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Opinions of Pre-service Elementary School Mathematics Teachers on Misconceptions*

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Abstract

The aim of this study is to determine the opinions of pre-service elementary school mathematics teachers about misconceptions. For this purpose, case study, which is one of the qualitative research methods, was used. The study was conducted with 54 pre-service elementary school mathematics teachers. The data collection tool of the research consists of written response papers that they give to open-ended questions asked to participants. The views of pre-service elementary school mathematics teachers to open-ended questions were analyzed by content analysis. In order to prevent misconceptions that may arise during the lesson, pre-service elementary school mathematics teachers stated that they would; investigate the misconceptions, prepare for the lesson, study the subject, concretize the subject, visualize, determine the pre-learning, give daily life examples, etc. In order to determine whether their students have misconceptions, they stated that they would ask questions, evaluate the answers, solve the test, examine the mistakes and questions, observe the reactions, etc. It is recommended for further research to examine how pre-service elementary school mathematics teachers take precautions to avoid misconceptions by preparing a lesson plan, and to examine the situations of determining and correcting mistakes in students by observing the lessons of the teachers.

Key Words

Mathematics education • Misconception • Pre-service elementary school mathematics teachers.

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Concepts are one of the important elements of mathematics teaching and learning. Despite this importance, students have difficulties in learning mathematical concepts. The reasons for this difficulty are that the concepts being learned are abstract due to the nature of mathematics, that they are related to previous concepts and that they form the basis for new concepts to be learned. As in all disciplines, teaching that is suitable for the structure of mathematics is directly related to students' understanding of mathematical concepts (Baykul, 2003). Since the concepts related to mathematics are abstract in nature, it is very difficult to perceive these concepts directly when the developmental levels of children are taken into account and require a number of development processes (Ersoy, 2006).

In addition to the abstract nature of mathematics, the fact that concepts are related is one of the issues that challenge students. Defining a concept in a math class can be difficult. In order to define a concept, it is sometimes necessary to explain related concepts (Gökkurt Özdemir et al., 2017). Since each concept is related to the previous, next and other concepts, it is necessary to establish a relationship between the concepts for mathematics, which is a cumulative science. This cumulative structure reveals the importance of associating new concepts to be learned with previous learnings and concepts (Adıgüzel et al., 2018). Individuals build on their previous prior knowledge while learning concepts, and this prior knowledge they have sometimes causes difficulties in learning new concepts (Baki & Bell, 1997) and even makes it impossible (Baykul, 2003). It has been stated that misconceptions create great obstacles to the perception of mathematical facts and models, and that misconceptions cause the disconnection between related subjects (Kaynak et al., 2000). Considering this relationship of mathematical concepts, it is not possible for students who learn the preconceptions incorrectly on related subjects to learn new information. The reason for this can be shown as the fact that mathematics is cumulative, as well as the spiral structure of the curriculum (Ersoy, 2006).

Skemp divides mathematical knowledge into transactional and conceptual knowledge (Baki, 1998). Transactional information is defined as the information about knowing which steps should be taken in order without questioning the reason for the realization of a transaction (Baki, 2008). Conceptual knowledge is not only knowing the definition and name of the concept, but also being able to see the transitions and relationships between concepts (Soylu & Aydın, 2006). As long as the meaning of the concept is understood, concept knowledge is realized (Baki & Kartal, 2004). Similarly, Ersoy (2002) stated that both transactional and conceptual knowledge is needed in learning mathematics, and that transactional knowledge can be learned by memorizing, while conceptual knowledge requires understanding. Therefore, he emphasizes that the acquisition of conceptual knowledge takes longer and involves more complex processes. Operations teaching devoid of conceptual understanding causes mistakes and dislike for mathematics (Van de Walle et al., 2014). For this reason, it is emphasized that conceptual and transactional knowledge should take place in mathematics teaching in a balanced way (Baki, 1998; Baki & Kartal, 2004; Soylu & Aydın, 2006). By balancing conceptual and transactional knowledge, it becomes easier for students to reveal high-level thinking skills necessary for understanding mathematics, to make assumptions, generalize and make connections between subjects (Birgin & Gürbüz, 2009). Realization of conceptual learning has an important place in mathematics education in terms of both more permanent knowledge and the formation of a more meaningful learning situation. Difficulties experienced while learning concepts and incorrect information about the concept may cause

difficulties in learning many subsequent concepts and misconception of concepts (Duatepe-Paksu, 2013). Students may have misconceptions because they interpret the concepts, they have difficulty in understanding in accordance with their own understanding (Mayer, 1987).

