence the child and make learning difficult when done incorrectly (Brualdi Timmins, 1998). Asking questions is seen as an important teaching skill in basic sciences. However, research shows that many teachers ask too many questions, especially closed-ended questions, which negatively affects children's intellectual engagement that includes scientific thinking (Forster & Penny, 2020). Moreover, teachers spend most of their time asking low-level cognitive questions and these questions focus on real information that can be memorized (Arslan, 2006). There is a common understanding that such questions will not help students understand the subject thoroughly and in detail and may limit students' learning (Brualdi Timmins, 1998). Students are often asked to describe the factual information they have learned in class with questions at this level (Lord & Baviskar, 2007). The most important emphasis on low-level or recall questions is that they encourage students to memorize information (Chin, 2004). These questions are widely used by teachers to evaluate students' real knowledge level in many classrooms (Yip, 2004). It is thought that the discourse of asking questions in the classroom should allow students to use higher-order thinking skills such as understanding, application, analysis, synthesis, evaluation, or inference (Eliasson et al., 2017). Yip (2004) referred to such questions as high-level questions. High-level cognitive questions can be defined as questions that require students to use reasoning skills such as questioning and analysis. Therefore, it is believed that it is revealed whether the students really grasp a concept or not with the help of such questions (Arslan, 2006). It is very important for teachers to ask higher level questions for students to acquire productive thinking skills (De Boer et al., 2021). The inclusion of high-level questions in lessons as part of the classroom discourse encourages students to think deeper and more reflectively (Eliasson et al., 2017). It has also been shown that students have a deeper understanding of science concepts, form hypotheses, and use evidence to draw conclusions about phenomena in classrooms where high-level inquiry is made (Smart & Marshall, 2013). Perhaps the clearest distinction between lower-and higher-level questions is that although lower-level questions are designed to elicit current answers (e.g., from the textbook, directly from the course) (Renaud & Murray, 2007), higher-level questions are questions that encourage students to think more deeply to make their learning happen,

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such as practice, analysis, or knowledge (Ayaduray & Jacobs, 1997). We also need to consider the purpose of science applications to understand what is a good question. The goal is to understand how and why something happens as it does in the natural world. The questions need to connect with the facts that need to be explained later. We need to go beyond some simple factual questions to help students understand what we aim for in science. If a question can simply be searched in a book or typed into Google to find its answer, this is not a good research question. Teachers need to go beyond yes/no questions like "Do fish breathe underwater?" in science. Moreover, teachers must ask questions based on explanation and mechanism, such as "How do fish get the resources they need to survive?". We also need to do more than simply asking questions with answers that simply name or categorize a phenomenon (Reiser et al., 2017). The most important change for teachers who produce questions during classroom instruction should be that they reduce the number of questions that can cause students to engage in shallow processes such as identification or recall, increasing the number of questions that result in deeper and more inferential processes (Morris & Chi, 2020). Finally, we need to move beyond questions that simply lead to empirical evidence. Good questions not only require empirical evidence from a study, but also create explanations and models that enhance our knowledge and apply to new situations (Reiser et al., 2017). Van Zee et al. (2001) suggested that teachers can help students develop their conceptual understanding and construct scientific knowledge by asking questions that reveal students' individual experiences and encourage students to learn. From this point of view, it is important what kind of questions teachers use to mediate the cognitive process (Hus & Kordigel Aberšek, 2011) because teacher questions and questioning in the classroom show that they are an important part of the big equation regarding effective teaching (Glenn, 2001). Five principles for effective inquiry and questioning in the classroom are expressed as follows (Formative Assessment in Science and Mathematics Education [FaSMEd], 2014):

- Plan to use questions that encourage reflection and reasoning: effective questions are really planned in advance. It is useful to plan a series of questions that improve students' thinking.
- Ask questions that involve everyone: It is very important that everyone is involved in thinking about the questions asked.
- Give students time to think.
- Avoid judging students' answers.
- Follow students' responses in a way that encourages contemplation.

It has been seen that there is a large study literature on the professional knowledge of science teachers in recent years. However, it is obvious that studies on assessment knowledge, which is one of the professional knowledge dimensions of science teachers, are more limited. In addition, it is seen that very few studies focus on teacher questions, which are an important element in determining the quality of classroom assessment processes of science teachers. For example, Kayima and Jakobsen (2020) have turned to developing a predefined question classification taxonomy to characterize the questioning practices of science teachers in the most recent of these studies. Eshach et al. (2014) focused on the number, level, and roles of science teacher questions in the classroom. The results of the research reveal that the vast majority of classroom questions are shaped by teachers and that teachers ask their students twice as many questions as they can. In addition, when the teacher questions are examined in compliance with their level, they determine that they include factual and low-level questions that demand an explanation of a certain procedure. Wood (1998) noted that there is a negative relationship between teachers' predominance of discourse about asking questions and children's ability to engage in a healthy scientific interaction, which is problematic. Biggers (2018) showed that teachers rely on questions provided by curriculum resources, and research questions in elementary classrooms are overwhelmingly teacher-directed, and students are not given the opportunity to develop their own questions for research. Therefore, the important thing is not to ask many questions, but to be able to ask questions that will push children to think at a high level. Morris and Chi (2020) searched the effectiveness of a professional development program in order to change the way two middle school science teachers have asked questions to include more questions that require deeper student answers. The researchers aim to improve teachers' use of interactive and constructive questions for students with this professional development program, which leads to inferential thinking, collaboration, deeper thinking, and therefore stronger learning outcomes. The results of the research indicated that the teachers' effective questioning before and after the practice shows a significant improvement. Moreover, the results of the research showed that there is a positive relationship between the development of teachers' constructive questions and students' learning. Eshach (2010) found that teacher questions play an important guiding role in order to manage

