



PRE-SERVICE PRIMARY SCHOOL TEACHERS' METAPHORIC PERCEPTIONS ABOUT GEOMETRY

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Abstract: Geometry can be defined as finding patterns and standard principles within and between the shapes, which contributes to learning of mathematics. This study aims at revealing the perceptions of pre-service primary school teachers on the geometry concept using metaphors. For this purpose, pre-service teachers were asked to fill in the blanks in a sentence, which was "Geometry is like/similar to..., because...". The study was conducted with 120 voluntary pre-service primary school teachers. Then, the metaphors they used were analyzed in three phases, consisting of determining the subject (1) and source (2) of the metaphor, and evaluating the relationship (3) between the source and subject. The responses of the participants were evaluated by the researchers, whose reliability was obtained as 97% using the reliability formula provided by Miles and Huberman (1994). The most commonly used metaphors were "puzzle" and "space" among the total 71 different metaphors generated by the pre-service teachers. These metaphors were classified into 11 categories under the titles of "feature" and "feeling". Results illustrated that pre-service teachers generally reflected geometry as "difficult" and "complex" but "entertaining" involving the relations between part and whole.

Key words: Geometry, metaphor, pre-service teachers, metaphor analysis

1. Introduction

One of the important subdomains of mathematics, geometry deals with the relationships between point, linear, planar shapes, space, and spatial shapes and is interested in dimensions, such as, geometric shapes, length, aperture, area and volume (Baykul & Aşkar, 1987). Learning of geometry starts with children's ability to see and know the physical world around them, and then continues with the geometrical thinking (Ubuz, 1999). There are many reasons why geometry is considered as one of the most significant sub-branches of mathematics. Sherard (1981, pp. 19-21) explains the importance of geometry as follows;

- Geometry plays an important role in communication as many geometrical terms are used in daily speaking and writing language.
- Geometry is important in finding solutions to the problems we encounter in daily life.
- Geometry is an intrinsic part of other sub-branches of basic mathematics.
- Geometry integrates other sub-branches of mathematics, adding visuality to the expression of arithmetic, algebra and statistics.
- Thanks to its features, geometry also provides a spatial perception power to humans.
- Geometry is a tool stimulating the mind, improving thinking and developing problem-solving skills.

Geometrical concepts and their interrelationships emerge in many areas of industry, architecture and interior architecture. Therefore, geometry must be an integral part of the mathematics program (Burns, 2000). Geometry topics have an important place in the elementary school (1st-4th grades) mathematics curriculum in Turkey. According to Altun (2000), in the teaching of geometry, it is very important to equip the children with knowledge about properties, shapes, generalizations, classification, and drawing and to make children perform applications of the acquired knowledge. The knowledge of

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teachers who teach the geometry subjects is also important. Studies examining the knowledge of pre-service teachers about geometry have determined a low level of readiness for geometry and geometric thinking (Duatepe Paksu, 2013), a low level of knowledge and problem solving about geometric objects (Gündüz, Bulut & Dünder, 2017), a weak knowledge of geometry field (Bütüner 2017), and misconceptions in defining and exemplifying of geometrical objects. People's views on geometry also enable them to explain and analyze their own worlds (Van de Walle, 2013). Hence, determining the perceptions of teachers who will teach the geometry-related subjects and their knowledge of geometry are important necessities.

Metaphors play an important role in revealing the perceptions of individuals. While the metaphor is a linguistics concept used in the literature for figurative expression and analogy, it has been used outside of the language field after Lakoff and Johnson (1980), who defined the essence of metaphor as experiencing and understanding something according to something else. A conceptual metaphor is defined as an affinity between two conceptual domains, and is a mechanism that allows us to understand one area relative to another, usually closer and more familiar to our daily experience. Metaphors with a strong cognitive function not only connect, but also activate our process of understanding the truth (Carreira, 2001). Metaphors are a way to visualize, conceptualize and explain our experiences (Nye, Faskey & Edwards, 2014). *“If a picture is worth 1,000 words, a metaphor is worth 1,000 pictures! For a picture provides only a static image while a metaphor provides a conceptual framework for thinking about something”* (Shuell, 1990 p. 102). Metaphors are just the transfer of meaning between different fields or the matching of meaning. The original source of metaphor is the emotions and feelings that appear in our bodies (Modell, 2009).

