Identifying Concepts Created for Geometric Objects: Mind Map

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Abstract
The purpose of this research is to determine the knowledge, perceptions and misconceptions of pre-service primary school teachers about geometric objects through mind maps. For this purpose, the research was designed with a case study, one of the qualitative research methods. The study group of the research consists of 52 pre-service primary school teachers studying at a state university in the Aegean Region of Turkey. After giving information about mind maps to pre-service primary school teachers, they were asked to create mind maps about the concept of "Geometric Objects". The created mind maps were subjected to content analysis and codes and categories were created. The mind maps of pre-service primary school teachers were analysed one by one, starting from the centre towards the outer branches and separated as related and unrelated concepts. As a result of the research, it was revealed that most of the pre-service primary school teachers who participated in the study used the concepts of geometric objects and geometric shapes interchangeably. In addition, as a result of the analysis of the first branches of mind maps, it was determined that unrelated concepts were more than related concepts. Very few of them have reached the fourth branch in the mind maps created by pre-service primary school teachers, and they had difficulty explaining the concept. In line with the results obtained from the research, the concepts related to geometric objects should be taught in the undergraduate education of pre-service primary school teachers to provide meaningful learning about geometric concepts in pre-service primary school teachers.
Keywords: Geometric objects, Mind map, Pre-service primary school teachers, Primary school, Concept.

Introduction

Geometry, which is used and encountered in every field in daily life, constitutes an important field in mathematics. In engineering and other branches of science, geometry has an important place in mathematical modelling, solving problems, solving daily life problems, recognising space and developing skills related to space, interpreting the physical environment and spatial visualisation (Aksu, 2005; Gündüz, Bulut and Dündar, 2017; Jones, 2002). In addition to these, geometry is expressed as a branch of science that reveals point, line, plane, planar shapes, space, spatial shapes and the relationships between them (Baykul, 2009). In addition to improving spatial thinking skills, geometry also develops questioning, reasoning and proof skills (Battista, 2007). In this context, the National Council of Teachers of Mathematics ([NCTM], 2000) and the Ministry of National Education ([MoNE], 2018) state that students' association skills should be acquired from an early age as well as recognising geometric shapes and objects and their properties. Sarama and Clements (2009) stated that learning and developing geometric concepts at an early age would increase the potential and capacities of the students for geometry. Therefore, it is necessary for students to recognise, define and name geometric objects and

shapes (Sarfaty and Patkin, 2013). It is seen that teachers have an important place in the development of geometric concepts and thinking in children at an early age (Tsamir, Tirosh, Levenson, Barkai and Tabach, 2015). The teacher is an important factor in developing geometric skills in students and increasing students' geometry achievements. Teachers need to know a certain content knowledge and the definitions of related geometric concepts. (Ball, Thames and Phelps, 2008; Ünlü, 2021).

Teachers' subject matter knowledge has an important place for students' success and all development processes. Shulman (1986) created a theoretical framework that consists of three categories of teaching content knowledge; subject matter knowledge, pedagogical content knowledge and curriculum knowledge. In addition, competencies related to the teaching profession have been established in the forms of pedagogical content knowledge, subject matter knowledge and curriculum knowledge by the Ministry of National Education in our country (MoNE, 2017). Teachers' pedagogical content knowledge impacts students learning, and subject matter knowledge has an important place in the formation of pedagogical content (Ball and McDiarmid, 1989; Ünlü and Horzum, 2018). It is stated that there is a relationship between teachers' subject matter knowledge and pedagogical content knowledge (Even, 1993; Lee, Capraro and Caprora, 2018; Ma, 2010; Zayyadi, Nusantara, Hidayanto, Sulandra and Sa'dijah, 2020). If the subject matter knowledge is sufficient, the relationship between the concepts will increase and teachers will be able to use different strategies and techniques in transferring the subject to the students (Cohen, 1993). Thus, the quality of the teaching process will increase with the desired level of subject matter knowledge and this will reflect positively on the academic success of the students. From this point of view, NCTM (2000) stated that the teachers' subject matter knowledge of mathematics and geometry became more important.