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classroom discourse to promote conceptual comprehension. Soysal (2020) explored the discursive function of a science teacher's questioning and the fundamental cognitive demand situation in his questions. The research results showed that the center of the discursive purpose of teacher questions is to invite students to recognize their conceptual, epistemological, and ontological conflicts. The researcher reported that the teacher questions in this study aim to reveal the thinking flaws of the students and enable the teacher to act as a compelling challenger. Eliasson et al. (2017) discovered the differences in the questions asked by male and female science teachers, and whether the type of these questions affect the answers of male and female students. The results of the research revealed that male and female teachers mostly use closed-ended questions. However, it showed that male students are more likely to respond to closed questions than female students regardless of whether the question is asked by a male or female teacher. The researchers emphasized that closed-ended questions would be considered for students to be questions that are not intended to achieve a high cognitive level, so excessive use of such questions means that students are given fewer opportunities to talk about science. In addition, it was emphasized in the research that closed-ended questions may adversely affect class interaction. In particular, it was reported that this situation may adversely affect the attitudes of female students towards science, which may be seen as a serious obstacle for girls to participate in higher scientific studies. According to these recent studies on the subject, it is clear that researchers are increasingly focusing on the quality and importance of the questions that science teachers use in their lessons. However, most of the research on the assessment quality of science teachers in the relevant literature includes the studies aimed at determining teachers' orientation towards new assessment goals in general.

Research Aim and Research Question

This study aimed to evaluate the diversity and quality of the questions created by a science teacher in the natural process of teaching, that is, in the classroom context, and to reveal due diligence regarding his interrogative discourse quality. This study is an in-depth case study aimed at capturing the quality of the questions that guide teaching in class as opposed to the more established research models used to examine a science teacher's assessment and evaluation thinking. In this context, the research question to be answered is as follows:

What is the type and quality of questions that a science teacher uses in teaching the subjects of 5th grade that are "Measurement of Force and Friction" and "Matter and Change"?

Research Methodology

Research Design

It is more effective to adopt qualitative approaches to examine teachers' actions in the classroom. Therefore, the exploratory case study was adopted in this research. According to Merriam (1998), this research design is the best tool to provide 'definitions and analyses of a single unit or a limited system such as an individual or a group' (p. 19). In the study, it was reported how a single science teacher has questions that shape their teaching practices in the subjects that are "Measurement of Force and Friction" and "Matter and Change" in the 5th grade science course. The main feature of this case study is the focus on the phenomenon of the science teacher questions. In order to conduct in-depth studies on the questioning behavior of the science teacher, the information to be obtained from the lessons was needed. In this context, the teaching process of the science teacher was examined, covering November-December 2018 for "Measurement of Force and Friction" topics, and December 2018 and January 2019 for "Matter and Change" topics.

Participant and Context

The teacher in this study was determined by a purposeful sampling method (Patton, 2015). It was aimed at selecting teachers with 10 or more years of teaching experience for the target sample. In this regard, many science teachers in the region where the study was carried out were consulted and four teachers initially stated that they could be interested in this study. Afterwards, only one of these teachers said that he could be a voluntary participant in the study. The teacher observed in this study is a male science teacher in his mid-thirties with nearly 10 years of teaching experience. It can be argued that the teacher participating in our study is in the period of empiricism-

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activity (7-18 years) as a professional career stage and that the teachers at this stage are more alive and consistent in their teaching processes (Huberman, 1993; Nixon et al., 2019). The method of appointment to places in different regions is applied by the central administration on the condition that they are successful in the undergraduate degree and vocational qualification exam in order to be a science teacher in public schools in Turkey. The teacher in this study passed the vocational qualification examination in the first year and has been still continuing his profession in the school to which he was first appointed at the time of the study. In addition, this teacher has a lot of experience with the subjects selected within the scope of the study. The study was conducted in a classroom consisting of 24 students between the ages of 11 and 12 at a secondary school in the city center of Kars in Turkey. The school where the study was conducted could be considered as a school with limited resources. The students were not direct participants in this study. However, while examining the teacher's questioning interactions, they were indirectly observed and videotaped in the classroom. In 2018, a new curriculum was defined for students between the ages of 10 and 13 in secondary school science education in Turkey. It was emphasized that originality and creativity are one of the basic competencies expected from teachers in order to ensure the effectiveness of these new curriculum assessment and evaluation practices. Therefore, teachers need to be able to ask qualified questions to effectively evaluate student learning in science classes. The subjects that are "Measurement of Force and Friction" (Kaniawati et al., 2019; Sulistri & Lisdawati, 2017; Wells et al., 2020) and "Matter and Change" (Ayas et al., 2010; Kirbulut & Geban, 2014; Sadler & Sonnert, 2016) are an important part of the secondary school science curriculum. In particular, many studies showed that students have a lot of erroneous interpretations about these subjects and struggle with various difficulties in learning these topics. While teaching these topics, teachers inevitably ask many questions. If teachers want to help students learn about these topics, they need to ask effective questions that can accurately diagnose their understanding. Teachers who can do this can only use the right teaching strategies while teaching these subjects to their students and carry out the process well.