Metaphors, which are one of the ways to examine individuals' beliefs about education, are also the most powerful conceptual tool that individuals use to make sense of their lives and work (Mahlios & Maxson, 1995). It is thought that students can benefit from metaphoric reasoning such as conceptual understanding, interpreting representations, associating concepts, developing remembering, calculating solutions, finding and verifying errors (Chiu, 2001). The usage of metaphor in teaching helps to make connections with the contents (Jensen, 1998). In defining the underlying awareness of people and their experiences, metaphors can be used successfully (Mahlios, Massengill - Shaw & Barry, 2010). In the providing comprehension and understanding of complex concepts such as teaching, learning, and schooling, metaphors also open a window for teachers to understand their personal experiences (Lin, Shein & Yang, 2012). One way to increase teachers' awareness of their belief systems is to focus on the images and metaphors they use to define their teaching (Marshall, 1990). Metaphors can be a useful tool to review and examine pre-service teachers' beliefs about mathematics (Reeder, Utley & Cassel, 2009).

There are lots of researches studying the perceptions of teachers, pre-service teachers and students about many concepts via metaphors (Engin Demir, 2007; Lin, Shein & Yang, 2012; Reeder et al., 2009; Saban, 2009). Studies, in which the perceptions about mathematics and mathematical concepts are revealed through metaphors, have focused on the concept of mathematics (Güveli, İpek, Atasoy & Güveli, 2011; Kılıç & Yanpar Yelken, 2013; Şahin, 2013; Şengül & Katrancı, 2012), learning and teaching mathematics (Allen & Shiu, 1997; Kuzu, Kuzu & Sıvacı, 2018; Noyes, 2006; Reeder et al., 2009; Şahinkaya & Yıldırım, 2016; Tarım, Bulut Özsezer & Canbazoğlu, 2017). Few studies are available examining the perceptions of the geometry concept through metaphors, which were conducted with pre-service mathematics teachers (Çöl, 2018), gifted and non-gifted middle school students (Bahadır, 2016) and high school students (Horzum and Yıldırım, 2016). Bahadır (2016) reported that the gifted and non-gifted middle school students produced the “games” and “shapes” metaphors mostly, and they see geometry as “infinite” and “indispensable”. In a study (Çöl, 2018), in which the pre-service mathematics teachers' metaphoric perceptions of geometry were examined, 104 participants produced 53 metaphors, which were collected in eight categories. The order of the most commonly used metaphors by teacher candidates was “puzzle”, “labyrinth” and “picture”. The aforementioned eight categories were “enjoyable geometry/game”, “the difficulty of geometry”, “interest and attitude to geometry”, “labor, importance and necessity of geometry”, “the content of geometry”, “understanding geometry and strategy use”, “small details in geometry” and “visuality in

geometry". Çöl (2008) observed that most of the metaphors were gathered in two categories, i.e., "enjoyable geometry/game", and "understanding geometry and strategy use".

In a study (Horzum & Yıldırım, 2016) conducted with 166 high school students to reveal the perceptions about geometry, 49 different valid metaphors emerged and these metaphors were grouped under 10 categories. The order of the most commonly used metaphors by high school students were "mathematics", "puzzle" and "figures". The categories that contain positive or neutral associations about geometry are the categories that emphasized the aspects of geometry to be an indicator of intelligence and mind, including terms, figures and operations, being in the nature, having a part-whole relationship and being entertained. Categories with negative connotations emphasized the geometry being complex, difficult, boring and unlimited (Horzum & Yıldırım, 2016). In the literature, although some studies were conducted on the preceptions of geometry through metaphors, there is none or limited studies aiming to reveal the pre-service primary school teachers' perceptions about geometry, which is the main focus of the present study. For this purpose, the following questions are sought:

1. Which metaphors are created by the pre-service primary school teachers regarding the concept of geometry?
2. In terms of their common characteristics, in which categories can the metaphors be classified?

2. Method

This study is qualitative research collecting data through metaphors. Data collection through metaphors is one of the qualitative data collection methods. It can be used to describe a situation and to speed up or improve a process. It is stated that collecting data through metaphors generally plays a descriptive role and rich data can be accessed through this way (Yıldırım & Şimşek, 2006).

2. 1. Participants

The participants of the present study were selected via non-random sampling with an easily accessible case sampling method. Easy access sampling method (Yıldırım & Şimşek, 2006) was used because it can provide speed and practicality to the research. In this context, in the spring semester of 2017-2018 academic-year in a state university of Turkey, 150 pre-service teacher candidates who have been studying in the third and fourth grade in the department of primary education have been selected. A total of 120 candidate teachers (55 girls, 3 boys at the fourth grade level, and 50 girls and 12 boys at the third grade level) participated in this study on a voluntary basis. The third and fourth grades pre-service teachers were selected for the study as they have been acquired the required basic knowledge about geometry within the scope of basic mathematics courses (I. and II.).