Geometry, a sub-branch of mathematics, makes it easier to understand the world and explain the universe with abstract representations (Baki, 2001). The geometry learning domain includes the concepts of space and shape (Fidan and Türnüklü, 2010). In the learning domain of geometry, it is aimed to develop students' visual perceptions, logical, spatial and critical thinking, questioning and problem-solving skills (Baykul, 2012; NCTM, 2000; Tapan and Arslan, 2009). Geometry has an important place in establishing relationships between daily life and mathematical concepts and also it plays an effective role in interpreting the other mathematical concepts (Karakuş, 2018). Since geometry is important in mathematics education and students have difficulties regarding geometry, research in this field has increased in recent years. In line with the report published by Trends in International Mathematics and Science Study (TIMMS) in 2019, although the success rate in the field of geometry increased in Turkey, the desired level could not be reached due to the difficulties of students in this field. In geometry, students have the most difficulty in geometric objects (Gökkurt, Şahin, Soylu and Doğan, 2015). The subject matter knowledge of teachers, who organise and guide learning processes, has an important effect on students difficulties related to geometric objects. However, it is seen that the majority of teachers cannot fully understand the concepts of geometric objects, which negatively affects the formation of content knowledge about geometric objects (Baumert, vd., 2010; Gökkurt and Soylu, 2016; Yıldızlı and Sarı, 2017). These problems experienced by teachers in concepts related to geometric objects are also observed in pre-service teachers who continue their university education (Bozkurt and Koç, 2012; Browning, Edson, Kimani and Aslan-Tutak, 2011; Gökbulut, 2010; Gutierrez and Jaime, 1999; Marchis, 2012; Ünlü, 2021). The basic problems regarding the teaching of geometric objects lie in the memorisation of concepts in geometry teaching and the use of insufficient examples and geometric shapes instead of objects (Fujita and Jones, 2007). In the preparation of an effective teaching environment by eliminating these problems, especially the pre-service primary school teachers who will teach the concepts related to geometry, pre-service teachers have an important place. The mental structures related to the concepts have an important place in the correct formation of conceptual information about geometry.

Knowing the concepts related to mathematics has an important place in the formation of mathematical thinking, distinguishing concepts and expressing

mathematical ideas (Çakıroğlu, 2013). Definition, presentation of related and unrelated examples are of great importance in the formation of the concepts (Gökbulut and Ubuz, 2013). Since a single definition of the concept cannot be made in different minds, each mind creates a different structure for the concept. Even though individuals make a correct definition of the concept, it does not mean that the concept is known by individuals (Vinner, 1991). Therefore, while an image related to the concept is formed in the minds of individuals, this image does not fully reflect the concept. It is important that the images of the concept and the concept definition are in interaction in forming concepts for geometry (Vinner and Herskowitz, 1980). The conceptual image develops as a result of the development of the cognitive structure that includes the definitions of the geometric concept, and the development of the conceptual image is also effective in the formation of the conceptual understanding (Ünlü and Horzum, 2018). It is important to know the conceptual knowledge, which has an important place in forming teachers' subject matter knowledge for geometry education. Because there are difficulties in understanding and defining geometric concepts in education at all levels from the beginning to the end of the formal education process (Barnabeu, Moreno and Llinares, 2021; Tirosh and Tsamir, 2021; Tsamir, Trosh and Levenson, 2008; Türnüklü and Ergin, 2016). Teachers constitute the biggest source of mistakes made, difficulties in geometry concepts emerging at all levels of education. In this direction, many studies have been conducted to determine the situations related to geometric concepts for teachers and pre-service teachers (Alkış Küçükaydın and Gökbulut, 2013; Gökbulut, 2010; Gökkurt, Şahin, Karakuş, 2018; Marchis, 2012; Soylu and Doğan, 2015; Ubuz and Gökbulut, 2015; Ulusoy, 2020; Kılıçoğlu, 2020; Ünlü, 2021; Ünlü and Horzum, 2018; Yıldızlı and Sarı, 2017; Yurtyapan and Karataş, 2020). Among these researches on geometric concepts, researches on geometric objects have an important place. Using mind maps to reveal which concepts pre-service teachers produce about geometric objects and the state of reaching the meaning of the conceptual definition with these concepts can give healthier results in revealing the mental structures related to the concept.

The mind map, which is expressed as an information network (Oxford Dictionary, 2021) that presents correlated ideas organised around a central idea, is a note-taking technique introduced by mathematician, psychologist and brain researcher Tony Buzan in the 1960s. The mind map is defined as a visual, graphic and nonlinear holistic thinking tool of memory, creativity, learning, ideas and relationships suitable for all kinds of brain functions (Biktimirov and Nilson, 2006; Buzan and Buzan, 2015; Yang, Gao, Li, Ye, Sun, and Huang, 2020). Mind maps are a method that helps to take a comprehensive view of a subject and to make the relationships between elements transparent (Schawel and Billing, 2018). By using visual elements in the process of accessing, retrieving, organising and storing information, it is ensured that a large information is stored in a small area with multiple senses (D'Antoni, Zipp and Olson, 2009; Huba and Freed, 2000). Mind map; can be used as a learning tool, teaching tool, visual learning tool to organise and remember information by systematically connecting it with previous information, to take notes, to write, to make presentations, to plan for the future, to reveal an individual's thoughts on a subject for evaluation purposes (Buzan and Buzan, 2015; Cockburn, 2011; Farrand, Hussain and Hennessy, 2002; Goodnough and Woods, 2002; Uysal and Sidekli, 2020; Wu and Wu, 2020; Yorulmaz, Uysal and Sidekli, 2021). Mind mapping is a pedagogical resource; it is used for many purposes in the field of education. It is used to increase students motivation (Wu and Wu, 2020) as a tool for creative learning and active learning (Stankovic, Besic, Papic and Aleksic, 2011), as a critical thinking tool (Rezapour-Nasrabad, 2019; Wu and Wu, 2020), and collective knowledge (Stokhof, de Vries, Bastiaens and Martens, 2020). Mind mapping for the first time in mathematics lessons by Entrekin (1992) is an effective and enjoyable tool in teaching the subjects. Mind maps, which enable individuals to visualise concepts and produce ideas, also clarify the information in the mind (Al-Jarf, 2009; Handoko, Nursanti, Harman to ve Sutriono, 2016). It supports the search for aspects related to a particular subject, helps to visualise the relationships between items, makes it easier to structure a complex

