ACTA DIDACTICA NAPOCENSIA
Volume 15, Number 2, 2022 - DOI: 10.24193/adn.15.2.17

EXAMINING THE SCENARIOS CREATED BY PRE-SERVICE TEACHERS REGARDING MISCONCEPTIONS THAT MAY OCCUR IN THE TEACHING PROCESS

Nurullah YAZICI, Mertkan ŞIMŞEK

Abstract: In this research, pre-service mathematics teachers were asked to prepare scenarios about what possible misconceptions might be in the classroom teaching process and how a solution strategy could be used based on the cognitive conflict approach in order to overcome these misconceptions. Based on these scenarios, it is aimed to determine what type of possible misconceptions may be related to which content standards. This research was conducted using an integrative mixed method design, which allows qualitative and quantitative methods to be used together or sequentially. The study group of the research consists of 60 primary school pre-service mathematics teachers who have successfully completed the "Misconceptions in Mathematics Teaching" and "Teaching Practice" courses. The data of this research consists of misconception scenarios created by pre-service teachers and a semi-structured interview form. In the analysis of the scenarios, correspondence analysis was used to evaluate the relationship between misconception types and content standards. Considering the research results based on misconception types, it was seen that the most common misconception type was overgeneralization, whereas the misconception type in the wrong translation did not emerge. When the research results are examined in the context of content standards of mathematics, it is seen that the misconceptions mostly belong to the subjects of numbers and operations.

Key words: Misconception, scenario, pre-service mathematics teachers, content standards.

1. Introduction

Concepts are expressed as mental tools that contribute to our thinking process (Bowen & Bunce, 1997; Novak, 2002; Tenenbaum, 2000; Senemoğlu, 2013). Again, concepts are the building blocks of knowledge and enable the organization of the knowledge to be learned (Bada, 2015; Palmer, 2001). It is known that the structuring process of knowledge begins in the early stages and is shaped because of the individual's interactions in daily life (Wild, Hilson & Hobson, 2013). Because an individual creates explanations for himself to make sense of all kinds of events or situations that occur around him in the time period he lives (Palmer, 2001). From this point of view, it can be said that individuals have some prior knowledge before coming to the learning environment. However, the prior knowledge and concepts that individuals bring to the learning environment generally cause them to take place in understandings that contradict scientific explanations and concepts (Talanquer, 2006). Establishing relationships between concepts and classifying the concepts will be possible with the correct meaning of the concept (Akgün, 2001). Therefore, concept teaching, which is seen as the starting point for the realization of meaningful learning, constitutes one of the basic steps of the teaching process (Temizkan, 2011).

As a result of incomplete or erroneous learning of concepts, not being able to shape them sufficiently in the mind and using them outside of their scientific meaning leads to misconceptions in the individual (Bahçeci & Kaya, 2010; Johnston & Southerland, 2000). Misconception is defined as the mismatch between the meaning of a concept formed in the mind of the individual and the scientific meaning of that concept, in other words, misperceptions against scientific facts (Novak, 2002; Ojose, 2015). Baki and Aydın-Güç (2014) stated that the way of understanding that causes the repetition of the mistake in a systematic way is a misconception. Graeber and Johnson (1991) classified misconceptions in four types: overgeneralization, overspecification, mistranslation and limited conception. Among these types,

Received March 2022.

Cite as: Yazıcı, N., & Şimşek, M. (2022). Examining the scenarios created by pre-service teachers regarding misconceptions that may occur in the teaching process. *Acta Didactica Napocensia,* 15(2), 256-268, https://doi.org/10.24193/adn.15.2.17

overgeneralization is the most common type of misconception. In overgeneralization, a learned rule is applied to all situations. For example, the conception that "the result of multiplication must always be greater than what is multiplied" (Graeber, 1993; Ojose, 2015) is a valid rule when operating on the set of natural numbers. But this rule may not apply to the set of integers or rational numbers. In over-specification, a concept or rule in mathematics is handled in one dimension. In other words, it is the transformation of a rule or concept that can be used in a wider context from a general to a more specific structure with a limited understanding (Ben-Hur, 2006). For example, Ryan and Williams (2007) stated that because of stereotyped thinking style in individuals, the square shape is not considered as a rectangle. In addition, they stated that almost many individuals have a single rectangle perception in their minds. In Figure 1, the inner region of the stereotyped rectangular shape in the minds of individuals is marked as shaded (Ryan & Williams, 2007).

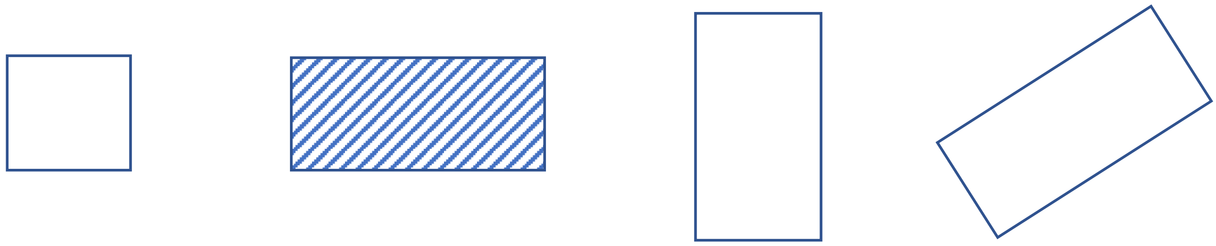

Figure 1. *Perception of a single rectangle because of stereotyped thinking*

In mistranslation, which is one of the types of misconceptions, the individual makes a systematic error while transitioning from one form to another (table, graphic, symbol, formula, operation). An example would be to make a mistake while expressing a mathematical sentence as an equation. Another example of this type of error is the individual's inability to correctly write the spelling of a given number or notation (Graeber & Johnson, 1991; Ojose, 2015).