Misconception is defined as the thought that contradicts the accepted meaning in science Nesher (1987), the understanding of students that produce systematic mistakes (Smith et al., 1993), the behaviors that emerge as a result of students' wrong beliefs and experiences (Baki, 1999), a concept that fits in the mind but is different from the definition of that concept scientifically (Yenilmez & Yaşa, 2008), a perception or understanding that is far from the view on which experts agree on a subject in the literature (Zembat, 2013), perceiving the concept differently from the scientifically accepted concept definition; maintain these perceptions in a systematic and persistent way (Okur, & Gürel, 2016). Definitions of misconceptions provide guidance on what to do to prevent misconceptions before they occur, or to remove them when misconceptions occur. Identifying and eliminating misconceptions is important and necessary for the quality of education (Ayyıldız & Altun, 2013; Özdemir Fincan, 2021). The first way to deal with the misconceptions that may exist in students is to be aware of the misconceptions. If students have misconceptions in their prior knowledge, they can prevent correct learning and lead to new misconceptions (Yenilmez & Yaşa, 2008). For this reason, first of all, students' misconceptions should be determined and then teaching methods should be applied to eliminate them (Alkan, 2009). Mistakes or lack of information detected at every stage of education should be corrected without losing time (Çetin, 2009).

Cornu (1991) classified the reasons that may lead to learning difficulties and misconceptions as epistemological, psychological and pedagogical. Epistemological reasons stem from the nature of the concept itself. Psychological reasons, on the other hand, are expressed as reasons arising from the student himself, such as the student's personal development, readiness, and mathematical comprehension ability. The reasons arising from teachers and teaching are called pedagogical reasons. In each field, pedagogical content knowledge gains importance (İpekoğlu, 2017). Shulman (1986) states that the types of knowledge about what kind of misconceptions students may have about the concepts taught and how these misconceptions can be eliminated are among the most important types of pedagogical knowledge that a teacher should have. However, concepts that are not learned correctly by teachers can be transferred to students (Ayyıldız, 2010). If teachers have misconceptions, they can negatively affect students' learning and transfer their misconceptions to their students (Adıgüzel et al., 2018). Similarly, Ryan and Williams (2007) stated that teachers have misconceptions among the causes of misconceptions in students.

While teaching mathematical concepts, teachers must have the right knowledge about the concept to be learned and prepare learning environments by using appropriate methods or techniques in a way that will not mislead students (Aktepe et al., 2015). Grouws and Schultz (1996) stated that teachers would be able to arrange their instructions if they knew possible misconceptions that students might have. This situation depends on how students can understand a certain mathematics subject, predicting the points that may seem complicated to students, and being aware of the misconceptions that may be found in students (Yavuz Mumcu, 2017). In order to recognize the misconceptions in students, teachers must first be aware of the misconceptions (Gökkurt Özdemir et al., 2017) and be able to analyze these misconceptions well (Zembat, 2013). Teachers who know the misconceptions and their

causes will be able to prevent possible mistakes or misconceptions of students (Gökkurt Özdemir et al., 2017). In case teachers realize that there is a misconception, they should first be provided to confront the misconceptions in the minds of the students. In this process, teachers should (a) identify students' misconceptions, (b) create a discussion environment among students so that they face their misconceptions, and (c) help students restructure and assimilate information with scientific approaches and models (Güneş, 2007). In addition, since misconceptions are based on the complex personal experience of each student in the past, they may have different misconceptions from other students (Yenilmez & Yaşa, 2008). Therefore, it can be stated that teachers have an important role in eliminating misconceptions. It is thought that it is important for pre-service elementary school mathematics teachers who are still in the training phase to know both possible misconceptions and how to correct them when they occur. In this direction, the aim of the study is to determine the views of pre-service elementary school mathematics teachers on misconceptions.