subject and provides a precise definition of the problem or issue (Schawel and Fatura, 2018). By clarifying the knowledge, mind maps provide an important advantage in determining the level of knowledge of the individual regarding the concept, revealing the situation of associating between concepts, detecting and eliminating misconceptions (Seyihoğlu and Kartal, 2010).

There are many reasons why primary school students are successful or have difficulties with geometric objects. The biggest reason students in primary school have difficulties with geometric objects is the lack of knowledge of primary school teachers about these concepts and the problems experienced in teaching the subject of geometric objects formed in this direction. The quantity and quality of a teacher's subject matter knowledge is critical in being a good teacher (Shulman, 1986). Subject matter knowledge has a great impact on raising successful students (Hill, Rowan and Ball, 2005). In this context, this study has an important place to define and make sense of the concept of geometric objects, which is one of the basic subjects of geometry, and reveal misconceptions and errors to raise students with high geometry success in primary school education. Because the depth of the subject matter knowledge of the pre-service primary school teachers, who will be the primary school teachers of the future, about geometric objects is important in terms of the quality of their education in future, if the situation of pre-service primary school teachers regarding geometric objects in the first year of their undergraduate education is determined, the content of the educational processes will be prepared in a way that will contribute to the professional development of the pre-service teachers. This study, which will be carried out from this point of view, is important in determining and developing the subject matter knowledge of pre-service primary school teachers about geometric objects. Mind maps have an advantageous structure in determining subject matter knowledge about geometric objects and revealing conceptual misconceptions and errors. From this point of view, the aim of the research is to determine the subject matter knowledge, conceptual misconceptions and mistakes of pre-service primary school teachers about the concept of geometric objects by using the mind map method.

Method

Research Model

The research was designed with the case study, which is one of the qualitative research designs. A case study is a qualitative research method in which one or more of a situation with defined limits is analysed in an intense and detailed manner (Christensen, Johnson and Turner, 2015). This method was preferred because it was aimed to reveal the knowledge and misconceptions of the pre-service primary school teachers about geometric objects in detail.

Participants

Participants of the study consist of 52 first grade, pre-service primary school teachers who continue their education in the Department of Primary School Teacher at the Faculty of Education of a state university located in the Aegean Region of Turkey in the first week of the fall semester of the 2019-2020 academic year. Participants were selected using purposeful sampling. In purposeful sampling, the characteristics of the individuals who will form the research universe are determined and the participants who fit these characteristics are selected (Büyüköztürk, Kılıç Çakmak, Akgün, Karadeniz and Demirel, 2017; Christensen, Johnson and Turner, 2015). The characteristics of the individuals to participate in the research are determined as being a student in first grade and taking a lesson of Basic Mathematics in Primary School.

Data Collection Tool and Process

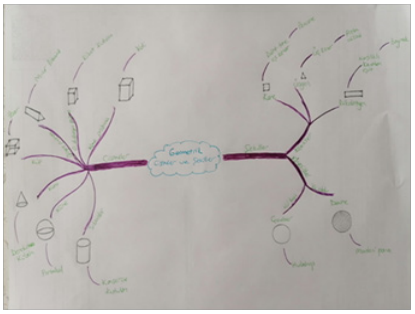
Mind maps were used to reveal the knowledge and misconceptions of the pre-service primary school teachers about geometric objects. Before having a mind map on geometric objects, the pre-service primary school teachers were informed by the researchers about how to make a mind map during 1-hour class. After the pre-service primary school teachers were given information about the mind map, they were given 30 minutes to create mind maps about "Geometric Objects". While the pre-service primary school teachers were creating mind maps, the researchers were in the classroom environment and reminded of the rules of the mind map.

There are certain rules when making a mind map and it is necessary to pay attention to these rules. When making a mind map, an A4 sheet of paper should be taken and kept parallel to the plane. At least 3 coloured pencils must be used. The subject can be written in the middle of the page, or the visual of the subject can be drawn. Associations related to the subject should be written on the branches and a relevant visual should be drawn. There should not be only writings on the branches and pictures should be included. Branches should be drawn from the centre to the outside, from thick to thin. In this way, a mind map is created (Buzan and Buzan, 2015).