For this case study, ethical rules were taken into consideration at every stage of the research. First, institutional permissions and teacher informed consent were obtained. The voluntary basis of the teacher involved in the research was taken into account, and maximum care was taken not to experience a conflict of interest. It was ensured that the teacher took the video recordings himself in a comfortable environment and in order not to feel under stress. No clues identifying the participant's identity were included. The participant was informed that the parts of the course records that he did not see appropriate could be removed. Due to the confidentiality of the data, no information was shared with third parties other than researchers. The research data was carefully analyzed in accordance with its originality and a non-exaggerated language was used to present the results.

Data Collection and Sources

In this study, transcribed video data was used to characterize the questions used by a science teacher in her lessons. Only qualitative data based on classroom observation collected from one teacher were used in the study. The teacher has recorded the teaching process by placing the video recorder wherever he wants before each lesson. The data were derived from transcriptions of lecture recordings in total 7 hours and 40 minutes for the teaching subjects of "Measurement of Force and Friction" and 8 hours and 17 minutes for the teaching of "Matter and Change". The observational data source allows to capture real classroom practices regarding teacher questioning quality unlike previous studies. Moreover, the researchers have determined the details of his questioning practices by observing the teacher in his classroom. The researchers have not taken part in the classroom environment while the course has been recorded.

Data Analysis

The data obtained in most of the previous studies on teacher and student questions have been analyzed by using Bloom's taxonomy. Bloom's (1956) classification is intended to describe questions aimed at revealing students' different thinking skills at the end of the learning process. Each level is measured by different types of questions. However, the researchers adopt the question classification of "Protocol for Evaluating the Question's Adequacy" put forward by Kayima and Jakobsen (2020) in their studies and use the language adaptation of this protocol for the analysis of the data in order to analyze the data of teacher questions emerging from classroom observations in this study. This approach includes a descriptive analysis as it aims to interpret the research data according to previously determined themes (Saldana, 2015, p.102; Yildirim & Simsek, 2013, p.224). This adapted

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form consists of two parts. The first part is a classification of the type of teacher questions. This section is divided into five subclasses that are A1, A2, A3, A4, and A5 depending on the type of problem. However, type A1 is also divided into eleven sub-dimensions (i-xi). Of these sub-dimensions, for example, vi is defined as "a question message for the development of explanations about a previously stated idea" (see Kayima and Jakobsen's study for a detailed description of the other sub-dimensions of A1). Among the other dimensions used for the classification of the variety of questions in the protocol, A2 describes "questions to capture affective learning"; A3 addresses "closed-ended questions to capture student learning with yes/no or just a word or phrase"; A4 includes "questions that are not intended to be answered, where a direct answer is not expected by the person asking the question and are often used to help the speaker emphasize his or her opinion on a topic (Ex: Can you not do something right?)" and A5 includes "structured questions". In addition, the quality of the teachers' questions is described in the protocol as "appropriate question", "partially appropriate question" and "inappropriate question". "Appropriate question" is a question with content that satisfactorily addresses what the evaluator aims to capture in students, "partially appropriate question" is rhetoric in which the teacher answers the question himself, where it is related to assessing learning but does not satisfactorily address the student's current answer, reaction, or situation, is asked unnecessarily, can be answered with yes/no or just a word or phrase and often represents a blind question that ends the current conversation. The "inappropriate" question, on the other hand, refers to questions that are incomprehensible, unclear, where the students are not really sure what the teacher is asking and which aspect of the question they should answer first, the answer to the question is implied in the question itself, and the students are asked even about non-related topics. The data obtained as a result of transcription of video recordings have been analyzed by using "Protocol for Evaluating the Question's Adequacy". The two researchers have first analyzed the transcripts of the same 2-hour lecture recordings randomly selected from the topics "Measurement of Force and Friction" by using the protocol for evaluating. In the next step, it is aimed to establish inter-rater reliability by comparing these descriptive analyzes. Many techniques with various advantages have been proposed for estimating inter-rater reliability, and one of these techniques is the Cohen Kappa statistic (κ) (Bilgen & Doğan, 2017). A reliability analysis is performed using κ to determine the consistency of interpretation between both raters (Cohen, 1960, p. 38; Viera & Garrett, 2005). In this regard, the consistency percentage of the two researchers in order to define the variety and quality of teacher questions has been calculated. The points from 1 to 5 have been given for five dimensions (A1, A2, A3, A4 and A5), each of which represents a separate question type in the first part of the "Protocol for Evaluating the Question's Adequacy" in order to make this calculation. In addition, type A1 is divided into 11 sub-dimensions in this section. Within this section, a scoring from 1 to 11 has been made. Furthermore, the classification of types in the second part of the "Protocol for Evaluating the Question's Adequacy" have been scored as 2 for the "appropriate question", 1 for the "partially appropriate question" and 0 for the "inappropriate question" in order to determine the quality of the questions used by the teacher. The adaptive value between the raters regarding the question types is Cohen's $\kappa = .72$, the adaptive value between the raters regarding the subtypes of the A1 questions is Cohen's $\kappa = .63$, and the adaptive value between the raters regarding the quality of the questions used by the teacher is Cohen's $\kappa = .74$ as a result of the scoring made in this way. Landis and Koch (1977) stated that Cohen's κ values in the range of .61 - .80 mean good agreement between raters. In this regard, it can be said that reliability is ensured in the analyses made by the raters on the sample data. In addition, the type of teacher questions and the reliability of interpreting their quality have been also reviewed by another science educator in this sample analysis study. The raters and the independent science educator aim to reach consensus on the discrepancies between the two raters by making evaluations. Finally, one of the researchers reveals the frequency distribution of the findings by analyzing all the observation data for the diversity and proficiency status of the questions used by the teacher in the teaching of "Measurement of Force and Friction" and "Matter and Change".