In limited conception, on the other hand, there is a limited understanding of a concept by the individual. Figure 2 shows an example of limited conception about fractions.

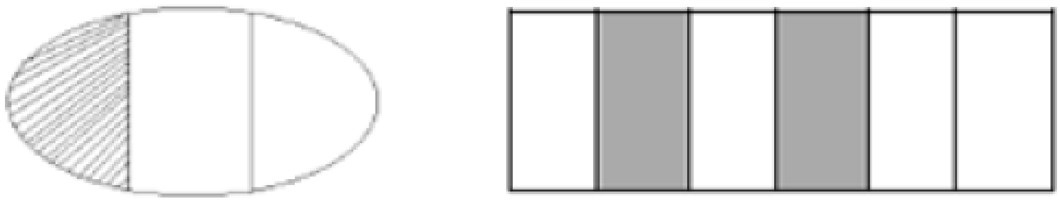

Figure 2. *Fraction example for constrained detection*

When Figure 2 is examined, an individual's response to the question "Which is the representation of the fraction 1/3" as the first figure shows limited conception (Lesh, Post & Behr, 1987; Ojose, 2015).

It is seen that many studies have been carried out in the field of mathematics education to detect and eliminate misconceptions (An & Wu, 2012; Brown & Quinn, 2006; Golan, 2011; Kazemi & Ghoraishi, 2012; Mohyuddin & Khalil, 2016; Moss & Case, 1999; Ojose, 2015; Swan, 2001; Prescott & Mitchelmore, 2005; Yazdani, 2006). Different suggestions have been put forward by the researchers in the studies carried out to eliminate the misconceptions. According to Moss and Case (1999), it is suggested that misconceptions can be eliminated by creating discussion environments for concepts, and according to Baki (2006), by showing the contradiction in the misconception that the student has experienced. On the other hand, Swan (2001) stated that teachers can take at least two different approaches to eliminate the misconceptions that arise in the classroom teaching process: In the first approach, there is direct telling the student the mistake based on mathematical reasons. In this approach, the student does not have the opportunity to realize his own mistake. In the other approach, which is called cognitive conflict, it is aimed to make the student realize the mistake experienced by the questions that the teacher will ask the student. In this approach, confronting the students by creating contradictions in their thoughts, interpretations or the solution path they use comes to the fore (Smith, Disessa, & Roschelle, 1993; Fischbein, 1993). In this context, Swan (2001) stated that pre-prepared scenarios can be useful to overcome the misconceptions that teachers may encounter in the classroom teaching process. As a matter of fact, misconceptions can appear suddenly in many situations in learning environments, so it is a situation that needs to be eliminated. In other words, teachers should be prepared for mistakes and misconceptions to be able to show an expert approach and produce solutions against mistakes made by students.

It is thought that learning approaches and teachers have a great impact on the process of correctly structuring the concepts that students acquire. For this reason, teachers' ability to use learning approaches correctly and to create correct conceptual understandings depends on their experience of learning approaches and having correct conceptual schemes. In this context, it is thought that with the scenarios they design, pre-service teachers can be prepared and overcome the difficulties and misconceptions they may encounter while carrying out the teaching profession. However, it is also important to determine in which content standard the types of misconceptions that students have experienced are frequently encountered. In this research, pre-service teachers were asked to prepare scenarios about what possible misconceptions might be in the classroom teaching process and how a solution strategy could be used based on the cognitive conflict approach to overcome these misconceptions. Based on these scenarios, it is aimed to determine what type of possible misconceptions may be related to which content standards. For this, the research problems were determined as follows:

Based on the scenarios prepared by the pre-service teachers, what is the level of relationship between the types of misconceptions and content standards?

How is the distribution of the scenarios prepared by the pre-service teachers according to the misconception types?

2. Methodology

2. 1. Model of the research

This research was carried out using an integrative mixed method design, which allows the use of qualitative and quantitative methods together or sequentially, to provide a more detailed and comprehensive understanding of the situation by using the advantages of qualitative and quantitative designs (Creswell & Creswell 2017; Mills & Gay, 2016). In the integrative mixed method, the aim of elaborating, exemplifying and explaining the results obtained with a determined design with the results of the other design is at the forefront (Greene 2007; Bryman, 2007). In this research, firstly, the compatibility between the scenario examples and content standards of the pre-service teachers was examined. Then, the approaches of the pre-service teachers were evaluated by conducting more in-depth interviews.

2. 2. Study group

The study group of the research consists of 60 pre-service primary school mathematics teachers who have successfully completed the "Misconceptions in Mathematics Teaching" and "Teaching Practice" courses.

Purposive sampling method was used while determining the study group of the research. Here, the pre-service teachers' experience of the classroom teaching process in the teaching practice course for at least one year and their sufficient knowledge of misconceptions were considered as criteria in forming the sample.