Method

Research Design

This study, which aims to determine the views of pre-service elementary school mathematics teachers on misconceptions, was conducted with the case study design, which is one of the qualitative research methods. The case study design serves the purpose of the study in revealing the current state of pre-service teachers' views on misconceptions, as it allows the researcher to analyze a situation, program, event, action, process or one or more individuals in depth (Creswell, 2003). Since the views of the participants were wanted to be presented in detail, it was thought that the most appropriate design among the qualitative research designs was the case study.

Participants

This study was carried out with 54 (41 female and 13 male) pre-service elementary school mathematics teachers studying at a state university in their third year. Participants were selected by criterion sampling, one of the purposeful sampling methods, and volunteers were included in the study. While determining the participants, attention was paid to the fact that they had taken the course on Special Teaching Methods and Misconceptions and the Nature of Learning. Thus, it was thought that the participants, who were knowledgeable about both teaching methods and misconceptions, would give a more detailed opinion on possible misconceptions. The names of the pre-service teachers, who were informed about the data collection process before the study, were kept confidential and the findings were presented with the coding of PT_1, PT_2, …, PT_{54}.

Research Instruments and Processes

The data collection tool of the research consists of the written response papers given to the two open-ended questions asked to the pre-service teachers. The following questions were asked to pre-service teachers in order to determine their views on misconceptions:

1. What kind of preparations do you make before the lesson in order to prevent misconceptions that may arise during the lesson? Please explain.

2. How do you know if your students have a misconception? Please explain.

Data Analysis

The answers of the pre-service elementary school mathematics teachers to open-ended questions were analyzed by content analysis. Content analysis enables the reduction of participants views into defined categories to better analyze and interpret them (Harwood & Garry, 2003). Before starting the analysis process, data collection tools were read several times to gain familiarity with the data. The opinions of the pre-service teachers were analyzed separately by the researchers and the categories were determined. It is considered important that different coders perform the data analysis rather than a single person (Patton, 2014). In addition, Miles and Huberman (1994) suggested using the intercoder reliability formula to determine the agreement between the analyzes performed by the two researchers separately. Accordingly, the inter-coder reliability coefficient was calculated as 86%. Then, the content analysis was concluded by reaching a consensus on different categories. Since repeated analyzes provide a more saturated and deep analysis from the data set (Miles & Huberman, 1994), all data were analyzed and reviewed once more, and the codings were checked and the categories were finalized. The categories in question and the related pre-service elementary school mathematics teachers who expressed their views on these categories were reflected in the tables and discussed in the findings section. The findings are presented with direct quotations from the views of pre-service elementary school mathematics teachers. While quoting the statements of the pre-service elementary school mathematics teachers, their opinions outside the relevant category were removed and replaced with "…".

Trustworthiness of the Study

It is stated that one or more of the trustworthiness criteria should be considered in evaluating qualitative research and checking the accuracy of the findings (Creswell, 2003; Guba & Lincoln, 1982; Merriam, 2009). Guba and Lincoln (1982) expressed trustworthiness criteria as (a) credibility, (b) dependability, (c) confirmability and (d) transferability (cited in Patton, 2014). For credibility, about one month after the study, the general research results were shared with the participants orally and participant confirmation was obtained. For Dependability, the analyzes were carried out by both researchers, paying attention to the consistency of the data with the results. A consensus was reached on the data analyzed by both researchers for confirmation and the codes were finalized. For transferability, the method of the study, participants, data collection tool and data analysis process are explained in detail.

Results

In this study, which aims to determine the views of pre-service elementary school mathematics teachers on misconceptions, the findings are presented in the context of the participants' preparations to prevent misconceptions and how they will determine whether their students have misconceptions. While presenting the findings, the pre-service teachers who expressed their opinions on the emergence of the codes are included in the tables. Thus, it was desired to provide transparency in data analysis and to allow comparison of direct quotations with the pre-service teachers who expressed the codes. Table 1 shows the preparations that pre-service elementary school mathematics teachers think to make in order to identify possible misconceptions that students may have before the lesson.

