

Questions Posed by Pre-service Teachers to 5th-8th Grade Students and Their Level of Interactions

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This study was aimed to reveal what types of questions were asked by pre-service teachers and what kind of interactions they established with the 5th-8th grade students. The extent to which the questions the pre-service teachers asked are related to the interactions they established with the students was also investigated. Case study, one of the qualitative research method, was employed. 50 pre-service teachers selected by using criterion sampling participated in the study. They conducted clinical interviews with a 5th-8th grade students. Content analysis was adopted while analyzing the data. Results showed that, pre-service teachers largely tended to ask factual questions. In addition, while the interaction level of most of the pre-service teachers having a high achievement level with the students was found to be Level 3, the interaction levels of the pre-service teachers having a medium and low achievement level with the students were found to be differentiated. When the interaction of the pre-service teachers through the questions they asked was evaluated, it was seen that the groups at Level 0 asked very few probing questions but a lot of factual questions. The percentages of the factual questions asked by the pre-service teachers at the other levels were found to be concentrated on the 2nd and 3rd quartiles and the percentages of probing questions asked by them were found to be concentrated on the 2nd quartile. Based on the results obtained, it is recommended to integrate such experiences into undergraduate programs so that pre-service teachers can encounter such experiences.

Keywords: pre-service teachers, teacher questioning, interaction with students, middle school students, clinical interviews

INTRODUCTION

In students building mathematical knowledge, the questions asked by the teacher to attract attention play a critical role (Harrop & Swinson 2003; Moyer & Milewicz, 2002). In addition to being seen as an effective teaching method, questioning also provides important learning opportunities for the teacher to have an insight about what and how the student thinks (Hannel, 2009) because teachers can encourage students to think and learn by asking effective questions (Harrop & Swinson, 2003; Ng et al., 2011). The importance of teachers' having knowledge about student thinking is also emphasized by institutions that give direction to mathematics education (National Council of Mathematics Teachers [NCTM], 2014). Teachers who can ask effective questions are more successful at uncovering and analyzing student thinking (Moyer & Milewicz, 2002; Myhill & Dunkin, 2002). At this point, researchers should explore what type of questions a teacher should ask in order to better understand and analyze the student thinking. Studies have shown that both teachers and pre-service teachers focus more on questions that require remembering rather than questions that serve the purpose of analyzing students' thinking styles comprehensively (Myhill & Dunkin, 2005; Sahin & Kulm, 2008; Tienken et al., 2010; Zhang & Patrick, 2012). In addition, observations indicated that more importance has been attached to the investigation of the types of questions asked by teachers and that less emphasis has been put on pre-service teachers' knowledge and skills regarding asking questions (McDonough, et al., 2002; Moyer & Milewicz, 2002; Sahin, 2007). However, revealing what type of questions the pre-

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service teachers ask and how they interact with students in this process can offer important insights about how to prepare pre-service teachers for teaching in the classroom (Moyer & Milewicz, 2002; Tanıslı, 2013). One of the important tools that can be used to easily observe this process is clinical interviews (Steinberg, et al., 2004). Clinical interviews can be seen as a strategy that allows the teacher to understand the student thinking, to analyze it in depth, and to see what's inside the student's mind through questioning (Moyer & Milewicz, 2002). Clinical interviews help the teacher to develop awareness of how the student thinks (Schorr, 2001). The aim of this study was to reveal what type of questions middle school pre-service mathematics teachers ask and how they interact with students on the basis of the clinical interviews they have prepared.

Teacher Questioning and Interactions with Students

The questions posed by the teacher can reveal the mathematical thinking of students and allow him/her to interpret this thinking and to get to know and understand students better and shape the teaching practices accordingly (Hannel, 2009; Sahin, 2007). In this context, researchers agree that teachers' ability to question well is an important skill (Harrop & Swinson, 2003; Moyer & Milewicz, 2002). However, the situation is a bit different for pre-service teachers. In this context, it should be one of the important goals of teacher training programs that pre-service teachers get an idea about students' mathematical thoughts and asking appropriate questions before they have graduated (Schorr & Ginsburg, 2000). However, studies show that asking appropriate questions is not an easy skill to master not only for pre-service teachers but also for teachers (Aizikovitsh-Udi & Star, 2011; Inoue & Buczynski, 2011; McCarthy et al., 2016; Ong, et al., 2010; Şahin & Kulm, 2008; Shahrill & Clarke, 2014; Weiland, et al., 2014; Yilmaz, 2019). For example, Inoue and Buczynski (2011) revealed that although pre-service teachers had attempts to ask open-ended questions, they could not use such questions effectively because they had difficulty in predicting how students would think and in understanding student thinking. Yilmaz (2019), on the other hand, observed that novice teachers who have just started their profession prioritize their own thoughts and ignore students' thoughts while asking questions. In order to overcome these difficulties, the teacher needs to have a better understanding of the student, that is, better interaction with the student (Tanıslı, 2013).

The interaction between students and teachers in this sense enables the teacher to better understand and interpret how students perceive and interpret the mathematical concepts (Schorr & Ginsburg, 2000). Studies have shown that the types of questions asked by teachers affect their interactions with students in different ways. The existing research shows that teachers/pre-service teachers tend to ask questions that focus mainly on revealing memorized knowledge of students and that they remain insufficient in including questions that will reveal how the student thinks and allow the student to justify his/her thought (González & DeJarnette, 2015; Kulcuoglu, 2019; Moyer & Milewicz, 2002; Ni, et al., 2014; Piccolo, et al., 2008; Sahin, 2007; Way, 2008; Weston, et al., 2018). For example, in their study focused on how the questions asked by teachers affect student responses, Ni et al. (2014) observed that low-level questions asked by teachers were positively related to students' "simple answers", while high-level questions were positively related to "highly participatory answers". The research also revealed that teachers' high-level questions were associated with tasks that required higher cognitive demand. A remarkable result obtained in the current study is that the low-level questions asked by the teachers are related to the search for multiple solution methods. In the context of revealing multiple solution methods, low-level questions serve the function of social scaffolding, which encourages students to participate, in addition to the function of providing access to the necessary mathematics content. Similar results have also been reported in the literature (Baxter & William, 2010; González & DeJarnette, 2015). Piccolo et al. (2008) evaluated teacher-student interaction in their work conducted with the participation of middle school mathematics teachers and tried to identify question categories that would lead to long-term interactions with students. They revealed that closed questions asked by the teacher restricted speech and did not yield evidence of