Research Results

In the presentation of the findings, firstly, the frequencies of the question quality used by the teacher, and then the frequencies of the question types used in the context of the science topics discussed were included.

The results of the quality of the questions used by the teacher in the lessons of "Measurement of Force and Friction" and "Matter and Change" are shown in Figure 1.

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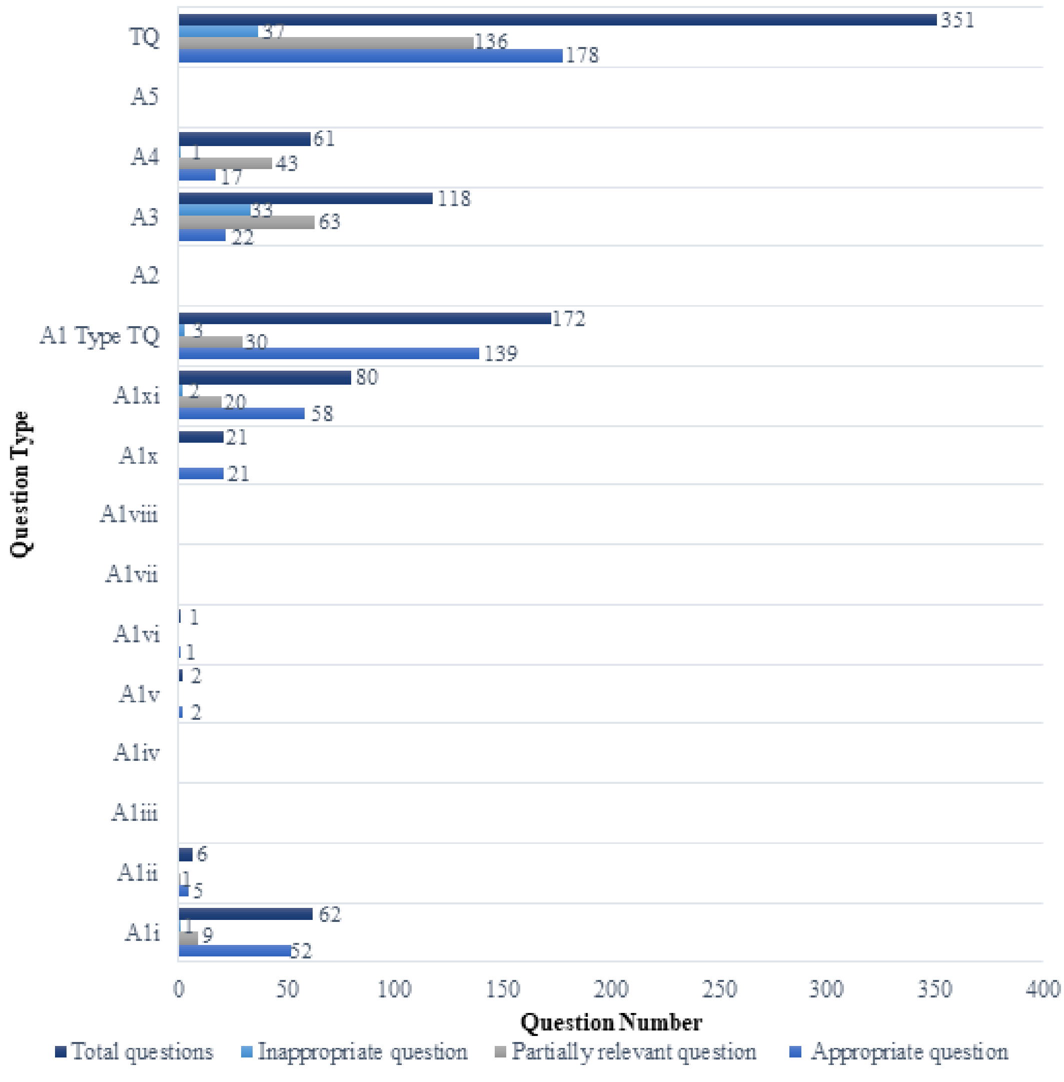
Figure 1
The Quality Status of the Questions Used by Science Teacher