2. 2. Data collection process

In the studies collecting data through metaphors, one of the data collection ways is a sentence structure similar to "(The concept to be informed about) is similar to/is like a....., because". In our study, the sentence of "*Geometry is similar to... / is like a....., because*" was used as a data collection tool. First of all, a presentation was given to the pre-service teachers about the purpose of the study and they have been informed about what a metaphor is. After this presentation, they were asked to fill in the blanks in the sentence of "*Geometry is similar to... / is like a....., because*" within a lecture hour. The pre-service teachers responded by handwritings and these hand-written responses were the main data source of the study.

2. 3. Data analysis

The responses of 120 primary school teacher candidates were analyzed by content analysis, bringing similar data together within a framework of specific themes and interpreting them in a comprehensible manner (Yıldırım & Şimşek, 2006). In this study, the analysis was performed according to the phases adapted from Saban (2009). Firstly, in the naming stage, the metaphor was examined to determine

whether it was clearly expressed in the given response. In the second stage of sorting and listing, the answers were examined in terms of three basic features that should exist in a metaphor relationship. These features are the subject (1) and source (2) of the metaphor, and the feature attributed from source to the subject (3) (Forceville, 2002). Only the answers which met all these three features were considered in the data analysis. A total of 20 out of 120 responses were eliminated because they did not meet all the three aforementioned features simultaneously. Hence, a total of 100 responses were taken into consideration and a metaphor list was created by determining the primarily used metaphors in the responses of pre-service teachers. In the category development phase, the third phase, metaphors were gathered in common categories in terms of their common features. Categories indicating the characteristics of geometry were collected under the title of “feature”, and categories indicating feelings about geometry were collected under the title of “feeling”. Frequencies related to data have been determined. These three stage studies were conducted by two researchers separately. In the fourth stage, validity and reliability stage, the data was examined by the number of consensus and disagreement between the researchers in order to determine the reliability between them. Reliability was calculated ($\text{reliability} = \text{consensus} / (\text{consensus} + \text{divergence}) \times 100$) as 97% according to Miles & Huberman (1994). The researchers disagreed on only a few answers, which were then evaluated by the researchers together and consensuses were reached. The metaphors, categories, and the distribution of metaphors by categories are tabulated together with the frequencies. Metaphors are ranked from highest to lowest according to the frequency of usage by the pre-service primary school teachers. One of the ways to ensure validity in qualitative studies is to explain the collected data in detail and to report how the results are obtained by the researchers (Yıldırım & Şimşek, 2006). In this study, data analysis (metaphors, categories obtained from metaphors and sample answers of participants) was explained in detail to ensure validity.

3. Findings

In this section, the metaphors created by the pre-service teachers about the concept of geometry are provided (Table 1).

Table 1. *Concept of geometry related metaphors created by pre-service primary school teachers*

METAPHORS (f)		
Puzzle (10)	Game of shapes (1)	Pyramids (1)
Space (7)	Hard work to see (1)	Ratio (1)
Solving puzzle (4)	House (1)	Real life reflection (1)
Picture (4)	Human (1)	Schema (1)
Universe (3)	Human view of the world (1)	Seeing single-celled organisms (1)
Life (3)	Inaccessible high mountains (1)	Sight (1)
Living (2)	Infinite number of points (1)	Sky (1)
Nature (2)	Intersecting path (1)	Spider web (1)
Intelligence cube (2)	Knitting lace (1)	Stack of connections (1)
Landscape (2)	Ladder (1)	Star (1)
3D figure (1)	Lego (1)	Stars (1)
Watching a 3D film without the 3D glasses (1)	Life itself (1)	Swimming in the sea (1)
An unknown mystery (1)	Lifestyle (1)	The functioning of life (1)
Artistic paintings (1)	Line drawing art (1)	The universe itself (1)
Chess (1)	Living itself (1)	Three-dimensional film (1)
Climbing car (1)	Love (1)	Three-dimensional image (1)
Tangled yarn (1)	Matchstick game (1)	Torture (1)
Diving into the sea (1)	Mathematics (1)	Turkish lesson (1)
English lesson (1)	Maze (1)	Uncertainty (1)
Everest summit (1)	Mosaic cake (1)	Understanding (1)
Eye that can see detail (1)	Mystery (1)	Understanding a deaf person (1)

Factorization (1)	Perspective drawing works (1)	Ungrateful man (1)
Find the differences questions (1)	Prejudiced friend (1)	Visual (1)
Game (1)	Puzzle activity (1)	

Then, the conceptual categories in which these metaphors are located were specified. In the explanation of each category, examples of participants' responses were also provided. Metaphors and their frequencies (provided in brackets, f = frequency) are given in Table 1.