students' understanding. They observed that probing and guiding questions were more likely to produce interactions that would yield evidence of students' understanding. Weston et al. (2018) examined the hypothetical classroom interactions of pre-service teachers. Results showed that the pre-service teachers who participated in the study most frequently asked asking for explanation questions, followed by short, focused questions. The least asked type of question was probing questions. Even in fictional environments, the pre-service teachers were insufficient in asking probing questions. Thus, Weston et al. (2018) concluded that although future teachers are willing to make their students express their thoughts, they may have difficulty in following the answers of students. In light of the results of the study, it can be argued that the questions asked by teachers affect their interactions with students. Kulcuoglu (2019) examined the interactions that emerged in the interviews conducted by two pre-service teachers with students and revealed that the interaction levels of the pre-service teachers with the students differed. It was observed that a pre-service teacher could focus on the student's thinking, ask questions that could reveal the student's mathematical thinking, listen to the answers, shape the questions according to the student, and ask follow-up questions based on the student's thoughts. The other pre-service teacher generally did not focus on the student's thoughts, did not ask questions that could reveal the student's mathematical thinking, and could not direct the interview according to the consistent or inconsistent statements in the answers given by the student. It was observed that instead of asking follow-up questions based on the student's thoughts, she asked more general and vague questions. Studies have also emphasized that one-on-one interactions with students are a useful strategy in understanding what students think and changing pre-service teachers' beliefs about mathematics teaching in general (Pianta, 2016). One of the tools that reveal and support teacher-student interactions is the questions posed by the teacher (Tanışlı, 2013). Clinical interviews are expressed as one of the important tools that give teachers the opportunity to observe the questions they ask and their interactions with students (Ginsburg, 1997).

Clinical Interviews

Researchers aiming to increase the effectiveness of teaching seek innovative approaches to support an increase in teacher-student interaction (Wei, 2021). Clinical interviews are one of the tools that enable teachers to understand how the concept or task focused on in mathematics education is perceived by students and to understand student thinking in depth (Hunting, 1997; Moyer & Milewicz, 2002). Another benefit of clinical interviews is that they allow interaction with students (Steinberg et al., 2004). Through this interaction, pre-service teachers gain deep information about how students perceive and make sense of concepts (Schorr & Ginsburg, 2000). The questions prepared for an effective clinical interview should be structured in a way that would prompt students to think mathematically and allow them to reflect on the solution (Hunting, 1997; Zazkis & Hazzan, 1999).

Investigating how the types of questions created by teachers shape the interactions between teachers and students is a difficult subject. Despite these challenges, it is of great importance to focus specifically on the different types of questions teachers pose and their contributions to mathematics teaching and learning (DeJarnette, et al., 2020). In addition, the role of the teacher in the quality of teacher-student interactions is emphasized (Piccolo, et al., 2008). All these show the necessity of revealing what kind of interactions pre-service teachers have with students and what kind of questions they ask. The focus of this study is to reveal what type of questions pre-service teachers with different levels of achievement ask students during the clinical interview process and how they interact with students in this process. In addition, another focus of this study is to define the how the questions pre-service teachers ask are related to their level of interaction with students. In this way, revealing what type of questions pre-service teachers are inclined to ask and what type of questions they have difficulty in asking will help the process of shaping teacher education programs because, according to NCTM (2000), the questions asked by teachers and the level of interaction with students are expressed as important factors that determine their effectiveness. In addition, a teacher who understands his/her

students can structure the teaching process much more efficiently (An et al., 2004; Moyer & Milewicz, 2002; Steinberg et al., 2004). In this context, answers to the following questions were sought.

1. What type of questions did the pre-service teachers at different achievement levels ask in the clinical interviews with students?
2. What kind of interaction did the pre-service teachers at different achievement levels get engaged in with students during the clinical interviews?
3. How are the types of questions asked by the pre-service teachers at different achievement levels related to their interaction with students?

METHOD

Research Design

In the current study, a qualitative research method was adopted, and the case study design was employed in order to examine in detail what type of questions the junior middle school pre-service mathematics teachers asked the students during the clinical interviews they conducted with the students and how pre-service teachers interacted with the students. The case investigated includes the third-year pre-service teachers studying at the middle education mathematics teaching department and taking the course of teaching numbers taken by these pre-service teachers.

Participants

The participants were 50 pre-service teachers taking the required course of “teaching numbers” instructed by the researcher of the current study in the fifth term of their undergraduate education. Of the participants, 9 were males and 41 were females. Such a difference resulted from the fact that female participants who prefer the middle school mathematics teaching program of universities in Turkey are more than male participants. The pre-service teachers were grouped according to the grade point averages stated below, and then these pre-service teachers were asked to form groups (2-3 people) on a volunteer basis. Researchers considered that both the content knowledge courses (e.g., Fundamental of mathematics, Analysis) and the pedagogical content knowledge (e.g., Mathematics teaching and learning perspectives, middle school mathematics curriculum) courses pre-service teachers take during their undergraduate education will affect the questions they will ask and the interactions they will establish with students while teaching the learning area of numbers, which is addressed in the current study. For this reason, the pre-service teachers were classified as high, medium, and low based on their grade point averages (GPAs). There were 8 groups (high) comprised of students with grade point averages in the range of 3.50-4.00, 9 groups (medium) comprised of students with grade point averages in the range of 3.00-3.49, and 7 groups (low) comprised of students with grade point averages in the range of 2.50-2.59. While naming these groups, the group number and achievement level were taken into consideration. For example, the 5th group at the high level was named as high-5th group.