Table 1

Opinions of Pre-service Elementary School Mathematics Teachers on the Preparations They Will Make in order to Prevent the Formation of Misconceptions in Their Students

Opinions	*Pre-service Teachers*	*f*
Searching for misconceptions	PT_1-PT_2-PT_3-PT_4-PT_5-PT_6-PT_7-PT_8-PT_9-PT_{11}-PT_{12}-PT_{15}-PT_{16}-PT_{17}-PT_{18}-PT_{20}-PT_{21}-PT_{22}-PT_{24}-PT_{25}-PT_{27}-PT_{31}-PT_{34}-PT_{35}-PT_{36}-PT_{37}-PT_{38}-PT_{39}-PT_{41}-PT_{43}-PT_{45}-PT_{46}-PT_{48}-PT_{50}-PT_{51}-PT_{52}-PT_{54}	37
Material preparation	PT_2-PT_5-PT_7-PT_{11}-PT_{12}-PT_{14}-PT_{15}-PT_{17}-PT_{21}-PT_{22}-PT_{23}-PT_{24}-PT_{25}-PT_{28}-PT_{30}-PT_{33}-PT_{34}-PT_{35}-PT_{42}-PT_{44}-PT_{45}-PT_{53}-PT_{54}	23
Lesson preparation	PT_3-PT_4-PT_{12}-PT_{13}-PT_{14}-PT_{22}-PT_{23}-PT_{24}-PT_{26}-PT_{30}-PT_{33}-PT_{35}-PT_{39}-PT_{40}-PT_{42}-PT_{44}-PT_{45}-PT_{46}-PT_{47}-PT_{48}-PT_{49}	21
Activity preparation	PT_5-PT_6-PT_7-PT_{10}-PT_{12}-PT_{14}-PT_{17}-PT_{21}-PT_{29}-$ÖA_{34}$-PT_{36}-PT_{41}-PT_{42}-PT_{43}-PT_{45}-PT_{47}-PT_{48}	17
Question preparation	PT_5-PT_{10}-PT_{13}-PT_{17}-PT_{20}-PT_{21}-PT_{23}-PT_{26}-PT_{40}-PT_{41}-PT_{45}-PT_{46}-PT_{47}-PT_{50}-PT_{52}	15
Studying the subject	PT_6-PT_{13}-PT_{17}-PT_{20}-PT_{25}-PT_{26}-PT_{27}-PT_{30}-PT_{35}-PT_{39}-PT_{42}-PT_{47}-PT_{48}-PT_{50}	14
Worksheet preparation	PT_{21}-PT_{26}-PT_{29}-PT_{31}-PT_{36}-PT_{42}-PT_{49}	7
Lesson plan preparation	PT_2-PT_7-PT_{11}-PT_{24}-PT_{39}-PT_{40}-PT_{52}	7
Concretizing the subject	PT_2-PT_7-PT_{27}-PT_{28}-PT_{34}-PT_{44}	6
Visualization	PT_{15}-PT_{41}-PT_{43}-PT_{45}-PT_{54}	5
Identifying prior learning	PT_{10}-PT_{18}-PT_{19}-PT_{53}	4
Giving examples of daily life	PT_2-PT_9-PT_{20}-PT_{45}	4
Game narration	PT_7-PT_{11}-PT_{40}	3
Conceptual test development	PT_1-PT_{22}	2
Motivating for the lesson	PT_{32}-PT_{33}	2
Concept map preparation	PT_4	1
Concept cartoon preparation	PT_4	1

When Table 1 is examined, it is observed that the majority of the participants stated that they would investigate the possible misconceptions of the students. The pre-service teachers stated that they could have information about the misconceptions and shape their preparations in the context of these misconceptions. For example, PT_{25} stated that with the help of the theses she will examine, she will have information about the misconceptions and will use this information while processing the subject as follows:

> *In order to know the misconceptions beforehand of the students about that subject and to have knowledge about it, I would examine the thesis on this subject and do research. I identify possible misconceptions and pay attention to these issues while explaining the subject. (PT_{25})*

23 of the pre-service teachers stated that they would prepare materials to prevent misconceptions. In order to prevent the occurrence of misconceptions, PT_{54} expressed his opinion that materials should be used if appropriate as follows:

Misconceptions about the course that the student may fall into should be investigated in advance. In order to avoid these misconceptions, materials should be used if necessary and appropriate. (PT_{54})

21 pre-service teachers stated that they will prepare for the lesson in order to prevent misconceptions that may occur in their students. On the other hand, 17 pre-service teachers stated that they would prepare activities to use in the lesson so that they could prevent possible misconceptions that students might have. PT_{42}'s view on the preparation to avoid misconceptions is as follows:

The teacher should come to the lesson prepared and well-informed. At the beginning of the lesson, the teacher should make a preparation that can attract the attention of the students. He can bring materials that he can use while teaching the lesson and prepare an activity or worksheet. (PT_{42})

There are 15 pre-service teachers who think that they can prevent the possible mistakes of the students with the questions they prepare. In addition, it is seen that 7 pre-service teachers have the opinion that misconceptions can be prevented with worksheets. PT_{13} stated that with the questions he prepared, PT_{49} could identify the types of misconceptions that students might fall into through the worksheets, as follows.