When the results regarding the quality of the questions used by the science teacher in Figure 1 are examined, it is seen that he has asked 351 questions in total, and 178 of these questions are appropriate, 136 are partially appropriate, and 37 are inappropriate (Figure 1). When the types of questions used by the teacher in his lessons are examined, it is determined that he has not included the A5 question type in any of his lessons. In addition, it stands out that this teacher mostly uses A1 question type with 171 questions in his lessons (Figure 1). Within the scope of the study, it is determined that the science teacher has used A1*i*, A1*ii*, A1*v*, A1*vi*, A*x* and A*xi* questions from A1 question types. It is highlighted that he has used 62 questions from A*1i* and 80 questions from A*xi* among these question types. It is also found that 20 of the 80 questions used in the type "A*xi*" are partially appropriate questions. In addition, it is seen that 33 of the 37 inappropriate questions used by the teacher in his lessons are "A3" question types. It is determined that the teacher has used partially appropriate questions, 63 of which are A3 and 43 of which are A4 questions among 137 questions.

The types and quality of questions used by the teacher according to the learning outcomes in the lessons of "*Measurement of Force and Friction*" and "*Matter and Change*" are shown in Table 1.

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Table 1

The Types and Quality Status of Questions Used by Science Teacher According to the Learning Outcomes in the Lessons

Topic	Acquisition	Question Type	Appropriate Question	Partially Appropriate Question	Inappropriate Question
Measurement of Force and Friction	Measures the magnitude of the force with a dynamometer (*S.5.3.1.1*)*	A1*i*	1	-	-
		A1*xi*	2	-	-
		A3	-	-	2
		A4	-	1	-
	Designs a dynamometer model using simple tools (*S.5.3.1.2*)	-	-	-	-
	Gives examples of friction force from daily life (*S.5.3.2.1*)	A1*i*	5	-	
		A3	1	3	-
	Explores the effect of friction force on motion in various environments by experimenting (S*.5.3.2.2*)	A1*i*	5	-	-
		A1*ii*	2	-	-
		A1*x*	6	-	-
		A3	-	2	3
		A4	-	2	-
	Generates new ideas to increase or decrease friction in daily life (*S.5.3.2.3*)	A1*i*	5	1	-
		A1*x*	10	-	-
		A1*xi*	-	1	-
		A3	3	23	9
		A4	3	-	-
Total number of questions		90	43	33	14
Matter and Change	Makes inferences based on the data obtained from its experiments that substances can change state with the effect of heat. (*S.5.4.1.1*)	A1*i*	29	4	-
		A1*ii*	4	1	-
		A1*x*	5	-	-
		A1*xi*	35	11	1
		A3	4	24	13
		A4	4	4	-
	As a result of his experiments, he determines the melting, freezing and boiling points of pure substances. (*S.5.4.2.1*)	A1*i*	4	1	1
		A1*xi*	16	8	1
		A3	6	8	4
		A4	10	2	1
	Explains the main differences between heat and temperature (*S.5.4.3.1*)	A1*i*	2	-	-
		A1*xi*	1	-	-
		A4	-	8	-
	Interprets the results by conducting experiments on heat exchange as a result of mixing liquids with different temperatures (*S.5.4.3.2*)	A1*i*	-	1	-
		A1*v*	1	-	-
		A1*xi*	1	-	-
		A3	4	1	-
		A4	-	5	-
	Discusses the results of the experiments by conducting experiments on the expansion and contraction of substances under the influence of heat (*S.5.4.4.1*)	-	-	-	-
	Relates examples from daily life with expansion and contraction events (*S.5.4.4.2*)	A1*i*	1	2	-
		A1*v*	1	-	-
		A1*xi*	3	-	-
		A3	4	2	2
		A4	-	21	-
Total number of questions		261	135	103	23

**S.5.3.1.1: The outcomes in the Science Curriculum are numbered according to the units. In the numbering system, the code of the course, grade level, unit number, subject number, outcome number are included.*

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When the questions used by the science teacher in the process of Measurement of Force and Friction unit are examined, it is found that he has used 90 questions I total, 43 of which are appropriate, 33 of which are partially appropriate and 14 of which contain the inappropriate question (Table 1). It is determined that the teacher has not used any questions in the process of the acquisition of *"S.5.3.1.2"* within the scope of the unit. In addition, it is determined that all of the questions asked by the teacher within the scope of this unit are aimed at one of the A1, A3 and A4 question types. It is determined that he has used 23 of the 33 partially appropriate questions and 9 of the 14 inappropriate questions in type A3 in the process of the acquisition *"S.5.3.2.3"*. Moreover, it is determined that all of the A1*x* question types used by the teacher in the process of the *"S.5.3.2.3"* are appropriate. The examples of the A3 question types used by the teacher in this process are given below.