Context of the Study

In Turkey, middle school mathematics teacher training programs give a four-year education. Graduated pre-service teachers can work as mathematics teachers in middle schools that provide education to students from 5th to 8th grades. Pre-service teachers are selected through a nationwide university entrance exam. Middle school pre-service mathematics teachers in the university where this study was conducted can be considered as students with high scores from the university entrance exam. The medium of instruction in the selected university is Turkish. While students mainly take mathematics courses in the first two years, a greater emphasis is put on the pedagogy courses in the last two years. The course of “Teaching numbers”, a compulsory course given in the first semester of

the third year, is taught three hours a week. In the first weeks of the course, approaches in mathematics education and the mathematics curriculum were discussed. How the learning area of numbers is addressed in the curriculum was investigated during this time. In this context, pre-service teachers focused on a concept related to numbers each week and discussions were conducted on how to teach theoretical knowledge and the subject and the difficulties that could be experienced by students. The last two weeks of the course focused on the clinical interviews. First, Hunting's (1997) study, one of the important articles on clinical interview in mathematics education, was translated into Turkish, and then was given to the pre-service teachers, and they were asked to read it. Then a classroom discussion was conducted about the article and the samples of clinical interview were examined. Afterwards, the pre-service teachers were asked to identify a topic/concept related to the learning area of numbers and prepare a clinical interview. The topics/concepts focused on by the pre-service teachers are shown in Table 1.

Table 1
Topics/concepts focused on by the pre-service teachers within the context of the clinical interviews

Achievement Level/Groups	The concept focused on	Grade level	Percent (%)	
High	1 st group	Integers	7 th grade	
	2 nd group	Exponential notations	8 th grade	
	3 rd group	Prime number, prime factor, divisibility rules	6 th grade	
	4 th group	Natural numbers	6 th grade	
	5 th group	Fractions	6 th grade	%33
	6 th group	Operations in fractions, decimal notations	6 th grade	
	7 th group	Decimal notations, fractions, percentage relation	8 th grade	
	8 th group	GCD-LCD	8 th grade	
Medium	1 st group	Division of natural numbers	5 th grade	
	2 nd group	Rational numbers	7 th grade	
	3 rd group	Fractions	5 th grade	
	4 th group	Ratio-proportion	8 th grade	
	5 th group	Fractions	5 th grade	%38
	6 th group	Operations in fractions	6 th grade	
	7 th group	Irrational numbers	8 th grade	
	8 th group	Exponential notations	8 th grade	
	9 th group	Ratio-proportion	7 th grade	
Low	1 st group	Absolute value	6 th grade	
	2 nd group	Square roots	8 th grade	
	3 rd group	Integers	8 th grade	
	4 th group	Square roots	8 th grade	%29
	5 th group	Operations in natural numbers	5 th grade	
	6 th group	Rational numbers	7 th grade	
	7 th group	Fractions and decimal notations	6 th grade	

While 33% of the pre-service teachers are at the high achievement level, 38% of them are at the medium achievement level. The pre-service teachers at the low achievement level constituted 29% of all the pre-service teachers.

Data Collection Tools and Process

The pre-service teachers were asked to prepare clinical interview questions regarding the concepts expressed in Table 1. During the preparation of clinical interview questions, a guideline was given to the pre-service teachers, and they were expected to prepare the interview questions accordingly (see

Appendix-1). Each group prepared the interview questions in line with this guideline. They were asked to carry out an interview with a student studying at the relevant grade level by using the clinical interview questions they developed. The selection of this student was on a volunteer basis. As a group, the pre-service teachers conducted clinical interviews with a student in a quiet environment. 24 students which were 5th-8th grade level participated in the clinical interviews. The ages of the students who were interviewed clinically ranged from 10 to 14. These interviews process was also recorded. In this way, observing how the groups and students interacted was aimed. The clinical interviews conducted by the pre-service teachers with the students lasted between 20 and 30 minutes. After the clinical interview, the pre-service teachers were asked to write a report. In the report, they were asked to give general information about the student they interviewed (gender, grade level, achievement, etc.), what type of questions they asked, and what they aimed with these questions (Appendix 2).

Data Analysis

Recorded clinical interviews were transcribed. The reports and clinical interview transcripts of each group were subjected to content analysis within the framework of the focused research question. For the first research problem, the analysis framework created by Sahin and Kulm (2008) was used. Sahin and Kulm (2008) classified them as (1) probing, which ask for clarification, justification, or explanation; (2) guiding; and (3) factual questions. Probing questions encourage students not only to remember previously learned knowledge or skills, but to use their prior knowledge to discover and develop new concepts and procedures. In other words, through these questions, the teacher can encourage students to think more deeply and explore their mathematical thinking (Franke, et al., 2009; McCarthy, et al., 2016; Sahin & Kulm, 2008). These questions will support teachers to focus on students' thinking (Moyer & Milewicz, 2002). Also, probing questions are structured in such a way as to activate students' higher order thinking skills such as analysis, synthesis, and evaluation. Instructions such as "Ask students to explain or elaborate their thinking, ask students to use prior knowledge and apply it to a current problem or idea, ask students to justify or prove their ideas." can provide guidance in the construction of probing questions (Sahin & Kulm, 2008, p.224).

Guiding questions serve the function of directing students in the most basic sense. In addition, they support the student in guiding and continuing their thinking process. In other words, guiding questions allow students to get support from teachers when they have difficulties (Sahin & Kulm, 2008). Sahin and Kulm (2008) exemplified these questions as follows: Asks for a specific answer or asks for the next step of solution when students are confused or stuck, asks students to think about or recall a general heuristic or strategy, asks a sequence of factual questions that provides ideas or hints that scaffold or lead toward understanding a concept or completing a procedure (p. 225).