Data Analysis

The content analysis method was applied to analyse the data from the data collection tool (mind maps). The data obtained were coded as "Z1, Z2, Z3 …" before proceeding to the analysis phase of the data. The branches of mind maps created by the pre-service primary teachers were analysed in separate categories one by one, in detail and intensely by the nature of the mind map. While analysing mind maps, the following steps were followed:

1. The main subject has been determined as "Geometric Objects". It has been checked whether the given topic was written correctly in the middle of the page. The mind maps of the pre-service primary school teachers who did not write "Geometric Objects" as the subject or wrote two subjects were removed from the analysis. Eight pre-service primary school teachers wrote "Geometric Shapes" as the main subject, and one teacher wrote "Geometric Objects and Shapes". For this reason, the mind maps of 9 pre-service primary school teachers (Z26, Z35, Z37, Z42, Z45, Z47, Z48, Z51 and Z52) were not included in the study. In Picture 1, the mind maps of a pre-service primary school teacher who wrote "Geometric Shapes" and "Geometric Objects and Shapes" as the main subject.



Z37

Z48

Picture 1: Misspelt mind maps

2. When analysing the mind maps, the branches of the mind map were finished and the next branch was not analysed. For example, the mind map was finished in the last second branch. While analysing the third branch, the analysis was made by removing this mind map.
3. Since the mind maps of the pre-service primary school teacher were analysed branch by branch, if one branch was correct and the other branches were incorrect, the analyses were continued on the correct branch.
4. After controlling the main subject, analyses were carried out with 43 mind maps. The first branches of mind maps coming out of the main subject were analysed. While analysing the first branches, investigations have been made about geometric objects as "related and unrelated concepts". Concepts related to geometric objects were written as related, concepts not related to geometric objects were written as unrelated concepts. Related concepts were previously determined by the researchers. Related concepts were decided to be geometry, cube, square prism, rectangular prism, cylinder, cone, pyramid, sphere, triangular prism, space, geoid, the properties of geometric objects, places where geometric objects are used. When analysing the mind maps of the pre-service primary school

teachers, if concepts related to geometric objects are determined, unlike these related concepts, they are added as related concepts.

5. After the analysis of the first branches, the second branches were started. While analysing the second branch, branches emerging from related concepts were analysed. Because unrelated concepts were detached from the main subject, this reason, it was concluded that the analysis would not be correct. In examining the second branch, attention has been paid to the concepts related to "Geometric Objects" and "Concept in the First Branch". The second branch they are divided into related and unrelated concepts.
6. After analysing the second branches, the third branches were started. While analysing the third branch, attention has been paid to its relation with "Geometric Objects" and "Concept in the Second Branch". Concepts in the third branch were also analysed as related and unrelated concepts.
7. After the third branch, mind maps with the fourth branch were analysed. While analysing the fourth branches, their relationship with "Geometric Objects" and "Concept in the Third Branch" was analysed. The fourth branch was analysed by dividing into two as related and unrelated concepts.

The qualitative data were quantified by taking the frequency of the concepts in the branches of the mind maps analysed and presented in the findings in tables. While tabulating the mind maps, it is stated in the related concepts in the previous branch to understand which branches are written. In addition to specifying the relationships between branches, the frequencies of all concepts are specified in the total column to determine how many concepts have been written. While analysing mind maps, each branch was analysed separately. Moreover, the relationship of each branch with the main subject and the previous branch was taken into account while analysing. The mind maps of all pre-service primary school teachers participating in the study were collected.

Findings

The findings obtained from the analyses of the first branch of mind maps on "Geometric Objects" by the pre-service primary school teachers are presented in Table 1.

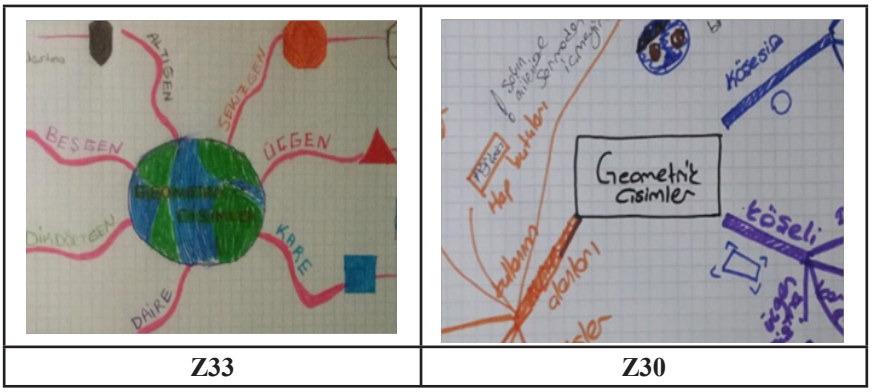
Table 1: The Concepts in the First Branch of the Mind Map on Geometric Objects