Quotes from the teacher's lesson for the A3 question type.

Teacher: *Now take out all the notebooks and books in your bag.*

Students (Altogether): *Okay, teacher.*

Teacher: *Yes, everyone should put their notebooks and books on their desks on top of each other. Now kids, Is it easy to push a book or push all the books?*

Since this question asked by the teacher in type A3 includes one-word answers such as yes or no from the student, this question is considered as a partially appropriate question.

Teacher: *Kids, if the friction force is high, the object gets too hot. Since this place is flat and smooth, friction is low.* (The teacher shows the iron-dust-free surface on which he drives the cars.) *That is, the force blocking the movement of the car is lower. That's why our car moves more easily. But there's iron dust over there. Think of it like a stony road. It prevents the car from moving. The friction is getting more.*

Students (Altogether): *Okay.*

Teacher: *The rougher the surface, the more friction, right?*

Since this question asked by the teacher in type A3 contains the answer in itself, this question is classified as an inappropriate question.

It is determined that all of the questions asked by the science teacher in the type A1 (A1*i*, A1*ii* and A1*x*) are used appropriately while teaching the acquisition *S.5.3.2.2* within the scope of the unit that is "Measurement of Force and Friction". The Quotes for the appropriate questions of type A1 used by the teacher in this process are presented below.

Quotes from the teacher's lesson for the A1 question type.

Teacher: *Well, children, do the objects change due to friction?*

It is determined that the teacher is trying to get the students' opinions about a situation by asking this question. Therefore, this question is considered appropriate in type A1*i*.

Teacher: *So, do you think if we drove that toy car on the lacy cover or on the flat ground, it would go further?* (The teacher spread the lace cover he brought to the classroom on the table and pushed the toy car on it. Then he lifted the cover and drove the car on the table floor.)

Students (Altogether): *Smooth.*

Teacher: *Smooth. So why did it slow down so much over there?* (The teacher showed the lacy cover to the students.)

Since the teacher tries to get the student to explain an idea that he has already stated by asking this question, this question is evaluated as an A1*ii* question type at the appropriate level.

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Teacher: *Now if we rubbed that pencil on sandpaper or shiny smooth glass, would it wear out too much?*

Students (Altogether): *Glass*.

Teacher: *If we rubbed the pencil on sandpaper, that is, on jugged rough paper, or that shiny slippery glass, would the pencil wear out too much?*

Students (Altogether): *Slippery glass.*

Teacher: *I say sandpaper is a jagged surface. It is rough. If we took that pencil and rubbed it on sandpaper or that smooth glass, would it wear and tear out?*

Since the teacher has asked this question and allowed the students to focus on the subject again, this question is qualified as an appropriate A1*x* question.

When the questions used in the matter and change unit are examined, it is determined that 261 questions in total are used, 135 of which are appropriate, 103 of which are partially appropriate and 23 of which are inappropriate. It is determined that the teacher has not used questions for the acquisition of *"S.5.4.4.1"* in the process of this unit in his lessons. In addition, it is emphasized that the teacher uses A1, A3 and A4 question types within the scope of this unit. It is determined that 24 of the 41 A3 question types used by the science teacher are partially appropriate and 13 of them are inappropriate questions within the scope of the acquisition that is *"S.5.4.1.1"*. It is determined that he has used 90 questions of type A1 and only 1 of these questions is inappropriate A*xi* question type within the scope of this acquisition. In addition, it is also highlighted that all of the A4 question types used by the teacher while teaching the acquisitions of *"S.5.4.3.1"*, *"S.5.4.3.2"* and *"S.5.4.4.2"* are partially appropriate questions. The quotations for the appropriate question type A4 and partially appropriate question types used by the teacher in this process are below.

Quotes from the teacher's lesson for the A4 question type.

Teacher: *So, let's try to heat and melt this.* (The teacher meant the snow in the beaker). *The water has frozen at zero degrees Celsius. What temperature does it freeze?* (The teacher put the spirit stove he had brought to the classroom on the table and began to melt the ice.) *Did it melt and turn into water?* (The teacher held up the beaker and asked the students.)

Students (Altogether): *Yes*.

Teacher: *Look, ice is slowly turning into water. Well, let it melt a little more.* (After the ice melts a little more,) *Now look, the ice melted and became water. At what temperature does the ice turn into water?* (The teacher showed the students in turn the thermometer in the beaker.)

Students: *Zero.*

The teacher allows students to express a situation they know and see by asking this question. Considering this situation, it has come to the fore that this question is an appropriate question type of A4, which is not a question.

Teacher: *You enter the house, and it is very cold. You immediately lit the stove. What will spread from the stove to the room? The heat will spread. What happens when that heat spreads? The temperature of the room will increase. If we open the window, what will come from outside? Cold weather will come. What happens when the cold weather comes? What will make the hot weather inside? The warm air will come out and the cold air will come in. So, the temperature will start to drop gradually.*

When this question is examined, it is determined that the answer is clear and the teacher knows how the students will answer this question, which is an A4 question type that is not intended to get an answer. In addition, since the teacher himself has given the answer after asking this question, the question is considered partially appropriate.