Factual questions, which are expressed as the type of questions most frequently asked by teachers in the literature, focus on reminding mathematical definitions or concepts (Myhill & Dunkin, 2005). Factual questions aim to reveal more basic information. Sahin and Kulm (2008, p. 225) exemplified these questions as follows: "Asks students for a specific fact or definition, asks students for an answer to an exercise, asks students to provide the next step in a procedure". At some point, factual and guiding questions may sometimes have connections, and some factual questions may lead the student to understand the skill or concept. In such cases, factual questions can be used as guiding questions (Sahin & Kulm, 2008).

The types of questions asked by each group during the clinical interview process were classified and the frequency values were calculated. An example regarding the coding process of the questions is presented in Table 2.

Table 2
Coding example regarding the question types that the pre-service teachers asked

Question Type	Example
Probing	<p>What is the reason for calling these numbers as rational numbers? How did you decide that the outcome of minus multiplied by minus is plus? Why is the resulting number smaller when performing an addition operation with two negative numbers? What did you pay attention to when placing the numbers on the number line?</p>
Guiding	<p>PT: Would you perform the following operation $5^5 \times 2^5$? S: I do not know how to do it. PT: Well, let's go on like this then. If we do it step by step, what do you think about the result of 5^5? -- PT: Can every number divisible by 4 be also divisible by 2? S: Hmm I couldn't remember. PT: Well, I might want you to think this. What was the rule for divisibility by 2?</p>
Factual	<p>What is the result of the following operation: $\frac{5}{6} \times \frac{1}{2} = ?$ What is \blacktriangle in the following operation: $14:7 = \blacktriangle:18$? What comes to your mind when you hear of absolute value?</p>

(PT: Pre-service teacher, S: Student)

In order to analyze how the pre-service teachers interacted with students, the framework prepared by Kulcuoğlu (2019) regarding the levels of pre-service teacher-student interaction was used. In Table 3, codes and levels of interaction regarding this framework are given.

Table 3
Levels of pre-service teacher-student interaction

Levels	Type of Interaction
Level 0: Not asking probing and follow-up questions	<ul style="list-style-type: none"> *Ignoring student thoughts *Presenting the problem – Not listening to the answer/Not asking probing questions – Rapidly progressing onto the next problem *Directing the student to the correct answer, starting to teach the subject, giving feedback, making explanation, using verbal confirmation statements
Level 1: Asking probing and follow-up questions at an inadequate level	<ul style="list-style-type: none"> *Ignoring student thoughts *Presenting the problem – Not listening to the answer *Asking ambiguous, general probing and/or follow-up questions not serving the purpose (Example: How did you find the result?) *Asking probing questions particularly in the face of wrong answers *Asking the same question repeatedly *Distracting the student's attention by asking more than one question simultaneously
Level 2: Asking probing questions but not follow-up questions	<ul style="list-style-type: none"> *Paying a little attention to student thoughts *Presenting the problem – listening to the answer *Asking specific probing questions serving the purpose *Not asking follow-up questions *Not establishing connections with the student's answers to the previously asked questions
Level 3: Asking probing and follow-up questions at an effective level	<ul style="list-style-type: none"> *Paying attention to student thoughts *Presenting the problem – Listening to the answer *Asking specific probing questions serving the purpose *Asking follow-up questions serving the purpose *Establishing connections with the student's answers to the previously asked questions *Re-arrangement/revision of the problem statement/question/explanation

In cases where pre-service teachers do not consider student thoughts, the level of interaction can be defined as Level 0 or Level 1. At Level 0, the pre-service teacher does not take into account the answer given by the student and tries to give feedback or direct him/her to the correct answer. At Level 1, although the pre-service teacher asks questions to the student, these questions are ambiguous/general follow-up questions without any intention of understanding the student thinking. In addition, the pre-service teacher mostly conducts questioning on wrong answers not considering how correct answers have been attained. At Level 2, although the pre-service teacher asks probing questions to reveal student thinking, he/she falls short in asking questions that will direct the interview based on the answer of the student. At Level 3, the pre-service teacher can both make inquiries to reveal student thinking and ask questions that will shape the interview process based on the student's answer. The collected data were coded according to the levels of interaction shown in Table 3. Based on the results of these encodings, general interaction levels were formed, and the dominant interaction level was defined according to the most observed interaction level. In Table 4, coding samples from the current study's data related to interaction levels are given.

Table 4
Coding samples related to the levels of pre-service teacher-student interaction