Level of the Branch		f	Concepts
First Branches	Related	23	Pyramid (8), cube (8), cylinder (6), cone (5), usage areas/their equivalents in daily life (5), sphere (4), objects (3), triangular prism (3), 3 dimensions (3), space (3), angular (3), prism (2), agonic (2), geometry (2), rectangular prism (2), properties, volume, regular, edge, area, height, square prism, geoid.
	Unrelated	52	Triangle (24), square (22), circle (21), rectangle (19), mathematics (11), pentagon (9), hexagon (9), shapes (7), circle (6), trapezoid (5), deltoid (4), teacher (3), angles (3), student (3), ruler (3), house (2), polygons (2), lesson (2), formula (2), school (2), head, monitor, classroom, parallelogram, plane, drawing, baklava, sport, mountain, honeycomb, telephone, table, world, Pythagoras, straight line, quadrilateral, questions, exam, hypotenuse, physics, octagon, two-dimensional, universe, design , the environment we live in, Picasso, sight, geometry question bank, concave, convex, modern architecture.

When Table 1 is analysed, it is seen that unrelated concepts (f = 52) take place more than related concepts (f = 23) in the mind map of pre-service primary school teachers. Pyramid (f = 8), cube (f = 8), cylinder (f = 5), usage areas/equivalents in daily life (f = 5) were determined as the most repeated concepts in related concepts. In unrelated concepts, triangle (f = 24), square (f = 22), circle (f = 21), rectangle (f = 19), mathematics (f = 11) are the most frequently repeated concepts. There is a

big difference between the most frequently repeated concepts in related and unrelated concepts. While the related concept "pyramid" was repeated 8 times, the unrelated concept "triangle" was repeated 24 times.

The branches created by the pre-service primary school teachers for the related and unrelated concepts belonging to the first branch in their mind maps are shown in Picture 2. The Z33 is the mind map of the pre-service primary school teacher who wrote unrelated concepts and the Z30 is the mind map of the pre-service primary school teacher who wrote related concepts.



Z33	Z30

Picture 2: Mind maps with unrelated and related concepts in the first branch

After analysing the first branch of mind maps, Z2, Z3, Z6, Z10, Z11, Z12, Z16, Z21, Z22, Z24, Z25, Z27, Z28, Z33, Z34, Z43 were removed from the second branch study. In addition, because the Z46 coded mind map consisted of only one branch, it was not included in the analysis for the second branch. For the second branch study, 26 mind maps were analysed. Findings belonging to the related concepts of the second branch of the mind maps created by the pre-service primary school teachers are presented in Table 2. The findings of unrelated concepts are shown in Table 3.

In Table 2, it was concluded that pre-service primary school teachers specified a total of 47 concepts related to "first branch" and "geometric objects" in their mind maps. Considering the sum of related concepts, the most repeated concept is "Cube (f = 7)", the least repeated concepts are "Right Angle, Cube Candy, Piggy Bank, Chimney, Bus, Toys, Geometry Lesson, While Painting, Cheese, Tablet, Laptop, Buildings, Egyptian Pyramids, Gift Box, Trash Can, Tin Can, Tent, Battery, Candle, Watermelon, No Edge, No Corner, Sphere, Intersection, Dimension, Pyramid, Eraser, Door, Book, Washing Machine, Face, Corner, Edge (f = 1). It was found that there were 33 concepts that were the least repeated. In addition, there are no related or unrelated branches in the second branch related to the related concepts of "Volume, Regular, Edge, Area, Height" in the first branch. The branch of "Usage Areas/Their equivalents in daily life (f = 17)" has the most concepts and the branch of "Geoid (f = 1)" and "Space (f =1)" has the least concepts in the first branch of pre-service primary school teachers.