2. 3. Data collection tools

The data of this research consists of misconception scenarios created by pre-service teachers and a semi-structured interview form. In the misconception scenarios, pre-service teachers identified a possible misconception situation, explained and justified this situation with the help of teaching practice observations and literature support. With the semi-structured interview form, the opinions of the pre-service teachers about the scenarios they created were evaluated. Therefore, the semi-structured interview form was supportive in the triangulation of the data. It was tried to determine how he determined which type of misconception the scenario he created in the interview form was and how he interpreted the underlying cause of the misconception.

The pre-service teachers who participated in the study took the misconceptions course for 12 weeks before the application and successfully completed the teaching practices course before. In this way, it has been verified that the pre-service teachers' knowledge about misconceptions is sufficient and they have experience in teaching mathematics in the classroom.

2. 4. Data analysis

In this study, misconception scenarios created by pre-service teachers were analyzed in the context of misconception types, according to the conceptual framework created by Graeber and Johnson (1991). Graeber and Johnson (1991) classified misconceptions in four types: overgeneralization, overspecification, limited conception and mistranslation. Since there was no example of mistranslation in the scenarios prepared by the pre-service teachers, this dimension consisted of three types. On the other hand, the scenarios were also evaluated with the dimension of mathematical content standards. National Council of Teachers of Mathematics [NCTM] (2001) has categorized the content standards as five content standards: Number and Operations, Algebra, Geometry, Measurement, Data Analysis and Probability. Since no example of measurement content standards was found in the scenarios, this dimension was analyzed in terms of four content standards.

In the analysis of the scenarios, correspondence analysis was used to evaluate the relationship between misconception types and content standards. Correspondence analysis is a multivariate statistical technique of descriptive type that is used when the relationships between variables are analyzed with two or more dimensional contingency tables. As a result of this analysis, the relationships between the categories of each variable are analyzed graphically and interpreted (Alpar, 2013). As an exploratory technique, correspondence analysis examines the relationship of data in two or more categories (Bartholomew, Steele, Moustaki, & Galbraith, 2008). In this research, two examples of misconceptions in different content standards are given for each misconception type to support the correspondence analysis. Then, misconceptions were discussed through these examples. In addition, quantitative data were supported by including direct quotations from the scenarios and interviews.

2. 5. Validity & reliability

There are many methods to increase validity. These are prolonged involvement, member checking, and peer debriefing (Holloway & Wheeler, 1996). In this study, it is thought that the fact that the researchers are actively conducting the "Misconceptions in Mathematics Teaching" course will increase the validity of the meaning and interpretation of the collected data. Because there was an interaction process between the participants and the researchers during the teaching period of the course (14 weeks). In addition, the inclusion of interviews with participants and their citations in the research findings shows that member checking is provided. As a result, it is thought that these interventions will increase the validity by reducing the Hawthorne effect (Smith & Coombs, 2003; Sedgwick & Greenwood, 2015).

Triangulation is the comparison of the results of two or more data collection methods (for example, interviews and observations) or two or more data sources (for example, individual interviews with different group members). In this way, the weaknesses of one of the methods can be compensated by the strengths of the other method (Mays & Pope, 2000; Speziale, Streubert & Carpenter, 2011). In this study, triangulation was made using document analysis, semi-structured interview, and direct quotations to ensure reliability, that is, more than one data collection technique was used. In addition, the involvement of two researchers in the collection, analysis, and interpretation of data is one of the factors that increase reliability (Denzin, 2017).

Ethical principles oversight has been adopted throughout the current research. Before starting the research, the participants were informed about the nature and process of the research. In addition, it was explained to the participants that the study would be conducted on a voluntary basis and that personal information would not be used for purposes other than the purpose of the study. The principles of scientific research and publication ethics were followed in the process of establishing the theoretical framework of the study, collecting data, analyzing, and interpreting the data. References to other publications in the study were made in accordance with scientific rules.

3. Findings

3. 1. Correspondence analysis of misconception types and mathematics content standards in misconception scenarios

In this section, the correspondence between misconception types and mathematics content standards in the misconception scenarios created by the pre-service teachers was examined. In this direction, firstly, the description was made with the correspondence table. Table 1 shows the findings related to mathematics content standards and the misconception types.

Table 1. *Correspondence Table*

Content Standard	Misconception Type			
	Overgeneralization	Overspecification	Limited Conception	Total
Numbers and Operations	31	4	6	41
Geometry	1	4	3	8
Algebra	5	1	1	7
Data Analysis and Probability	3	0	1	4
Total	40	9	11	60

When Table 1 is examined, it is seen that most of the misconception scenarios created by pre-service teachers are about numbers and operations. In addition, it is seen that the least misconceptions are given in the data analysis and probability content standard. On the other hand, when Table 1 is examined in terms of misconception types, it is determined that most of the misconception scenarios deal with overgeneralization. Overspecification is the least common type of misconception in scenarios. The data on dimensions and inertia values obtained as a result of the analysis carried out to determine the compatibility of misconception types with mathematics content standards in misconception scenarios are presented in Table 2.

Table 2. *Number of Dimensions and Explained Inertia Value*

Dimension	Singular Value	Inertia	Chi Square	Sig.	Proportion of Inertia	
					Accounted for	Cumulative
1	.476	.226	14.034	.029[a]	.967	.967
2	.088	.008			.033	1.000
Total		.234			1.000	1.000

When Table 2. Number of Dimensions and Explained Inertia Value is examined, as a result of the chi-square test carried out to determine whether the inertia is different from 0, it is seen that the total inertia is different from 0. ($\chi2(6)=14.034$, $p<0.05$). Accordingly, it can be said that there is a relationship between the row and column variables, that is, the rows and columns are not independent of each other. In addition, it is seen that 96.7% of the total inertia is explained by the first dimension and 3.3% by the second dimension. Two dimensions explain all the inertia. In , the contribution of the row and column variables to the dimensions and the inertia values they explain are given.