Interaction Levels	Dialogues
Level 0	<p>*Ignoring student thoughts *Presenting the problem – Not listening to the answer/Not asking probing questions – Rapidly progressing onto the next problem “PT: <i>How did you solve it? Please explain.</i> S: We cannot share 5 kilograms of tomatoes among 15 friends, but if we divide 5 kilograms of tomatoes into smaller units, then we can share it. (Not asking probing questions – Progressing onto the next problem) PT: <i>How did you solve the other question?</i>”</p> <p>*Directing the student to the correct answer, “PT: <i>So, what do you think zero is for? (Talking about decimal notations)</i> S: PT: <i>Well, the reading of this can be zero point one?</i> PT: <i>Actually, these numbers are the same, right?</i>”</p> <p>*Using verbal confirmation statements “PT: <i>What comes to your mind when you hear of absolute value?</i> S: Converting negative and positive numbers to positive PT: <i>Isn't it? The number in absolute value turns into positive.</i>”</p> <p>*Giving feedback “PT: <i>Now, we place the next digit below, right? Did you forget to place the eight below?</i> PT: <i>Where did we make the mistake?</i>”</p> <p>*Making explanation “PT: <i>Ok, now let's examine the data given in the question? There is a car. It drives for twenty hours at a speed of a hundred twenty kilometres. Let's draw this. Draw a road.</i> PT: <i>No, do not think like that. Now, if divide apples by pears in the following way $\frac{3}{2}$ then 3 shows the number of apples and 2 shows the number of pears.</i>”</p>
Level 1	<p>*Ignoring student thoughts *Presenting the problem – Not listening to the answer *Asking ambiguous/general follow-up questions not serving the purpose “PT: <i>How did you think?</i>”</p> <p>*Asking probing questions particularly for wrong answers *Asking the same question repeatedly “PT: <i>Why would you divide by 600?</i> S: Because it was said that the television was paid in cash. Then, we can find the instalments. PT: <i>Now let's read the question again. Did it ask for this from us?</i> S: Some cash has been given. PT: <i>Yes, now I'm asking why would you divide by 600?</i></p> <p>*Distracting the student's attention by asking more than one question simultaneously “PT: <i>What does the term root evoke in you?</i> S:..... PT: <i>Do you think the number $\sqrt{8}$ is equal to the number 8?</i>”</p>
Level 2	<p>*Paying a little attention to student thoughts *Presenting the problem – listening to the answer *Not establishing connections with the student's answers to the previously asked questions * Asking specific probing questions serving the purpose “PT: <i>Is $\frac{8}{0}$ a rational number?</i>”</p>

S: It is not a rational number.
 PT: *Why do you think it is not a rational number?*
 Ö: Because its denominator is 0.
 PT: *What happens if the denominator is 0? Why is it not a rational number when its denominator is 0?*
 S: I think the reason could be this. For example, we divide something but there is no divisor here."

*Not asking follow-up questions

PT: *Is the result of the expression $\frac{15}{\sqrt{3}}$ irrational or rational?*

S: (tries to factor 15 into its prime factors).

PT: *Why did you perform such an operation?*

S: I did it to find out if there is a root number. But later I realized it wasn't in the root. 15 cannot be divided by $\sqrt{3}$. So, it is an irrational number.

PT: *Let's progress onto the other question (Of course, not asking the question)"*

Level 3

*Paying attention to student thoughts

*Presenting the problem – Listening to the answer

*Asking specific probing questions serving the purpose

*Asking follow-up questions serving the purpose

PT: *After an ant moved 108 cm forward from where it was located, it came back $\sqrt{48}$ cm. How far did this ant move forward from where it was originally located? *What do you think about this question?**

S: $\sqrt{108} - \sqrt{48} = \sqrt{60}$

PT: *Why did you solve it like that?*

S: Because I thought it was supposed to be that way.

PT: *So, is there any other solution to this problem? You may want to think about it.*

S: There may be. We can get these numbers out of the root.

PT: *Then, how would you solve it?*

S:

PT: *What do you think is different from your previous solution? Which one can be correct?*

S: The second one.

PT: *Why?*

S: It seems more logical.

PT: *How did you decide that it is more logical?*

S: because in order to operate on rooted expressions the root inside must be the same

*Establishing connections with the student's answers to the previously asked problems

PT: *So why do you think pi is an irrational number? We have already talked about in the previous question.*

S: Pi is an irrational number.

PT: *Why?*

S: Because continues irregularly (3.14...).

PT: *So, Beyza, how do we find the pi number?*

S: We write it as follows; $22/7$.

....

PT: *What do you think about the expression $2^2 + 14^0 = 5$?*

S: Square of 2 is 4, because $2 \times 2 = 4$.

PT: *What did you say for 17 with 0 exponent in the above question?*

S: I said 0. Here I say 0 again. Therefore, $2^2 + 14^0$ is not equal to 5.

*Re-arrangement/revision of the problem statement/question/explanation

PT: *I give you 3 numbers. These numbers are 0.2, 0.20 and 0.02, can you express these numbers as fractions and percentages? Can you tell me the digit values of the numbers?*

S: Digit values $2/10$, $20/100$ and $2/100$; I can show them in percentages as follows; 20% no 0.2%-20%-2% and as fractions; $2/10$, $20/100$ and $2/100$.

PT: *You gave the same answers for the digit numbers and fractional expressions. Do you think we express the digit value like that?*

S: No

PT: *For example, what is the digit value of 0 in 0.2?*

S: One

PT: *What about for the digit value of 2?*
 S: one tenth
 PT: *Okay, what about the digit value of the 0 on the left in 0.20?*
 S: One
 PT: *What about the digit value of 2?*
 S: One tenth

(PT: Pre-service teacher, S: Student)

The percentages obtained related to the types of questions posed by the pre-service teachers in order to reveal whether the questions asked by the pre-service teachers are related to their level of interactions with students, and what kind of relations they are, if there are any, were tabulated by dividing them into slices of 25%. These slices were named as quartile (Q) and these quartiles were determined to be Q1 (0%-25%), Q2 (26%-50%), Q3 (51%-75%) and Q4 (76%-100%). Below is given a coding sample. Let's assume that the percentage of asking probing questions of a group having a medium achievement level is 26%, that of asking guiding questions is 10% and that of asking factual questions is 64%. And let's assume that the level of interaction with students is 1. The relevant coding table is given below.

Table 5

Interactions established by the pre-service teachers with the questions they asked

	Probing				Guiding				Factual			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Level 1												
Medium group		■			■						■	

The relationship between the types of questions asked by all the groups and the level of interaction they established with their students was coded as shown in the table above and the obtained findings were interpreted.

Some measures were taken to establish the validity and reliability of the current study. For the credibility of the study, data were collected from different data sources. Moreover, the conclusions reached were supported with direct quotations when necessary. For the transferability of the study, detailed explanations were made about the participants of the study, research setting, and research process. For the reliability and confirmability of the study, consistency was analyzed by comparing the findings obtained from interview records and reports and the data analysis process was explained in detail. Moreover, the data were coded in different time intervals (at a three-month interval) by the researcher and the agreement between the codings was found to be 85%. Furthermore, 25% of the data were given to another researcher having studies on student knowledge and he/she was asked to code the given data. Inter coder reliability was found to be 83%. The results obtained show that the study is valid (Miles & Huberman, 1994).