According to Table 1, pre-service primary school teachers generated a total of 71 different metaphors. A total of 10 metaphors have been repeated more than once. These were “puzzle”, “space”, “solving puzzle”, “picture”, “universe”, “life”, “living”, “nature”, “intelligence cube” and “landscape” metaphors. Among these metaphors, “puzzle” ($f=10$) was the most commonly used metaphor by the participants. The second highest frequency ($f=7$) was observed for the “space” metaphor. A total of 61 metaphors was used only once by the participants. The metaphors and their distribution according to the categories are provided in Table 2.

Table 2. Distribution of metaphors related to the concept of geometry by category

THEME	CATEGORY	METAPHORS
FEATURE	Looking and seeing (n*=33)	Picture (4**), Landscape (2), Life (2), Puzzle (2), Star (1), Diving into the sea (1), Turkish lesson (1), Sight (1), Line drawing art (1), Matchstick Game (1), Eye that can see detail (1), Three-dimensional image (1), Pyramids (1), Artistic paintings (1), Find the differences questions (1), Solving puzzle (1), Mystery (1), Love (1), Visual (1), Human view of the world (1), Mathematics (1), Watching a 3D film without the 3D glasses (1), Intersecting path (1), Perspective drawing works (1), Maze (1), Infinite number of points (1), 3-D figure (1)
	Part/whole relations (n=14)	Puzzle (4), Solving puzzle (2), Puzzle activity (1), Stack of connections (1), Puzzle (1), Ladder (1), Chess (1), Lego (1), Stars (1), Knitting lace (1)
	Rules and order (n=9)	Universe (2), Nature (2), Living (1), Ratio (1), Game (1), Game of shapes (1), The functioning of life (1)
	Being in touch with life (n=9)	Life (1), living (1), Life itself (1), Life style (1), Universe (1), House (1), The Universe itself (1), Living itself (1), Real life reflection (1)
	Being abstract (n=2)	Schema (1), Three-dimensional film (1)
FEELING	Having difficulty (n=11)	Climbing car (1), Torture (1), Space (1), Intelligence cube (1), Seeing single-celled organisms (1), Hard work to see (1), Inaccessible high mountains (1), Everest summit (1), Ungrateful people (1), English lesson (1), An unknown mystery (1)
	Entertaining (n=6)	Puzzle (3), Mosaic cake (1), Solving puzzle (1), Intelligence cube (1)
	Unlimited (n=6)	Space (4), Uncertainty (1), Sky (1)
	Requiring extra effort (n=5)	Understanding a deaf person (1), Space (1), Understanding (1), Swimming in the sea (1), Factorization (1)
	Complex (n=4)	Spider web (1), Tangled yarn (1), Space (1), Human (1)
	Easy (n=1)	Prejudiced friend (1)

* n is the total number of metaphors, ** Number in parenthesis illustrates frequency.

The metaphors about the concept of geometry were gathered under eleven categories (Table 2). The categories pointing out the feature of geometry were listed under the “feature” title, whereas the categories expressing the sense of geometry were listed under the title of “feeling”. The categories in which metaphors were collected are given in Table 2. The category of “looking and seeing” is the first category that includes 33 metaphors. The categories under the title of the “feature” and some examples of the participants' responses are explained below in detail.

Looking and seeing category was named acknowledging that visuality is important due to the structure of geometry. This category consisted of 33 metaphors created by the pre-service primary school teachers under the title of “feature” and the highest number of metaphors was located in this category. The most commonly used metaphor in this category was the “picture” metaphor, which was

used four times. Also, “landscape”, “life” and “puzzle” metaphors were used more than once. A teacher candidate who described geometry with the “picture” metaphor created the following response *“Geometry is similar to a picture because it appeals to those who know how to look, who sees it, and who can understand what it evokes. While many of my geometry teachers were looking at the geometry question, they were looking at the problem a few steps away from the board and continued solving it. For this, geometry is like a picture”*. Another participant using the “picture” as a metaphor expressed that *“Geometry is similar to a picture because it is a vision. You solve when you see it. When you look at a picture, you see and feel what's going on there. If you see the same in geometry, you can solve it”*. Another participant used the “picture” metaphor as *“Geometry is like a picture because in order to be able to solve it, you need to take a good look and see the relationships”*. There were 23 metaphors used in this category once. One of the most interesting among them is the “matchstick game” metaphor and the teacher candidate used this metaphor as *“Geometry is like a matchstick game because a matchstick that you are going to turn will solve the problem or it can close all the roads to the solution. Every move is important. In geometry, two shapes are so intertwined that the connection to be established between the two shapes depends on small lines. Sometimes seeing an angle, seeing the relationships between the angles and edges can open all the doors”*. Another metaphor was the “watching a 3D film without the 3D glasses” explained in the following sentences as *“Geometry is like watching a 3D film without the 3D glasses because it does not make sense, and we cannot solve geometry without a certain perspective”*. Another metaphor created was the “perspective drawing works”, which was used in the following sentences as *“Geometry is similar to perspective drawing works because it requires versatile and multi-dimensional vision with different perspectives as well as evaluating the clues that are essential in geometry”*. Metaphors in this category indicate that geometry is related with looking and seeing. Accordingly, it can be said that most of the pre-service primary school teachers made explanations about this feature of geometry.