Table *3.* , the contribution of the row and column variables to the dimensions and the inertia values they explain are given.

Table 3. *Contribution to Dimensions and Explained Inertia Values*

Variables		Mass	Score in Dimension		Inertia	Of Point to Inertia of Dimension		Of Dimension to Inertia of Point		Total
			1	2		1	2	1	2	
Content Standard	Numbers and Operations	.683	-.280	-.069	.026	.113	.037	.989	.011	1.000
	Geometry	.133	1.750	.057	.194	.859	.005	1.000	.000	1.000
	Algebra	.117	-.116	-.268	.001	.003	.096	.503	.497	1.000
	Data Analysis and Probability	.067	-.424	1.064	.012	.025	.862	.464	.536	1.000
	Active Total	1.000			.234	1.000	1.000			
Misconception Type	Overgeneralization	.667	-.462	-.067	.068	.299	.034	.996	.004	1.000
	Overspecification	.150	1.346	-.403	.131	.572	.278	.984	.016	1.000
	Limited Conception	.183	.579	.573	.034	.129	.688	.847	.153	1.000
	Active Total	1.000			.234	1.000	1.000			

When , the contribution of the row and column variables to the dimensions and the inertia values they explain are given.

Table *3.* is examined, the inertia values of content standards and misconception types, the coordinates of the points, the contribution of the points to the dimensions and the contribution of the dimensions to the points are seen. Accordingly, geometry makes the most contribution in the first dimension among the categories of the content standards variable. Similarly, limited conception makes the most contribution to the second dimension of misconception types. When the inertia values are examined, while geometry explains most of the total inertia from the content standards variable, the overspecification category explains most of the inertia from the misconception type variable. **Error! Reference source not found.**In Figure 1, the representation of the categories on the plane is presented.

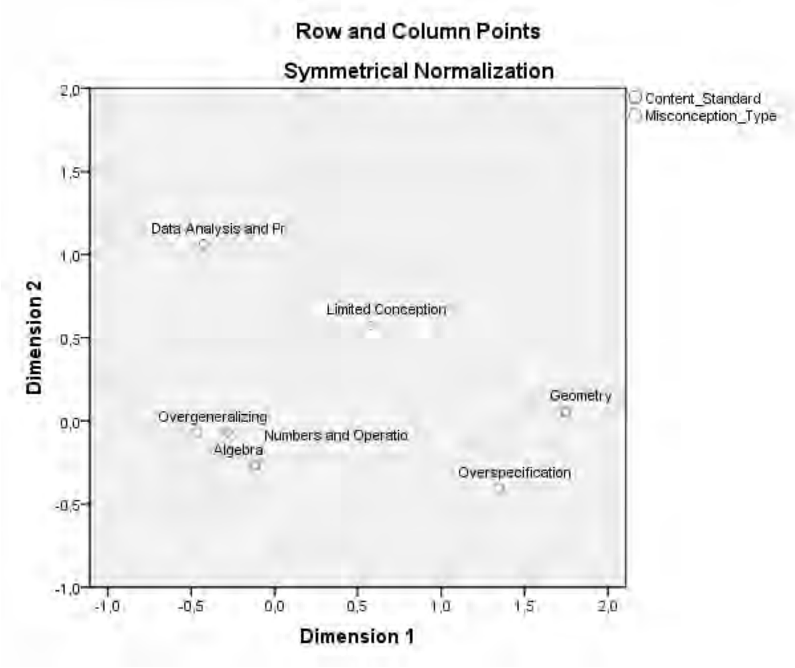

Figure 3. *In-Plane Co-representation of Row and Column Points*

When Figure 1 is examined, it is seen that overgeneralization type misconceptions are mostly related to numbers and operations and Algebra, while overspecification type misconceptions are related to geometry. In addition, the misconceptions in data analysis and probability are more related to overgeneralization and limited conception type than to overspecification type.

3. 2. Misconceptions and Scenario Examples

3.2.1. Examples of the overgeneralization type

Example 1:

In a lesson on exponential expressions, students are asked the following question;

"Every day the number of bacteria in a bacterial culture increases 100 times that of the previous day. If there are 250 bacteria in the bacterial culture at the end of the first day, how many bacteria are in the culture at the end of the third day?"

A student named Ali gave the following answer to this question.