FINDINGS

In order to find an answer to the first research question “What type of questions did the pre-service teachers at different achievement levels ask in the clinical interviews with students?”, the data were analyzed and the types of questions asked by the pre-service teachers according to the achievement level are presented in Table 6.

Table 6

Percentage distribution of the questions types asked by the pre-service teachers in clinical interviews

Achievement Level/Groups		Question Types (%)		
		Probing	Guiding	Factual
High	1 st group	47	6	47
	2 nd group	43	0	57
	3 rd group	39	4	57
	4 th group	33	4	63
	5 th group	60	0	40
	6 th group	16	5	79
	7 th group	31	12	57
	8 th group	38	8	54
Medium	1 st group	34	10	56
	2 nd group	44	0	56
	3 rd group	29	25	46
	4 th group	42	13	45
	5 th group	34	3	63
	6 th group	14	0	86
	7 th group	22	0	78
	8 th group	29	5	66
	9 th group	10	0	90
Low	1 st group	66	0	34
	2 nd group	51	0	49
	3 rd group	44	0	56
	4 th group	66	5	29
	5 th group	11	0	89
	6 th group	36	3	61
	7 th group	49	5	46

The pre-service teachers with a high level of achievement largely asked factual questions in the clinical interviews they conducted with students. Only one group (High-5th group) was found to have a higher percentage of asking probing questions than factual questions. Another group (High-1st group) was found to have asked equal percentages of probing and factual questions in their interviews. When compared to the other types of questions, the percentage of guiding questions used in the interviews is very small and two groups did not ask any guiding questions (High-2nd and 5th group).

The data obtained for the pre-service teachers with a medium level of achievement revealed that the percentage of the factual questions asked in the interviews is higher than the percentages of all the other types of questions. In addition, nearly half of the groups (4 groups) were found to have not included guiding questions in their interviews with students. In the remaining groups, few guiding questions were used in the interviews.

Four of the groups with a low level of achievement (Low-1st, 2nd, 4th and 7th groups) were found to have asked more probing questions than factual questions. However, in the other groups, percentages of factual questions asked during the interviews were found to be higher than the percentages of the probing questions. In more than half of the low groups (4 groups), no guiding questions were used in the interviews. These results show that regardless of their achievement level, the pre-service teachers tended to ask factual questions. They were followed by probing questions and the type of questions asked the least was found to be guiding questions.

On the basis of the analysis of the data to find an answer to the second research question “What kind of interaction did the pre-service teachers at different achievement levels get engaged in with students during the clinical interviews?”, Table 7 was constructed.

Table 7

The pre-service teachers at different achievement levels level of interaction with students

Interaction Level	Achievement Level/Groups	Percentage (%)
Level 3	High-3 rd group	21
	High-4 th group	
	High-5 th group	
	High-6 th group	
	High-7 th group	
Level 2	High-2 nd group	33
	Medium-1 st group	
	Medium-4 th group	
	Medium-7 th group	
	Low-2 nd group	
	Low-4 th group	
	Low-6 th group	
Low-7 th group		
Level 1	High-1 st group	33
	High-8 th group	
	Medium-2 nd group	
	Medium-3 rd group	
	Medium-5 th group	
	Medium-8 th group	
Level 0	Low-1 st group	13
	Low-3 rd group	
	Medium-6 th group	
	Medium-9 th group	
	Low-5 th group	

When the pre-service teachers were subjected to a holistic evaluation, five groups (21%) were found to be at Level 3, eight groups (33%) were at Level 2, eight groups were at Level 1 (33%), and three groups (13%) were at Level 0. While the interactions of the pre-service teachers having a high level of achievement with students were found to be largely at Level 3, the interactions of the pre-service teachers having a low level of achievement with students were found to be largely at Level 2. The interactions of the pre-service teachers having a medium level of achievement with students were found to be largely at Level 1.

In order to find an answer to the last research question, “How do the questions of pre-service teachers at different achievement levels relate to their interactions with students?”, the obtained findings are presented in Table 8.

Table 8

How the types of questions asked by the pre-service teachers at different achievement levels related to the interactions they established with students

Interaction Levels/Question Types	Probing				Guiding				Factual			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Level 3												
High-3 rd group		■			■						■	
High-4 th group		■			■						■	
High-5 th group			■							■		
High-6 th group	■				■							■
High-7 th group		■			■						■	
Level 2												
High-2 nd group		■										■
Medium-1 st group		■			■							■
Medium-4 th group		■			■					■		
Medium-7 th group	■											■
Low-2 nd group			■							■		
Low-4 th group			■		■							■
Low-6 th group		■			■							■
Low-7 th group		■								■		
Level 1												
High-1 st group		■			■					■		
High-8 th group		■			■							■
Medium-2 nd group		■										■
Medium-3 rd group		■			■					■		
Medium-5 th group		■			■							■
Medium-8 th group		■			■							■
Low-1 st group			■							■		
Low-3 rd group		■										■
Level 0												
Medium-6 th group	■											■
Medium-9 th group	■											■
Low-5 th group	■											■

The percentages of the factual questions asked by the pre-service teachers whose dominant interaction level with students during the clinical interviews was at Levels 3, 2, and 1 were found to be concentrated on the 2nd and 3rd quartiles and the percentages of probing questions were found to be concentrated on the 2nd quartile. While the percentages of guiding questions asked by the groups from all the levels were found to be concentrated on the 1st quartile, there is only one group which did not include guiding questions at Level 3 (20%) and the number of groups which did not include guiding questions at Levels 2 and 1 was found to be three (37.5%). On the other hand, the percentages of the

factual questions asked by the groups located at Level 0 were found to be in the 4th quartile while their percentages of probing questions were found to be in the 1st quartile, and they did not use any guiding questions.