Table 2: The Concepts in the Second Branch of the Mind Map on Geometric Objects

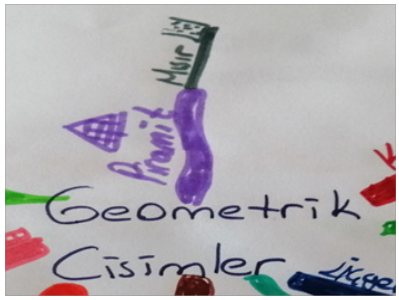
Concepts of the First Branch	Related Concepts of the Second Branch	Sum
Pyramid	Keops Pyramid (3), triangle, rightangle	Cube (7), dice (6), ice cream cone (6), ball (5), square prism (5), box (5), Earth (4), cone (4), cylinder (4), triangular prism (4), rectangular prism (4), Keops Pyramid (3), three- dimensional (3), Rubik's cube (2), triangle (2), square (2), refrigerator (2), right angle, sugar cube, piggy bank, chimney, bus, toys, geometry lesson, while painting, cheese, table, laptop, buildings, Egyptian Pyramids, gift box, trash can, tin can, tent, battery, candle, watermelon, no edge, no corner, sphere, intersection dimension, pyramid, eraser, door, book, washing machine, face, corner, edge
Cube	Dice (4), Rubik's cube (2), sugar cube, gift box, square	
Cylinder	Piggy bank, chimney, trash can, tin can	
Cone	Ice cream cone (3), funnel, party hat	
Usage areas/Their equivalents in daily life	Box (5), ice cream cone (3), ball (3), dice (2), bus, toys, geometry lesson, Earth, while painting, cheese, table, laptop, buildings, Egyptian Pyramids, tent, battery, candle	
Sphere	Ball (2), Earth (2), watermelon, no edge, no corner	
Objects	Cube (2), cone (2), cylinder (2), square prism (2), triangular prism, sphere, rectangular prism	
Triangular prism	Roof (2), grater, pizza slice	
3 dimensions	Sphere (2), cylinder (2), cone (2), pyramid, cube, area, volume	
Space	Intersection	
Angular	Rectangular prism (2), square prism (2), cube (2), triangular prism (2), three-dimensional	
Prism	Dimension, pyramid, cube, rectangular prism, square prism, triangular prism	
Agonic	Cylinder (2), sphere (2), cone (2), three-dimensional	
Rectangular prism	Refrigerator, eraser, book, door	
Square prism	Refrigerator, washing machine	
Properties	Three-dimensional, face, corner, edge	
Geometry	Triangle, square	
Geoid	Earth	

Table 3: The Unrelated Concepts in the Second Branch of the Mind Map on Geometric Objects

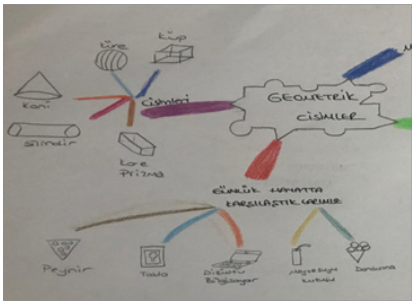
Concepts of the First Branch	Unrelated Concepts of the Second Branch	Sum
Pyramid	Egypt (2), civilizations	Egypt (2), civilizations, book, The New Year
Cube	Book	
Cone	The New Year	

When Table 3 is analysed, it is seen that unrelated concepts are less than related concepts at the second branch level. Since the specified concepts are not related to "first branch" and "geometric objects", they are considered unrelated concepts. There are 4 concepts in total in second-level branches as unrelated concepts. Considering the total of unrelated concepts, it was seen that the most repeated concept was "Egypt (f = 2)". The "Pyramid (f = 2)" branch has the most unrelated concepts, and the least unrelated concepts are the "Cube (f = 1)" and "Cone (f = 1)" branches in its first branch.

The branches created by the pre-service primary school teachers for related and unrelated concepts belonging to the second branch in their mind maps are shown in Picture 3. The Z18 is the mind map of the pre-service primary school teacher who wrote unrelated concepts and the Z32 is the mind map of the pre-service primary school teacher who wrote related concepts.



Z18



Z32

Picture 3: Mind maps with unrelated and related concepts in the second branch

After analysing the second branch of the mind maps of the pre-service primary school teachers, mind maps that did not have any branches at the third level and had unrelated concepts were removed from the third level branch study. Mind maps with codes Z4, Z5, Z7, Z17, Z18, Z23, Z29, Z30, Z31, Z32, Z38, Z39, Z40, Z44, Z50 were not included in the third-level branch study because they did not have these features. In the third level branch analysis, 11 mind maps were used. The findings of the analysed mind maps regarding the related and unrelated concepts are presented in Table 4 and Table 5.

Table 4: The Concepts in the Third Branch of the Mind Map on Geometric Objects

Concepts of the Second Branch	Related Examples of the Third Branch	Sum
Triangle	Pyramid	Unfolding shape(4), 6 faces(2), 12 edges(2), Rectangle(2), rollable (2), Space(2), Pyramid, Medicine box, Refrigerator, 8 corners, square, tent, roof, ice, sugar cube, equal, peak point, party hat, cone, Earth, ball, full Moon, full circle, paint can, battery, wood
Square	Rectangle	
Rectangular prism	Medicine box, unfolding shape, rectangle	
Square prism	Refrigerator, 6 faces, 12 edges, 8 corners, bottom base square	
Triangular prism	Tent, roof, unfolding shape	
Cube	Ice, sugar cube, equal, 6 faces,12 edges, unfolding shape	
Cone	Unfolding shape, peak point, party hat, cone	
Sphere	Earth, ball, full Moon, rollable, full round	
Cylinder	Rollable, paint can, battery, wood, unfolding shape	
Volume	Space	
Area	Space	

When Table 4 was analysed, it was seen that pre-service primary school teachers wrote a total of 26 concepts related to "second branch" and "geometric objects". Considering the sum of the related concepts of the third branch, the most repeated concept was "Unfolding shape (f = 4)", the least repeated concepts were "Pyramid, Medicine Box, Refrigerator, 8 Corners, Square, Tent, Roof, Ice, Sugar Cube, Equal, Peak Point, Party Hat, Cone, Earth, Ball, Full Moon, Full Circle, Paint Can, Battery, Wood (f = 1) ". It was concluded that there were at least repeated 20 related concepts in the third branch. The branch with the most concepts from the second branch of the mind maps of the pre-service primary school teachers was determined as "Cube (f = 6)" and the branches with the least concept were determined as "Triangle, Square, Volume, Area (f = 1)".