The conceptualization of teacher questions based on the research results is shown in Figure 2.

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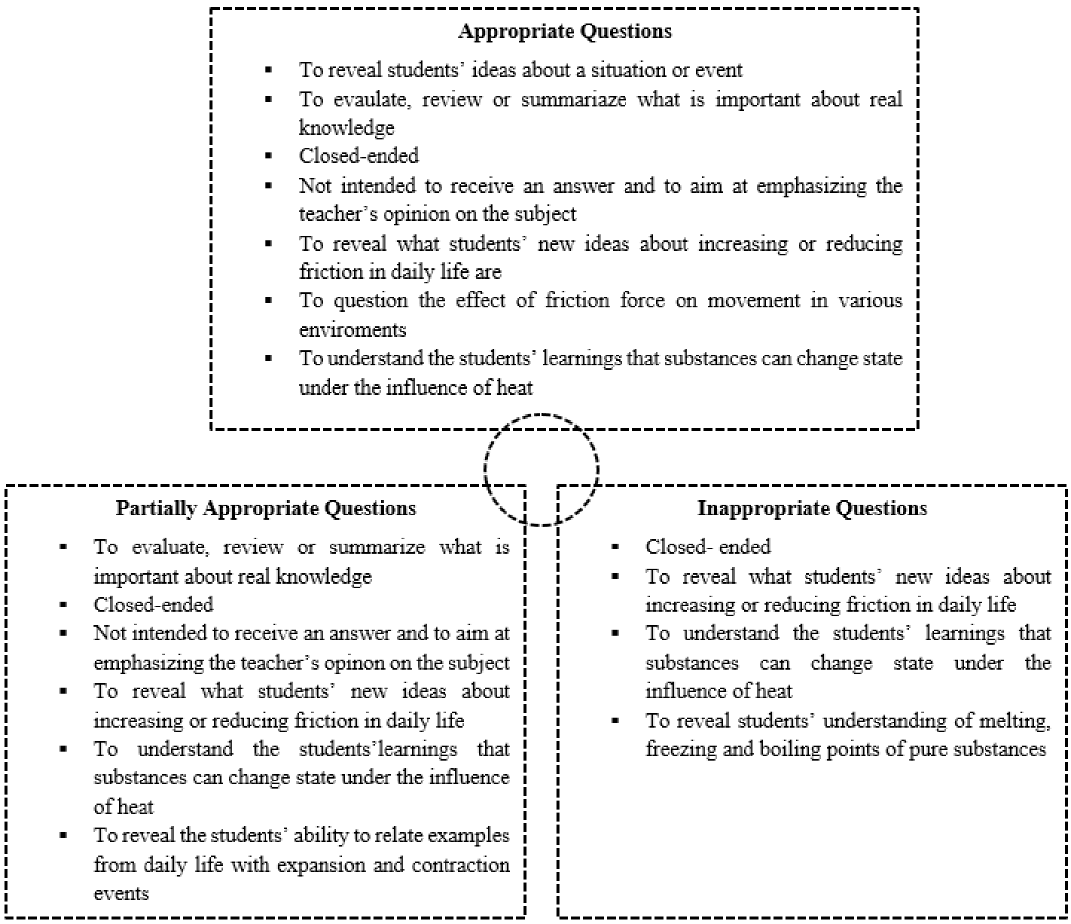
Figure 2
The Quality of Teacher Questions



Discussion

The results obtained from lesson observations regarding the type and appropriateness of the questions used by a science teacher in teaching the subjects in the units that are "Measurement of Force and Friction" and "Matter and Change" are discussed in this section. The aim of this study was to describe the situational appropriateness of the questions used by a science teacher in his lessons. The results provided information about the pedagogical patterns of asking questions, which is one of the in-class formative assessment types of science teachers. The preferred method for this research was an effective way to understand a teacher's practice of asking questions in teaching the broad subject area of thirty-eight hours in the 5th grade science program.

Today, when science teachers are viewed from the perspective of professional knowledge proficiency, a teacher should not only have effective subject area knowledge and be able to apply teaching methods effectively in their lessons, but also have professional knowledge proficiency and depth that can effectively reveal student learning. The analysis results here show that the science teacher under consideration is not able to achieve the goals of asking questions at the desired level in his lessons. It is determined that almost half of the questions used by the science teacher in his lessons include partially appropriate and inappropriate question structures in terms of both subject areas (see Figure 1). It also showed that the vast majority of partially appropriate and inappropriate questions used by the teacher consist of closed-ended questions intended to evaluate, review, or summarize what is important. Eliasson et al. (2017) reached similar results with this research in their study. The researchers found out that the vast majority of science teachers mostly use lower-quality, closed-ended questions rather than high-cognitive