DISCUSSION, CONCLUSION AND RECOMMENDATIONS

In this study, answers to three research questions were sought. First of these questions was related to what type of questions the pre-service teachers asked during the clinical interviews they conducted with students. Another question investigated was related to what kind of interaction the pre-service teachers got engaged in with students during the clinical interviews to reveal their mathematical thinking. Finally, an answer was sought for the question of what kind of relation there is between the questions asked by the pre-service teachers and the interactions established by them with students.

Results showed that the pre-service teachers tended to ask factual questions during the clinical interviews they conducted with students regardless of their achievement level. The factual questions asked by 79% (16 groups) of the pre-service teachers during the interviews were found to constitute more than 50% of all the questions they asked. The percentage of the probing questions asked during the interviews was found to be lower than that of the factual questions and the probing questions asked by 17% (4 groups) of the participants were found to constitute more than 50% of all the questions they asked. The percentage of the guiding questions asked during the interviews was found to be quite low and 42% (10 groups) of the participants were found to not have asked this type of question in their interviews at all.

The fact that the teacher/pre-service teachers mainly asked factual questions is a result that many researchers have found and draw attention to (Stevens, 1912). The fact that factual questions can be asked at any time during the course may have led to such a result (Sahin & Kulm, 2008). Another reason for the pre-service teachers' tendency to ask factual questions may be their lack of experience. The pre-service teachers' having less experience on asking questions to students compared to in-service teachers may have laid the ground for such a result. Teachers having lack of experience on asking questions and how to shape questions tend to ask factual questions (Ong, et al., 2010; Tanışlı, 2013). In addition, the pre-service teachers' perception of mathematics teaching may have caused this result. For example, if pre-service teachers tended to examine what the student thinks more superficially, that is, if they thought that it would be more appropriate to shape the concept/subject according to their own perspective, they may have given more importance to asking factual questions and thus structured the clinical interview process in this way. On the other hand, pre-service teachers attaching greater importance to how students think may have structured clinical interview process in such a way as to reveal students' thinking and accordingly may have attached greater importance to asking probing questions and even considered asking guiding questions at points where students experienced difficulties. The very low percentage of guiding questions asked by the pre-service teachers and not including such questions in many of the interviews may be due to the fact that the pre-service teachers are not aware of the importance of supporting students with clues (Moyer & Milewicz, 2002). The likelihood that the pre-service teachers have not received enough training about how to ask questions may be another factor leading to the emergence of this result (Subramaniam, 2005; Zhang & Patrick, 2012). In the current study, the time allocated to training given to the pre-service teachers about the types of questions that should be asked and the clinical interview process was short, which can be considered to be a limitation of the study. In addition to this, the fact that the pre-service teachers met the students they worked with in the clinical interview process for the first time; that is, they were not much acquainted to them may have resulted in the emergence of this result. The pre-service teachers' deficiencies in the content knowledge and pedagogical content knowledge may be another factor contributing to the emergence of such a result. Their inclusion of guiding questions in the clinical interviews to a lesser extent may be because the pre-service teachers may not

be aware of the importance of providing guidance to the students (Groth, et al., 2016). Studies in the literature except for one support this finding. The questions asked by teachers and pre-service teachers are largely factual (Faruji, 2011; Jiang, 2014; Myhill & Dunkin, 2002; Ong et al., 2010; Sahin & Kulm, 2008). In the study having results conflicting with the findings of the current study, the percentage of the factual questions asked by two teachers was very low (10%-17%) while the percentage of guiding questions asked by one of these teachers was found to be quite high (77%) and the percentage of probing questions asked by the other teacher was also found to be high (51%; Yılmaz, 2019).

When the pre-service teachers' interactions with students were examined, the pre-service teachers at Level 0 (13%) were observed to direct students towards the correct answer and gave verbal confirmation to them during the clinical interviews. The pre-service teachers, who interacted with the students at Level 0, either did not listen to the answer or did not ask a probing question after asking questions to the students. Instead, they tended to direct the student to the correct answer, give feedback or use verbal affirmations. This level of interaction of the pre-service teachers with students is a result pointed out in many other studies (Dunphy, 2010; Heng & Sudarshan, 2013). In the current study, what should be done to carry out the clinical interview process effectively was discussed, and sample clinical interview processes were presented. Although the importance of student thinking and interaction with students were mentioned while informing the pre-service teachers about the clinical interview process, the obtained results showed that pre-service teachers had difficulties in internalizing this information (NCTM, 2000). Another result found in the current study is that the interactions established by nearly one third of the pre-service teachers (66%) are at Levels 1 and 2. In addition, the pre-service teachers were found to tend to ask probing questions particularly in relation to wrong answers. In other words, they tended to pay some attention to or ignore student thoughts. While the pre-service teachers sometimes listened to students' answers to the questions they asked, sometimes they did not. It was revealed that the pre-service teachers who had Level 1 interaction with students sometimes distracted students by asking vague, general, irrelevant probing and/or follow-up questions and asking more than one question at the same time. The pre-service teachers who had Level 2 interaction with students, on the other hand, were insufficient in asking follow-up questions, although they asked students appropriate probing questions and they had difficulty in creating associations with the answers given by students to other questions they asked. When the literature is examined, it is seen that even in-service teachers tend to evaluate student thinking instead of understanding them (Ellemor-Collins & Wright, 2008; Fernandez et al., 2012; Heng & Sudarshan, 2013; Moyer & Milewicz, 2002).