In order to prevent misconceptions that may arise during the lesson, I study and prepare for the subject of the lesson in advance. In order to prevent misconceptions, I prepare questions in a way that corresponds to the tricks so that I can see which student falls into which misconception. (PT_{13})

We can prevent misconceptions and take precautions with the worksheets we prepare ourselves before the lesson. (PT_{49})

Some of the pre-service teachers think that they can prevent their students from making mistakes by working on the subject. The opinion of PT_{26}, one of these candidates, is as follows.

In order to prevent misconceptions that may arise during the lesson, I study the subject I am going to teach in that lesson well before coming to the lesson, and I pay attention teaching my lesson without hesitation. (PT_{26})

While 7 of the pre-service teachers emphasized the importance of preparing a lesson plan, 6 pre-service teachers stated concretizing the subject and 4 pre-service teachers stated using real-life examples among the preparations they would make to prevent students' misconceptions. In this context, the statements of PT_2 are as follows:

Before the lesson, the teacher can determine the misconceptions that the students can make about the subject to be covered and make an appropriate lesson plan to prevent them. In order to understand the subject in this plan, examples of daily life and our environment should be given. We need to make the subject concrete. Appropriate mathematics material related to the subject to be covered in the lesson can be prepared and taken to the class. (PT_2)

There are 5 pre-service teachers who stated that they would use visual elements in their lessons with the thought that visualization can prevent possible mistakes of students. PT_{43} expressed his opinion that he could avoid misconceptions by visualizing the concept with the help of tables and figures he would prepare, as follows.

Before the lesson, I would try to identify the misconceptions that students might fall into. Then, in order to prevent these misconceptions, I would prepare activities that would attract students' attention and facilitate their learning, and I would apply them in the lesson. I would make a figure or table to visualize the concept. (PT_{43}*)*

6 of the pre-service teachers stated that they would try to determine the pre-learning of their students. Thus, the opinion of PT_{10}, who stated that he aimed to prevent the formation of misconceptions due to the deficiencies in the pre-learning of the students, is as follows:

For students not to fall into misconceptions at the level of readiness, I would be related to that subject and make sure that the subjects they learned were understood. I would provide this through a readiness test or question and answer in class… (PT_{10}*)*

Pre-service teachers stated that they would look for ways to motivate students before the lesson, develop a conceptual test, and prepare a game, concept map or concept cartoon in order to prevent the misconceptions that may occur in their students. In this context, the views of PT_{33}, PT_{22}, PT_{40} and PT_4 are as follows.

The course preparation process is very important in this sense. In order to increase the motivation in the lesson, students should be chatted with… (PT_{33}*)*

… Considering the misconceptions that may occur in educators beforehand, a conceptual test can be prepared according to the misconceptions that may occur. If the subject is difficult to understand and the use of materials is appropriate, the material should be prepared and brought to the class before the lesson. (*PT_{22}*)

First of all, I prepare a lesson plan so that I do not experience confusion while teaching in the classroom. I research which game is easier for my students to learn and bring it to class. (PT_{40}*)*

Students may have misconceptions on some issues. Many techniques and methods can be used to prevent them. Many methods such as concept maps and concept cartoons should be used to find out where and how children will go wrong. And in this way, by making a good preparation, it will prevent misconceptions. (PT_4*)*

In addition to taking precautions to prevent the formation of misconceptions, it is also very important to be able to determine the formation of misconceptions. In this direction, middle school mathematics pre-service teachers were asked for their opinions on how to determine whether their students had misconceptions. Findings related to these views are given in Table 2.