Table 5: The Unrelated Concepts in the Third Branch of the Mind Map on Geometric Objects

Unrelated Concepts of the Second Branch	Unrelated Concepts of the Third Branch	Sum
Keops Pyramid	History	Game(2),history, tea, life, human, tree, football, medium sized ball, small ball, big ball, lose, win, chimney, architecture, effort, intelligence, special days, happiness, food, seed, red, green, summer, cold, crazy, milk, cake, archeologist, entertainment, cheese, tomato, space
Sugar cube	Tea	
Earth	Life, human, tree	
Ball	Football, medium sized ball, small ball, big ball	
Dice	Game(2), lose, win	
Roof	Chimney	
Dimension	Architecture	
Rubik's Cube	Effort, intelligence	
Boxes	Special days, happiness, food	
Watermelon	Seed, red, green	
Ice cream cone	Summer, cold	
Funnel	Crazy, milk	
Party hat	Cake, archeologist, entertainment	
Grater	Cheese, tomato	

When Table 5 was analysed, it was seen that pre-service primary school teachers stated a total of 32 concepts unrelated to "second branch" and "geometric objects". In the third branch of mind maps, the pre-service primary school teachers stated much more unrelated concepts than related concepts. Considering the total of unrelated concepts, only the concept of "game" was repeated twice; all the other concepts were repeated once. The branch with the most concepts from the second branch of the mind maps of the pre-service primary school teachers was determined as "Ball (f =4)", and the branches with the least concept were determined as "Keops Pyramid, Sugar Cube, Roof, Dimension (f = 1)". As we moved away from the main subject of "Geometric Objects", it was found that the number of unrelated concepts written by the pre-service primary school teachers increased.

The branches created by the pre-service primary school teachers for the related and unrelated concepts belonging to the third branch in their mind maps are shown in Picture 4. The Z1 is the mind map of the pre-service primary school teacher who wrote unrelated concepts and The Z41 is the mind map of the pre-service primary school teacher who wrote related concepts

Z1 | Z41

Picture 4: Mind maps with unrelated and related concepts in the third branch

After analysing the third level branches of the pre-service primary school teachers mind maps, it was checked whether there were mind maps with the fourth branch. After the controls, it was found that 3 pre-service primary school teachers drew a fourth level branches. The fourth branches of Z9, Z36 and

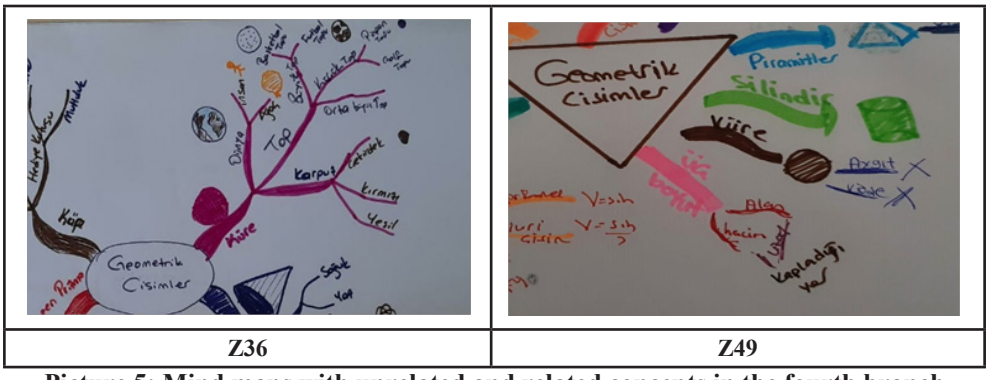
Z49 coded mind maps were analysed. Related and unrelated concepts belonging to the fourth branch of mind maps are given in Table 6.

Table 6: The Concepts in the Fourth Branch of the Mind Map on Geometric Objects

Concepts of the Third Branch	Concepts of the Fourth Branch	Related/Unrelated
Life	Flower	Unrelated
Small ball	Ping pong ball, golf ball	Unrelated
Big Ball	Basketball, football	Unrelated
Space	Space occupied	Related

When Table 6 was analysed, the number of pre-service primary school teachers who draw a branch at the fourth level was low. Considering the relation between the "third branch", "geometric objects", and the concepts are written by the pre-service primary school teachers, it was seen that unrelated concepts were written more than related concepts. Considering the related concept, only the concept of "Space occupied" has been removed from the "Space" branch. The concepts of "Flower, Ping Pong Ball, Golf Ball, Basketball, Football" as unrelated concepts have been repeated once. The branches with the most concepts from the third branch of the mind maps of the pre-service primary school teachers were determined as "Small Ball" and "Big Ball" the branches with the least concept were determined as "Life" and "Space". As we moved away from the main subject of "Geometric Objects", it was found that the number of related concepts written by the pre-service primary school teachers decreased.