It can be thought that the difficulties experienced by pre-service teachers in their interactions with students are related to their subject area and student knowledge because the structure of the questions asked by teachers is shaped by their subject area and student knowledge (Ball et al., 2008; Kulcuoğlu, 2019). It is a result emphasized by researchers that the characteristics of the students with whom clinical interviews were conducted supported/limited their interactions with pre-service teachers (Kulcuoğlu, 2019; McDonough et al., 2002). Seen from this perspective, another reason for the difficulties experienced by the pre-service teachers in their interactions with students may be the characteristics of the students. Pre-service teachers find the opportunity to encounter students in an actual classroom environment mostly in the "Teaching Practice I-II" courses they take in the fourth year of their undergraduate education. The fact that this study was carried out on third year pre-service teachers suggests that another reason for the difficulties they experienced might be lack of experience. Some studies state that even experienced teachers have a low level of interaction with students and have difficulty in bringing student thinking to the fore (Steinberg et al., 2004).

In addition, the interaction of approximately one-fifth (21%) of the pre-service teachers with students was at Level 3. One of the common characteristics of these pre-service teachers was that they all have a high level of achievement. The pre-service teachers who showed this level predominantly were able

to focus on student thinking, ask questions that would reveal student thinking on the topic/concept, and were able to organize questions according to the student. Also, the pre-service teachers were able to ask probing and follow-up questions not only on the students' wrong answers but also on their correct answers. It can be thought that the pre-service teachers' being able to interact with students at Level 3 might have been because of the discussions they had conducted on the related mathematical concept and evaluations they made on possible difficulties that could be experienced by students before the clinical interviews. In the literature, attention is drawn to the positive contribution of pre-service teachers' experiences about the difficulties that students may experience (Crespo, 2000; Kazemi & Franke 2004). In addition, the pre-service teachers conducted the clinical interview process (before, during, after) as a group. The positive contribution of group work and the evaluations made in this process to the development of teachers is emphasized by many researchers (Baker 2017; Fernandez et al., 2012; Hord, 2009; Kazemi & Franke 2004).

In the last question, revealing whether the questions asked by the pre-service teachers are related to the level of interaction they established with students was aimed. When the types of the questions asked by the pre-service teachers and their level of interaction with students were examined, there were two points that need to be emphasized. The first of these was that the percentage of the probing questions was quite low, and the percentage of factual questions was quite high in the groups at Level 0. In addition, the pre-service teachers did not include any guiding questions. The percentages of the factual questions asked by the pre-service teachers at the other levels were found to be concentrated on the 2nd and 3rd quartiles while the percentages of probing questions were found to be concentrated on the 2nd quartile. A remarkable variation in the types of questions was not observed across the levels. On the other hand, guiding questions were found to be asked more by the pre-service teachers at Level 3 than the pre-service teachers at Levels 1 and 2. The two points that may have led to these results should be emphasized. First, the fact that they were unaware of the importance of interacting with students and focusing on understanding them may have directly affected the types of questions they asked. Second, the emphasis that the pre-service teachers' deficiencies in their content and pedagogical content knowledge directly affects their tendency to ask guiding questions (Groth et al., 2016; Moyer & Milewicz, 2002) may have paved the way for such a result.

Some suggestions can be made based on the findings obtained about what type of questions the pre-service teachers asked during the clinical interviews with students and how they interacted with them. The first of these is that the types of questions asked by pre-service teachers should shift towards probing type in a way that takes student thinking more into account. At this point, a suggestion can be made that undergraduate programs where pre-service teachers are expected to develop their content and pedagogical content knowledge should be organized in this direction. In addition, clinical interview, which is one of the important opportunities for pre-service teachers to meet with students before starting their profession, can be considered as one of the important factors that should be emphasized more in pre-service training programs, so that they can better get to know students and establish better interactions with them. One of the limitations of the current study was that the pre-service teachers were able to conduct clinic interviews just once. Pre-service teachers' experiencing this process more than once can make greater contribution to their more detailed analysis of the types of questions they asked and to the development of their knowledge and skills. In this way, pre-service teachers can start their profession as teachers who have a better understanding of how students with different mathematical thinking and are more experienced on the issue. This can make positive contributions to the efficiency of the instructional process because the types of questions asked by teachers serve an important function in revealing student thinking. The more the teacher knows his/her students, the better he/she can shape the instructional process (Franke et al., 2009; Moyer & Milewicz, 2002; Sahin & Kulm, 2008). The current study focused on subjects/concepts related to the learning

area of numbers. Future research can investigate what type of questions is asked by pre-service teachers on subjects/concepts from different learning areas and their interactions with students.

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Appendix-1**THE GUIDELINE FOR THE PREPARATION OF THE CLINICAL INTERVIEW QUESTIONS**

In this study, you are expected to examine how secondary school students understand concepts of mathematics. For this purpose, you are asked to interview a secondary school student (5th-8th grade) about the mathematics subject/concept (numbers, fractions, ratio-proportion, etc.) you have chosen.

In this context, clinical interview questions should be prepared in accordance with the following guideline.

- Express the math problems/activities to be used during the interview.
- Explain why, how, and on what basis you have chosen these problems.
- Prepare the interview questions and a general plan of the interview (the order in which the questions will be asked, how the questions will be related to each other, the predictions of what kind of answers may come from the student, what kind of guidance can be offered according to the student's answers, etc.).

Appendix-2**POST-CLINICAL INTERVIEW REPORT**

- With which student did you conduct the clinical interview? (You are expected to provide general information about the student, such as what grade is he/she studying in?, academic success level, etc.).
 - How long did it take for you to conduct the clinical interview?
 - Did your questions work towards your goal? (Support with examples from student answers).
 - Interpret your student's thoughts (What does he/she know/what doesn't he/she know? Where is he/she having problems? What role did your interviews play in revealing the student's thoughts?).
 - Have you had any difficulties during the implementation process? If so, explain.
 - What went well during the implementation process? Please explain.
 - If you prepared clinical interview questions for the same purpose, what would you do differently, why, and how?
 - If you did the same application again, what would you do differently, why, and how?