Table 2

Opinions of pre-service teachers *on determining their students' misconceptions*

Opinions	Pre-service teachers	f
Asking questions	PT_1-PT_1-PT_{14}-PT_{17}-PT_{18}-PT_{19}-PT_{11}-PT_{12}-PT_{13}-PT_{14}-PT_{16}-PT_{17}-PT_{18}-PT_{19}-PT_{20}-PT_{21}-PT_{22}-PT_{23}-PT_{24}-PT_{25}-PT_{26}-PT_{27}-PT_{33}-PT_{34}-PT_{37}-PT_{38}-PT_{40}-PT_{41}-PT_{42}-PT_{45}-PT_{46}-PT_{50}-PT_{52}-PT_{53}-PT_{54}	35
Evaluating answers	PT_1-PT_3-PT_4-PT_6-PT_7-PT_8-PT_{12}-PT_{13}-PT_{14}-PT_{15}-PT_{17}-PT_{18}-PT_{21}-PT_{22}-PT_{25}-PT_{27}-PT_{29}-PT_{31}-PT_{32}-PT_{33}-PT_{36}-PT_{38}-PT_{39}-PT_{40}-PT_{41}-PT_{44}-PT_{45}-PT_{51}-PT_{52}-PT_{53}	30
Giving test	PT_2-PT_5-PT_6-PT_7-PT_{10}-PT_{12}-PT_{13}-PT_{15}-PT_{19}-PT_{20}-PT_{21}-PT_{23}- PT_{28}-PT_{31}-PT_{35}-PT_{39}-PT_{43}-PT_{47}-PT_{49}-PT_{52}-PT_{53}	21
Examining errors	PT_6-PT_9-PT_{19}-PT_{26}-PT_{27}-PT_{32}-PT_{36}-P_{45}-PT_{49}-PT_{50}	10
Examining errors	PT_8-PT_{11}-PT_{17}-PT_{21}-PT_{32}-PT_{42}-PT_{44}-PT_{45}	8
Observing reactions	PT_{29}-PT_{30}-PT_{31}-PT_{36}-PT_{47}-PT_{48}	6
Getting the students involve in activities	PT_1-PT_5-PT_{10}-PT_{14}-PT_{24}-PT_{35}	6
Getting feedback	PT_{21}-PT_{33}-PT_{42}-PT_{54}	4
Creating a suitable classroom environment	PT_{24}	1

When Table 2 is examined, it is seen that 35 of the secondary school mathematics pre-service teachers stated that they would ask questions to their students in order to determine whether there was a mistake in their students. For example, PT_{40} stated that he would prepare questions about his possible misconceptions, and after examining the answers to these questions, he could reveal whether his students had any misconceptions and, if any, the reasons for their misconceptions. Similarly, PT_{52} stated that he would understand whether his students had any misconceptions by the answers they gave to the questions he asked, and that he would try to be a better teacher by improving his teaching methods. PT_{33}, on the other hand, stated that the student's giving correct answers does not mean that he does not have a misconception, therefore, the students' solutions should be examined and questioned as follows:

> *I prepare questions that they can experience misconceptions. Then I check their solutions one by one to try to understand how they solved it, what they thought. Or I write questions on the board and check how they solve them. In this way, if they made a mistake, I would understand at that moment what mistakes they made and why. (PT_{40})*

> *I understand whether my students have misconceptions by the answers they give to the questions I ask. Thus, I try to develop solutions and my way of explaining according to their answers in order to become a better teacher. (PT_{52})*

> *Just finding the right answer does not mean that the student does not fall into misconceptions. Therefore, distinctive questions should be asked to the student and feedback should be obtained. A lot of attention should be paid to the points where the student can make mistakes. In addition, the way of going should be looked at, not the result of the answers. The student should be constantly asked questions. How did you think about this question? Why did you follow such a path? such questions should be asked. (PT_{33})*

Teacher candidate drew attention to the importance of evaluating student responses in determining whether students have misconceptions. PT_{54}, one of the 30 pre-service teachers who expressed an opinion in this direction, stated that what kind of misconceptions the students (if any) had could be revealed through an evaluation to be made at the end of the subject teaching. PT_{21} emphasized the necessity of making assessments throughout teaching as follows:

> *After teaching the subject, an evaluation is made and it is determined whether the students have misconceptions and what kind of misconceptions, if any, have occurred. These misconceptions do not have to be determined by evaluation, questions are asked to the students during the lesson and the misconceptions are determined according to the feedback received. (PT_{54})*