The branches created by the pre-service primary school teachers for the related and unrelated concepts belonging to the fourth branch in their mind maps are shown in Picture 5. The Z36 is the mind map of the pre-service primary school teacher who wrote unrelated concepts and the Z49 is the mind map of the pre-service primary school teacher who wrote related concepts.



Z36 **Z49**

Picture 5: Mind maps with unrelated and related concepts in the fourth branch

Discussion and Conclusion

When the mind maps created by the pre-service primary school teachers regarding the concept of geometric objects were analysed, it was revealed that they could not expand the branches related to the concept much. 9 of the pre-service primary school teachers who took part in the study made a mistake and wrote "geometric shapes" instead of "geometric objects", which is the main concept. This result is similar to writing geometric shapes instead of geometric objects obtained in the study called Pedagogical Content Knowledge on geometric objects by Gökbulut (2010). In the study conducted by Mutlu, Deniz, and Polat (2017) with primary school teachers, teachers included geometric shapes under geometric objects and geometric objects under the heading of geometric shapes. In addition, in the study conducted by Yeşildere and Türnüklü (2007) with the eighth-grade students in elementary school, it was found that the concepts of geometric object and shape were used interchangeably. It can be said that pre-service teachers consider the concepts of geometric objects and geometric shapes as synonyms for each other. This may be caused by teachers' use

of these two concepts interchangeably in educational processes.

For this reason, while introducing geometric shapes and objects in the classroom, conceptually paying attention to which ones are shapes and which ones are objects will reduce the errors in the concept. Errors between the concepts of geometric objects and shapes made by pre-service teachers should be eliminated in the university education process. Teachers' knowledge of defining geometric concepts and the structures under the definitions while performing their profession will directly affect the learning processes of students in the future (Shulman, 1986; Zazkis and Leikin, 2008). Because the incomplete learning of geometric concepts will prevent the primary school teachers from fully forming the subject matter knowledge, the teaching process in the classroom will not be carried out effectively. For this reason, it is necessary for teachers to have good subject matter knowledge about geometric concepts. In the education process of primary school teachers, more emphasis should be placed on teaching concepts and structures that are under the concepts in the content of the lessons taken for geometry.

When the mind maps created by the pre-service primary teachers regarding the concept of geometric objects were analysed, there were only three pre-service primary school teachers who have passed to the fourth branch. When the first level branches of mind maps created related to the concept of geometric objects were analysed, it was revealed that the number of concepts related to geometric objects, which is the main concept, was less than the unrelated concepts. When the related concepts related to geometric objects were analysed, it seemed that the concepts of "Pyramid", "Cube", "Cylinder" were mostly specified, the concepts of "Triangle", "Square", "Circle" and "Rectangle" were created the most as unrelated concepts. The fact that the concepts related to the geometric objects are more than unrelated shows that the pre-service primary school teachers' knowledge of geometric objects is limited and inadequate. The inadequacy of pre-service primary school teachers conceptual knowledge regarding the concept of geometric objects has also been revealed in the studies conducted by Gökbulut (2010), Yıldız and Sarı (2017). When unrelated concepts are analysed, it is seen that the concepts created are mostly geometric shapes, and the reason for this can be their misconceptions about the concepts of geometric objects and geometric shapes. While analysing the second level branches of the mind maps regarding geometric objects, the concepts created by 26 pre-service teachers were related, and the concept of "cube" was repeated the most. When the branches in the third level were analysed, the mind maps created by 11 pre-service primary school teachers and 3 pre-service primary school teachers at the fourth level were analysed because of their relevance. In the third branch, the concept of "unfolding shape" occurs the most, and the concept of "space" takes place the most in the fourth branch. Based on mind maps created, the number of concepts related to "geometric objects" decreases as you move away from the main concept. It can be said that the reason for the decrease of concepts at each branch level is that the pre-service primary school teachers do not have sufficient knowledge about the concept of geometric objects and that different concepts also connotate due to the nature of the mind maps. This situation will ensure that the pre-service primary school teachers' subject matter knowledge about geometric objects and geometry will be insufficient and incomplete in their teaching life in the future. It is seen that the concepts created by the pre-service primary school teachers about the concept at each branch level have moved from close to far and contain more detailed concepts. The reason for this can be said that the geometric thinking process related to the concept is more developed.

In line with these results, it is necessary to give more detailed geometric objects and concepts included in the university education of pre-service primary school teachers. In addition, pre-service primary school teachers should be given information on preparing activities for teaching geometry concepts in primary school. The implementation of the prepared activities should be made possible in the education process.

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