"First day, there are 250 bacteria, next day 250x100 of them, 3. day 250x100x100 of them so there are 250. 100^2 bacteria. Let's reorganize, by writing 10^2 instead of 100. $250.(10^2).(10^2)$. It is $250.(10^2)^2$. So there is an exponential expression of an exponential expression. Then we can write it as $250.10^{2^2}=250.10^4$. Similarly, it can be expressed as $25.10.10^4 \Rightarrow 25.10^1.10^4$. While doing multiplication in exponential expressions, we multiply the bases with each other and the exponents with each other. So our value is $25.(10.10)^{1.4} = 25.100^4$. when we write 10^2 instead of 10^2 we get $25.(10^2)^4$ again we have an exponential expression of an exponential expression so it is $25.10^{2^4} =25.10.$"

According to the scenario created by the pre-service teacher in Example 1, instead of multiplying a and b at the exponent of the expression $(x^a)^b$, the student considers that part as a separate exponential expression and calculates like a^b. That is, it generalizes the exponential calculation method for the exponent of the exponent case. Another misconception encountered in this scenario is that the expression $x^a.y^b$ is calculated as $(x.y)^{a.b}$. Here, the pre-service teacher stated that the reason for the operation was the rule learned in multiplication of rational numbers and that this rule was generalized to exponential numbers. The pre-service teacher expressed this situation as:

"Ali thinks that the knowledge, formulas and rules he has learned in other subjects are valid for exponential expressions and uses what he has learned in exponential expressions. Ali makes his mistakes in certain places and regularly, that is, systematically. He also makes his mistakes with justification. In other words, Ali does not make random mistakes, he has misconceptions about exponential expressions."

Example 2:

Let's assume that the students are asked a question like the following in the lesson in which the subject of probability is covered;

"It is known that in the experiment of tossing a coin 5 times, it comes up heads 3 times. Let's find out how many heads can come up in the experiment of tossing the same coin 500 times."

Let's assume that a student named Mustafa gives the following answer to this question.

"When the coin is tossed 5 times, it is heads 3 times. So, when it is tossed 500 times, it will come up heads 300 times."

According to the scenario created by the pre-service teacher in Example 2, the student thought that heads and tails, which are two events with equal chance of happening, would be affected by previous trials. Moreover, he thought that this would take place proportionally, and he reached the conclusion by establishing a direct proportion. Therefore, in this case, the student generalized the logic of direct proportion to probability. The pre-service teacher expressed this situation as:

"By establishing a proportional relationship, Mustafa applied a solution in the form of heads 3 times when the coin is tossed 5 times, and heads come 300 times when tossed 500 times. Therefore, he thought 3/5=300/500. Mustafa's mistake is not a random mistake. While Mustafa is solving this question, he doesn't know anything. We can say that he applied his knowledge about another subject to this question by overgeneralizing."

3.2.2. Examples of the overspecification type

Example 3:

Suppose the following question is asked to the students in a lesson in which the subject of rectangles is taught;

"Mehtap teacher, who took an A4 paper in her hand, asked what we should do to get a square from this rectangle and what is the necessary condition for a rectangle to be a square."

Let's assume that a student named Ayse gives an answer to this question as follows.

"The rectangle needs to be divided in half, so that a square can be obtained."

According to the scenario created by the pre-service teacher in Example 3, the student thinks of the rectangle as a figure with 4 right angles and the length of its long side twice the length of its short side. Therefore, she perceived the concept of rectangle as a much more special version of its original definition. Therefore, it seems that the type of misconception in this example is overspecification. The pre-service teacher expressed this situation as:

"If Ayse carelessly chose the longer side of the rectangle to be twice the shorter side, the error could be a random one. However, this error is not random, assuming you think the square is half of the rectangle or that the rectangle is made up of two squares. We can say that Ayse does not fully understand the definition of a rectangle and thinks that its sides should always be double of each other, that is, she thinks that it consists of the union of two squares."

Example 4:

Suppose that the students were asked a question like the following in a lesson in which the subject of rational numbers was taught;

"Which of the following numbers is a rational number? Explain the reason for your answer.

A)-6 B)0 C) $\frac{2}{7}$ *D) All"*

Let's assume that a student named Nilsu answers this question as follows.

"It is option C, teacher. Because rational numbers consist of numerator and denominator."

According to the scenario created by the pre-service teacher in Example 4, the student thinks that for a number to be rational, it must have components that are separated by a fraction line and include the numerator and denominator. That is, she thinks that rational numbers have a special notation, not realizing that they can normally be represented in many ways. Therefore, it is seen that the misconception here is in the type of overspecification. The pre-service teacher expressed this situation as:

"He has not learned exactly what the concept of rational number means. He knows that rational numbers consist of numerator and denominator. But he could not learn that the set of rational numbers includes the set of natural numbers and integers, and he made a mistake. This is not a random error. Because the student could not understand what the rational number set means exactly, he fell into a misconception."

3.2.3. Examples of the limited conception type

Example 5:

Suppose that the students were asked a question like the one below in a lesson in which the subject of constructing triangles was covered;

"Which of the following is sufficient to construct a triangle ABC??

A) $s(\hat{A}),\ s(\hat{B}),\ s(\hat{C})$

B) $|AB|,\ |BC|,\ s(\hat{C})$

C) $s(\hat{C}),\ s(\hat{A}),\ |AB|$

D) $|BC|,\ |AB|,\ s(\hat{B})$ *"*

Let's assume that a student named Piraye in your class answers this question as follows.

"Choice A, if the angles are, then the triangle is also"

According to the scenario created by the pre-service teacher in Example 5, the student thinks that having three angles is sufficient to construct a triangle. Therefore, the student ignored that there could be triangles of different side lengths with the same angles. This situation shows that the student has a misconception of limited conception about triangle constructions. The pre-service teacher expressed this situation as:

"The mistake made by the student is not random because if we look at the student's explanation here, we can easily say that the student has fallen into misconceptions. Because the student has explained with confidence and thinks that if we know only three angles, a triangle will form."

Example 6:

Let's assume that a question like the one below is asked to students in a lesson that teaches the subject of solving equations:

"Can you show the reason for each operation you did to find the solution set of the equation 8(x+2)-14= 3x + 32?"