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thinking questions for students. A similar result is reported by Kira et al. (2013). The researchers determined that 80% of the teachers observed do not have an advanced level of using effective questions to measure students' comprehension. In addition, more than 80% of all teachers stated that they have problems about encouraging students to think by striking a balance between different questions. They stated that these teachers have serious weaknesses in guiding classroom discussions through effective questioning as their ability to ask questions is low. It is known that many science teachers today generally avoid using challenging questions in their lessons. This is because teachers think that when they ask effective open-ended questions, they will have difficulty in getting feedback from students. This can be very closely related to a lack of subject matter knowledge. If science teachers want to immediately apply the right teaching processes in their lessons, they should use effective questions that enable students to reveal their knowledge. However, the teacher tends to turn to closed-ended questions to reveal the understanding of his students for the purpose of focusing on the information written and memorized in the textbook. The science teacher we have observed remains weak in asking questions that can improve students' questioning skills. Therefore, the low-quality questions mostly preferred by the teacher reveal that they do not contribute to the development of students' higher-level thinking processes. Therefore, low-quality questions, which are largely preferred by the teacher, reveal the conclusion that they do not contribute to the development of students' higher-level thinking processes. A teacher's ability to ask effective questions is also closely related to the student's cognitive demands. It is emphasized that relying heavily on lower-level questioning strategies is associated with students' activation at lower cognitive levels (Smart & Marshall, 2013). Soysal (2020) has reached confirmatory conclusions in his study. The teacher's need to finish his lesson as soon as possible is one of the most important reasons why he rushes to ask effective questions. It can be said that both research results point to the weakness of the science teacher regarding effective questioning competency. The result here is important because teacher educators and researchers mostly focus on teachers' professional knowledge of assessment and evaluation techniques. However, understanding the nature of teacher questions as the most effective way of assessing students in a real classroom context is an important aspect of recognizing teachers' formative assessment weaknesses. Although the studies of science teachers' understanding of student evaluation often reveal descriptions of their various questioning practices and beliefs, they are not reliable enough as indicators of actual evaluation behavior. This can only be considered as the behavior of teachers to respond to what researchers want to hear. So, this study provides a way to see real questioning practices. A few points that need to be discussed here stand out. This is partly due to the multiplicity of appropriate and inappropriate questions of the teacher and the reasons for this. Another is why the teacher discussed prefers too many closed-ended question types. The most important reason for the deficiencies in the eligibility of the teacher to ask questions can be cited as the lack of understanding and awareness of science teachers on reforms related to assessment knowledge from professional knowledge areas. It is known that there are significant deficiencies in the evaluation of professional knowledge in both pre- and post-service science teacher training. That's because the understanding of how to teach the subject area is largely dominant in both periods. Beyond this point of view, it can be assumed that the pressure of the science teacher to present the curriculum and the impositions of the examination system in Turkey make it difficult to respond to the need for open-ended inquiry, which is the real way to learn science. It may also be one reason why many teachers prefer questions at a lower level than their traditional understanding of self-control of lessons within traditional academic rigidity. That is because related studies showed that teachers still strictly control most of the classroom interactions in science lessons (Jurik et al., 2013).

Conclusions and Implications

The results of the study indicated that the individual situation of the science teacher in questioning his students in his lessons consists mainly of lower quality and closed-ended questions. The results of the research showed that there is much to be done about effective questioning in science teacher education. Moreover, it showed that there are serious deficiencies in the preparation of science teachers to ask high-level cognitive questions. This initiative to conceptualize the ability of an experienced science teacher to ask questions in a real classroom context could encourage science educators to find new ways to capture teachers' professional knowledge weaknesses in assessment.

The results from this study have several implications for science teacher education. First, science teacher educators need to direct pre-service science teachers to the practices that will shape their understanding of asking effective questions in the pre-service period. In addition, educators should support teachers' in-service professional development to gain sensitivity to the development of assessment knowledge on the basis of effective question-

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ing. In particular, these training courses should include practices that will improve the ability of science teachers to ask the kind of questions that will lead their students to question and explore. In this regard, it may be useful for science teachers to examine and discuss the competencies of educators and teachers to ask questions on video sections of their lessons. In addition, such studies can shed light on the applications of educators on how to improve the understanding of new pre-service teachers about asking effective questions. However, there is a need to monitor the status of science teachers regarding their quality to ask questions effectively at all stages of their careers and to conduct more research on this subject. In addition, many factors such as school culture, classroom culture, affective and psychological variables, classroom layout, number of students, teacher's academic culture and teacher professional experience should be examined in this context in order to reveal stronger implications for the teacher's questioning discourse. Finally, we can say that there is a need for other studies that will examine the consistency between what science teachers know about asking questions in their lessons and classroom practices.

Limitations

The conclusions that can be drawn from the case study that deals with the ability of a single science teacher to ask questions are naturally limited. The state of questioning quality that arises here cannot be generalized beyond a single participant of this study. In addition, here are the results that emerge from the observations related to the teaching of only two subject areas. There is a need to observe the teaching of a broader subject area and to examine more science teachers for broad interpretations. In this study, the only data collection tool including video recordings has been used. There is no single tool capturing all aspects of this science teacher's professional knowledge quality in asking questions. Therefore, alternative data sources such as interview and lesson planning forms are needed.

Consent to Participate

The research involves human participants. Signed informed consent has been obtained from a single participant before starting the data collection process.

Declaration of Interest

It is reported that there is no conflict of interest between the authors regarding this article.

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