> *… We also need to make frequent assessments while teaching. We can have students solve some examples and find out if there are any misconceptions in the same way. (PT_{21})*

21 of the pre-service teachers stated that they could identify their mistakes, if any, by having their students solve the test. For example, PT_{21} emphasized that after the lesson was taught, she would use the test questions to get feedback from the students and that she could reveal possible misconceptions by examining student responses. PT_6, on the other hand, stated that with the test he will prepare at the end of the subject, he will examine the solutions of the students and determine the reasons for making mistakes, and that he can support the students in eliminating the mistakes by solving the questions in the classroom environment.

> *After the lesson is done, we have to get feedback from the student. We can do this with a little test we prepared. We can examine these answers and find out on which subjects he has misconceptions...* (PT_{21})

> *At the end of the subject, I prepare a test to cover the misconceptions about the subject and have them solve it. Afterwards, I collect the solved tests from the students and identify the questions that the students got wrong. By examining their solutions, I try to understand whether the reasons for making mistakes are due to misconceptions. I provide the solutions on the board so that all students can see the questions of the test, and I help the students to correct and understand the mistakes they make. (PT_6)*

Ten of the pre-service teachers think that they can reveal whether they have misconceptions by examining the mistakes made by their students, and 8 of them by examining the questions asked by the students. There were 6 pre-service teachers who expressed the opinion that they could have an idea about whether they had a mistake or not by observing the reactions of the students. In this context, the opinions of PT_{36}, PT_{45} and PT_{48} are as follows:

> *...Then I collect the solved tests from the students and identify the questions the students got wrong. By examining their solutions, I try to understand whether the reasons for making mistakes are due to misconceptions. I solve the questions of the test on the board in a way that all students can see, and I help the students to correct and understand the mistakes they make*. (PT_{36})

> *We can understand whether students have misconceptions from the question solutions and the questions they ask during the lesson. (PT_{45})*

... I could understand whether the students had misconceptions from the reactions of the students while I was explaining them during the lesson. (PT_{48})

Pre-service teachers stated that they can determine whether their students have misconceptions by performing activities in the classroom (6 participants), making evaluations with the feedback they receive (4 participants), and creating a suitable learning environment. In this context, the opinions of PT_{24} and PT_{42} are as follows:

... I also prepare the activities that I will have my students do in order to eliminate these misconceptions. I provide them with a suitable classroom environment where they can freely express their thoughts. (PT_{24})

Feedback from students shows whether they have misconceptions or not. (PT_{42})

Discussion, Conclusion & Suggestions

The results obtained in this study, which aimed to determine the opinions of pre-service elementary school mathematics teachers about misconceptions, will be discussed in two groups: (a) what kind of preparations they will make before the lesson in order to prevent misconceptions that may arise during the lesson, and (b) how they will understand whether their students have misconceptions. In order to prevent misconceptions that may arise during the lesson, pre-service elementary school mathematics teachers expressed their opinions about searching for mistakes, preparing for the lesson, studying the subject, concretizing the subject, visualizing, determining the pre-learnings, giving examples of daily life, explaining with games, developing a conceptual test, motivating the lesson and using materials, activities, questions, worksheet, lesson plan, concept map, concept, preparing the cartoon.

The pre-service elementary school mathematics teachers stated that they would try to improve both their field and field teaching knowledge by studying the subject before the lesson, preparing for the lesson, and investigating the misconceptions. In different studies, it is also emphasized that misconceptions should be known by teachers (Alkan, 2009; Berg & Brouwer, 1991; Güneş, 2007; Yavuz Mumcu, 2017; Gökkurt Özdemir, Bayraktar & Yılmaz, 2017). Because having the knowledge of misconceptions helps teachers to interpret the behaviors and ideas of their students and to prepare effective teaching plans (Geddis, 1993; Magnusson et al., 1998 as cited in Halim & Meerah, 2002). Thus, teachers who have knowledge about possible misconceptions will be able to determine effective teaching strategies (Jordaan, 2005) to prevent them and organize their teaching (Grouws & Schultz, 1996, cited in Williams, 2001). In order to prevent the formation of misconceptions, pre-service elementary school mathematics teachers also drew attention to the importance of being prepared for the teaching process by preparing a lesson plan, as well as investigating misconceptions.