Let's assume that a student named Hakan gives an answer as follows to this question.

"8(x+2) -14= 3x + 32

8x +16 -14 = 3x +32 (I distributed 8 in parentheses)

8x +2 = 3x + 32 (I subtracted 14 from 16)

11x = 34 (I threw the unknown aside, the known aside)

x= 34/11 (I found the result)"

According to the scenario created by the pre-service teacher in Example 6, during the equation solving process, the student tries to group the unknown and the known on one side, and while doing this, he did not change the sign while crossing the other side of the equation. Therefore, it is seen that there is limited conception about the equation solving process. Kieran (1992) stated that changing sides and changing signs in teaching equation solving may cause such errors, and instead stated that the equation should be solved by adding the same values to both sides of the equation in the equation solving process. The pre-service teacher expressed this situation as:

"The student made a mistake while using the pass-through method, ignored the negative signs and found the result incorrect. It can be said that students generally ignore the signs in equations with negative coefficients and avoid difficulties and make mistakes. I think Hakan's mistake is a systematic mistake. Because Hakan will repeat the same mistake if his misconception is not removed."

4. Discussion conclusion and recommendations

Considering the research results based on misconception types, it was seen that the most common misconception type was overgeneralization, whereas the misconception type in the wrong translation did not emerge. When the literature is examined in terms of misconception types, it is seen that generalization is a very common misconception type (Graeber & Johnson, 1991; Ben-Hur, 2006). Therefore, it can be said that the results of the research are in parallel with the literature in this respect. In addition, in some studies, the types of misconceptions were classified as overgeneralization and overspecification only (Ben-Hur, 2006; Özmantar, Bingölbali, & Akkoç, 2010). This result also explains that there were few examples of limited conception types and that there was mistranslation type in our study.

When the research results are examined in the context of content standards of mathematics, it is seen that the misconceptions mostly belong to the subjects of numbers and operations. Adiguzel et al. (2018) stated that studies on misconceptions are mostly focused on numbers and operations at the middle school level. In addition, it has been determined that in studies on misconceptions and solution proposals in mathematics, numbers and operations are emphasized (Ben-Hur, 2006; Ojose, 2015). In addition, studies examining the distribution of misconceptions according to mathematics subjects also show that misconceptions about numbers and operations are in the majority (Green, Piel, & Flowers, 2008; Mohyuddin & Khalil, 2016; Bowers, 2021).

Examples of misconception scenarios related to geometry and algebra are very limited in the research. In addition, no sample related to measurement was found. However, when we examine the literature, it is seen that misconceptions regarding these content standards have been identified (Goodwin & Goodwin, 1999; Atebe & Schäfer, 2008; Rusell, O'dwyer & Miranda, 2009; Luneta, 2015; Tan Sisman & Aksu, 2016; Stegall & Malloy, 2019). It is thought that this situation may be since pre-service teachers' conceptual understanding levels are higher towards numbers and operations rather than subjects such as geometry, algebra, and measurement. As a matter of fact, the fact that Brown and Burton (1978) stated that the types of problems that lead students to mistakes the most are the problems related to numbers and operations, emphasizing the importance of conceptual understanding of numbers and operations.

As a result of the research, it was determined that the misconceptions in the type of overspecification were related to geometry. Ryan and Williams (2007) state that the predominance of overspecification type misconceptions in geometry may be since individuals generally have uniform stereotyped perceptions about shapes. On the other hand, van Hiele (1986) stated that in terms of geometry thinking levels, students at the first level perceive shapes as being limited to the special states that are usually presented to them. This situation explains the relationship between geometry and overspecification type misconceptions.

In line with the results of the research, the following suggestions can be made:

In our research, many misconception scenarios related to generalization and specialization types have been identified. Therefore, it may be beneficial to conduct direct research on restricted perception and mistranslation in future studies.

In order to cope with the misconceptions in the type of overspecification about geometry, it is recommended not to be limited to only one and the most specific example, that is, to include shapes with different stances and sizes when introducing geometric shapes.

References

Adıgüzel, T., Şimşir, F., Çubukluöz, Ö., & Gökkurt Özdemir, B. (2018). Türkiye'de matematik ve fen eğitiminde kavram yanılgılarıyla ilgili yapılan yüksek lisans ve doktora tezleri: tematik bir inceleme [Master's theses and doctoral dissertations on misconceptions in mathematics and science education in turkey: A thematic analysis]. *Bayburt Eğitim Fakültesi Dergisi, 13* (25), 57-92. Retrieved from https://dergipark.org.tr/en/pub/befdergi/issue/38072/411387

Alpar, R. (2013). *Uygulamalı çok değişkenli istatistiksel yöntemler [Applied multivariate statistical methods].* Ankara: Detay Yayıncılık.

An, S., & Wu, Z. (2012). Enhancing mathematics teachers' knowledge of students' thinking from assessing and analyzing misconceptions in homework. *International Journal of Science and Mathematics Education*, *10*(3), 717-753. https://doi.org/10.1007/s10763-011-9324-x

Atebe, H. U., & Schäfer, M. (2008). "As soon as the four sides are all equal, then the angles must be 90° each". Children's misconceptions in geometry. *African Journal of Research in Mathematics, Science and Technology Education, 12*(2), 47-65. https://doi.org/10.1080/10288457.2008.10740634

Bada, S. O. (2015). Fostering creativity among children in the 21st century classroom: The emerging perspectives. *Academic Research International, 6*(6), 136-145.

Bahçeci, D., & Kaya V. H. (2010). Kavramsal algılamalar ve kavram yanılgıları [Conceptual perceptions and misconceptions]. *Bilim ve Teknik Dergisi,* 515, 30-33.

Baki, A. (2006). *Kuramdan Uygulamaya Matematik Eğitimi (3. Baskı)[Mathematics Education from Theory to Practice (3rd Edition)].* İstanbul: Derya Kitabevi.

Baki, A., & Aydın Güç, F. (2014). Dokuzuncu sınıf öğrencilerinin devirli ondalık gösterimle ilgili kavram yanılgıları [The misconceptions of minth grade students about cyclic decimal notation]. *Turkish Journal of Computer and Mathematics Education, 5*(2), 176-206. Retrieved from https://dergipark.org.tr/en/pub/turkbilmat/issue/21573/231511

Bartholomew, D. J., Steele, F., Moustaki, I., & Galbraith, J. I. (2008). *Analysis of multivariate social science data (2nd Edition).* Florida: Chapman & Hall.

Ben-Hur, M. (2006). *Concept-rich mathematics instruction: Building a strong foundation for reasoning and problem solving*. ASCD.

Bowen, C.W., & Bunce, D.M. (1997). Testing for conceptual understanding in general chemistry[1]. *The Chemical Educator*, *2*, 1–17. https://doi.org/10.1007/s00897970118a.

Bowers, B. E. (2021). *Teachers identifying and responding to learner errors and misconceptions in numbers, operations and relationships in the ıntermediate phase*. [Unpublished master's thesis]. Stellenbosch University. https://scholar.sun.ac.za/handle/10019.1/109975

Brown, G., & Quinn, R. J. (2006). Algebra students' difficulty with fractions: An error analysis. *The Australian Mathematics Teacher, 62*(4), 28–40. https://search.informit.org/doi/10.3316/informit.153305808535500

Brown, J. S., & Burton, R. R. (1978). Diagnostic models for procedural bugs in basic mathematical skills. *Cognitive science, 2*(2), 155-192.

Bryman, A. (2007). Barriers to integrating quantitative and qualitative research. *Journal of Mixed Methods Research, 1*(1), 8-22. https://doi.org/10.1177/2345678906290531

Coombs, S., & Smith, I. (2003). The Hawthorne effect: Is it a help or hindrance in social science research? *Change: Transformations in Education*, *6*(1), 97-111. https://search.informit.org/doi/10.3316/ielapa.200307649

Creswell, J. W., & Creswell, J. D. (2017). *Research design: Qualitative, quantitative, and mixed methods approaches.* Sage Publications.

Denzin, N. K. (2017). *The research act: a theoretical introduction to sociological methods*. New York: Routledge

Fischbein, E. (1993). The theory of figural concepts. *Educational Studies in Mathematics, 24*(2), 139-162. https://doi.org/10.1007/BF01273689.

Golan, M. (2011). *Origametria and the van Hiele theory of teaching geometry*. P. W. Iverson, R. J. Lang & M. Yim (Eds.), Origami 5: Fifth International Meeting of Origami Science, Mathematics and Education (5OSME) (pp. 141-150). Boca Raton: CRC Press.

Goodwin, L. D., & Goodwin, W. L. (1999). Measurement myths and misconceptions. *School Psychology Quarterly, 14*(4), 408.

Graeber, A. O. (1993). Misconceptions about multiplication and division. *Arithmetic Teacher, 40*(7), 408-412.

Graeber, A., & Johnson, M. (1991). *Insights into secondary school students' understanding of mathematics.* College Park, University of Maryland, MD.

Green, M., Piel, J. A., & Flowers, C. (2008). Reversing education majors' arithmetic misconceptions with short-term instruction using manipulatives. *The Journal of Educational Research, 101*(4), 234-242.

Greene, J. C. (2007). *Mixed methods in social inquiry*. San Francisco: Jossey-Bass.

Holloway, I., & Wheeler, S. (1996). *Qualitative research for nurses*. Oxford: Blackwell Science Ltd.

Johnston, A. T., & Southerland, S. A. (2000, April). A reconsideration of science misconceptions using ontological categories. *In Annual Meeting of the National Association for Research in Science Teaching*, New Orleans, LA.

Kazemi, F., & Ghoraishi, M. (2012). Comparison of problem-based learning approach and traditional teaching on attitude, misconceptions and mathematics performance of University Students. *Procedia-Social and Behavioral Sciences*, 46, 3852-3856. https://doi.org/10.1016/j.sbspro.2012.06.159

Kieran, C. (1992). *The learning and teaching of algebra*. In D.A. Grouws (Eds). Handbook of research on mathematics teaching and learning, (pp.390-419). New York: McMillan.

Lesh, R., Post, T. & Behr, M. (1987). *Respresentations and translations among representations in mathematics learning and problem solving.* In C. Janvier (Ed). Problems of representation in the teaching and learning mathematics. Hillsdale, NJ: Lawrence Erlbaum Associates.

Luneta, K. (2015). Understanding students' misconceptions: an analysis of final Grade 12 examination questions in geometry. *Pythagoras, 36*(1), 1-11.