In order to prevent the formation of misconceptions, pre-service elementary school mathematics teachers stated that they will visualize, determine preliminary learning, give an example of daily life, explain with a game, develop conceptual tests, motivate the lesson and prepare materials, activities, questions, a working paper, a concept map, a concept cartoon. Based on this, it can be stated that pre-service elementary school mathematics teachers who are aware of the possible misconceptions that students may have, plan to design a learning environment that will support students' conceptual understanding. While teachers' knowledge of misconceptions ensures that the concepts are

permanent and meaningful learning (Özdemir Fincan, 2021), it will also prevent possible misconceptions of students (Gökkurt Özdemir et al., 2017). In this respect, it is thought that it is important to consider misconceptions during the planning of teaching and thus to create opportunities that support learning (Kula & Bukova Güzel, 2014).

Pre-service elementary school mathematics teachers stated that they can understand whether their students have misconceptions during the lesson by asking questions, evaluating the answers, solving the test, examining the mistakes and questions, observing the reactions, doing activities, getting feedback, and creating a suitable classroom environment. In this context, Şandır and Aztekin (2013) also stated that knowing misconceptions is not enough, that these misconceptions should be understood in detail and strategies to reveal them should be used. Because it is important to identify the misconceptions of the students and to carry out the elimination studies (Jonnes, & Tanner, 2000 cited by Ayyıldız & Altun, 2013). In this context, besides knowing the effective strategies to prevent misconceptions (Graeber, 1999), teachers who identify misconceptions should also have knowledge of teaching methods to eliminate them (Alkan, 2009).

In line with the opinions of the pre-service elementary school mathematics teachers, it can be stated that they do not have enough information to detect the misconceptions. In fact, Duru (2011) focused on counterexamples and suggested presenting contradictory examples in the classroom in order to eliminate students' misconceptions. This will help students come face to face with their misconceptions by creating a suitable learning environment. Jonnes and Tanner (2000) also emphasized that by creating environments where learners can express their thoughts comfortably, practices that will enable them to confront existing misconceptions should be implemented (cited by Ayyıldız & Altun, 2013).

Since misconceptions are based on the complex personal experience of each student in the past, they may have different misconceptions than other students (Yenilmez & Yaşa, 2008). In this respect, it is thought that teachers' knowledge and experiences about learners are also very important in overcoming misconceptions. Therefore, it is thought that it is important to have both subject matter and pedagogical content knowledge in knowing misconceptions and overcoming them. Teachers who do not have sufficient content knowledge have difficulty in recognizing students' misconceptions (Halim & Meerah, 2002). Therefore, teachers are expected both to carry out their teaching to prevent the formation of misconceptions and to know how to overcome misconceptions when they arise in addition to knowing students' possible misconceptions (Kula, Bukova Güzel, 2014). For this reason, the teachers must be informed of students' misconceptions (Grouws & Schultz, 1996). Knowledgeable teachers, on the other hand, can reveal students' misconceptions to a large extent (Gess-Newsome, 1999). For this reason, pre-service elementary school mathematics teachers' development of their subject matter knowledge will contribute to preventing the formation of misconceptions, identifying and eliminating the misconceptions. It was determined that pre-service elementary school mathematics teachers had some views on preventing, identifying and eliminating misconceptions. However, it is thought that it is important for pre-service elementary school mathematics teachers to be informed in detail about how to prevent possible student misconceptions, to identify the misconception and to correct it when faced with it. In this direction, it can be stated that besides having field knowledge, it is also important to have knowledge of field teaching in order to know and overcome misconceptions. This study was

carried out in order to determine the opinions of pre-service elementary school mathematics teachers about misconceptions in general. In particular, it will be possible to investigate the opinions of the pre-service elementary school mathematics teachers regarding the possible misconceptions that may be held in certain concepts. For further research, it is recommended to examine how pre-service elementary school mathematics teachers take precautions to avoid misconceptions by preparing a lesson plan, and to examine the situations of identifying and correcting students in case of misconceptions by observing their lessons.

Ethic

This study was conducted in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments. Informed consent was obtainted from all students.

Author Contributions

The authors made equal contribution to this study. Therefore, each author is equally responsible.

Conflict of Interest

The authors declare that they have no conflict of interest

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