Mays, N., & Pope, C. (2000). Assessing quality in qualitative research. *British Medical Journal (BMJ), 320*(7226). https://doi.org/10.1136/bmj.320.7226.50

Mills, G. E., & Gay, L. R. (2016) *Education research: Competencies for analysis and applications.* London, England: Pearson Education.

Mohyuddin, R. G., & Khalil, U. (2016). Misconceptions of Students in Learning Mathematics at Primary Level. *Bulletin of Education and Research, 38*(1), 133-162.

Moss, J., & Case, R. (1999). Developing children's understanding of the rational numbers: A new model and an experimental curriculum. *Journal for research in mathematics education, 30*(2), 122-147. https://doi.org/10.2307/749607.

NCTM, (2001). *Principles and standards for school mathematics*. Reston, VA: National Council of Teachers of Mathematics.

Novak, J. D. (2002). Meaningful learning: The essential factor for conceptual change in limited or inappropriate propositional hierarchies leading to empowerment of learners. *Science Education, 86*(4), 548-571. https://doi.org/10.1002/sce.10032

Ojose, B. (2015). Common misconceptions in mathematics: Strategies to correct them. University Press of America.

Özmantar, M.F., Bingölbali, E. & Akkoç, H. (2010). *Matematiksel kavram yanılgıları ve çözüm önerileri[Mathematical misconceptions and solution suggestions]*. Ankara: Pegem Akademi Yayıncılık.

Palmer, M.W. (2001). Extending the quasi-neutral concept. *Folia Geobot 36*, 25–33. https://doi.org/10.1007/BF02803135.

Prescott, A. & Mitchelmore, M. (2005). *Teaching projectile motion to eliminate misconceptions.* Proceedings of the 29th Conference of the International Group for the Psychology of Mathematics Education. Edited by: Chick, H. L. and Vincent, J. L. Vol. 4, pp.97–104. Melbourne, Australia: PME.

Russell, M., O'dwyer, L. M., & Miranda, H. (2009). Diagnosing students' misconceptions in algebra: Results from an experimental pilot study. *Behavior research methods, 41*(2), 414-424. https://doi.org/10.3758/BRM.41.2.414

Ryan, J., & Williams, J. (2007). *Children's mathematics 4-15: learning from errors and misconceptions.* McGraw-Hill Education (UK).

Sedgwick, P., & Greenwood, N. (2015). Understanding the Hawthorne effect. *British Medical Journal (BMJ), 351*:h4672. https://doi.org/10.1136/bmj.h4672

Senemoğlu, N. (2013). *Gelişim, öğrenme ve öğretim, (23. Baskı) [Development, learning and teaching, (23rd Edition)].* Ankara: Yargı Yayınevi.

Smith, J.P., Disessa, A.A., & Roschelle, J. (1993). Misconceptions reconceived: A constructivist analysis of knowledge in transition. *The Journal of the Learning Sciences, 3*(2): 115–163. https://doi.org/10.1207/s15327809jls0302_1.

Speziale, H. S., Streubert, H. J., & Carpenter, D. R. (2011). *Qualitative research in nursing: Advancing the humanistic imperative*. Lippincott Williams & Wilkins.

Stegall, J. B., & Malloy, J. A. (2019). Addressing Misconceptions in Algebra 1. *The Mathematics Teacher, 112*(6), 450-554. https://doi.org/10.5951/mathteacher.112.6.0450

Swan, A. (2001). Dealing with misconceptions in mathematics. (Eds. Gates, P.) *Issues in mathematics teaching,* 147-166. RoutledgeFalmer: New York.

Talanquer, V. (2006). Commonsense chemistry: A model for understanding students' alternative conceptions. *Journal of Chemical Education, 83*(5), 811. https://doi.org/10.1021/ed083p811.

Tan Sisman, G., & Aksu, M. (2016). A study on sixth grade students' misconceptions and errors in spatial measurement: Length, area, and volume. *International Journal of Science and Mathematics Education, 14*(7), 1293-1319. https://doi.org/10.1007/s10763-015-9642-5

Temizkan, M. (2011). The effect of creative writing activities on the story writing skill. *Educational Sciences: Theory and Practice, 11*(2), 933-939. https://eric.ed.gov/?id=EJ927384

Tenenbaum, J. B. (2000). *Rules and similarity in concept learning*. S. A. Solla, T. K. Leen, & K. R. Müller (Eds.), Advances in Neural Information Processing Systems 12 (59-65), Cambridge, MA: MIT Press.

van Hiele, P. M (1986). *Structure and insight: A theory of mathematics education*. Academic Press: Inc. Orlando, Florida.

Wild, T. A., Hilson, M. P., & Hobson, S. M. (2013). The conceptual understanding of sound by students with visual impairments. *Journal of Visual Impairment & Blindness, 107*(2), 107-116. https://doi.org/10.1177/0145482X1310700204.

Yazdani, M. A. (2006). The exclusion of the students' dynamic misconceptions in college algebra: A paradigm of diagnosis and treatment. *Journal of Mathematical Sciences & Mathematics Education, 3*(2), 56-61. http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.578.329&rep=rep1&type=pdf

Authors

Nurullah YAZICI, Department of Mathematics and Science Education, Tokat Gaziosmanpasa University, Tokat (Turkey). E-mail: yazicinurullah@gmail.com

Mertkan ŞİMŞEK, Department of Mathematics and Science Education, Agri Ibrahim Cecen University, Agri (Turkey). E-mail: mertkans@gmail.com