There were 14 metaphors in the category of **part/whole relations**. The “puzzle” metaphor that was used four times under this title was the most repeated metaphor. The “solving puzzle” metaphor was used twice and eight other metaphors were used once. A participant using the “puzzle” metaphor explained that *“Geometry is like a puzzle, because the rules of geometry are interconnected similar to the pieces in a puzzle. Each piece belongs to a whole and completes it”*. Another participant used the following explanation *“Geometry is like a puzzle because the relations between the parts are important on the way to the solution and all the parts are necessary to reach to the whole”*. Many of the participants expressed the relationship between the piece and the whole. In the “stack of connections” metaphor, *“Geometry is like a stack of connections; because everything is both a piece and the pieces are connected with the whole in various ways”*. The metaphors and the explanations used under this category have revealed the pre-service primary school teachers' part/whole relation about geometry and reflected their perceptions about the feature of geometry.

Both the **rules and order** and **being in touch with life** categories include nine metaphors. From the nine metaphors in the category of rules and order, “universe” and “nature” metaphors were used twice. One of the teacher candidates expressed the “universe” metaphor as *“Geometry is like the universe because everything in the universe has an order in itself. There are galaxies in the universe. Each of them has a certain order and rule. Geometry is also a work of order and rule”*. Another explanation by a participant was *“Geometry is similar to the universe because, geometry is in a certain order and proportion like the universe”*. Another participant who likens the geometry to a “game” used the expression of *“Geometry is similar to a game because there are rules both in geometry and games”*. The category, in which these metaphors were collected, points to the rules of geometry and therefore reflects the perceptions of this feature of geometry.

Nine metaphors were also collected under the category of **being in touch with life**. Each of the metaphors produced were used only once. Using the metaphor of “life itself” from these metaphors, the teacher candidate used the expression of *“Geometry is similar to life itself because everything we encounter has geometry in it.”* Another teacher candidate, using the metaphor of “life” said that *“Geometry is like life because it appears everywhere from the smallest piece to the biggest one in life.”* The category of “being in touch with life”, in which these metaphors were collected, reflects the

connection of geometry with life, and therefore the pre-service teachers' perceptions about this feature of geometry.

The category of **being abstract** was the last category collected under the title of “feature of geometry”. The “being abstract” category included “schema” and “three-dimensional film” metaphors. They were used only once by the pre-service primary school teachers. The explanations related with these two metaphors were; *“Geometry is similar to a schema because it is the reflection of the human mind in the form of diagrams, it exists in the mind of the human”*. The statement of the teacher candidate regarding the “three-dimensional film metaphor” was *“Geometry is similar to a three-dimensional film because the things that seem real in the movie are things that do not exist just like geometry”*. In this category, the perceptions of the participants about abstract feature of the geometry were reflected in their expressions.

The categories, in which the metaphors were used by teacher candidates, explained with emotional expressions were gathered under the title of “feeling”. Under the theme of “feeling”, the categories defined were “having difficulty”, “entertaining”, “unlimited”, “requiring extra effort”, “complex” and “easy”. There were 11 metaphors belonging to the **having difficulty** category, which ranked the first among the categories under the “feeling” theme. Each of the metaphors in this category was used once and the participants highlighted the difficulty of geometry. A participant using the metaphor of “Everest summit” made the expression of *“Geometry is similar to the Everest summit, because it is a difficult area to understand like reaching the summit of the Everest”*. Another pre-service teacher used the metaphor of “inaccessible high mountains”, saying that *“Geometry is similar to an inaccessible high mountain because the concept of geometry and its subject has always been distant and inaccessible for me. It has always been difficult for me throughout my life. I wish geometry had never existed”*. The teacher candidate who used the metaphor of the “English class” said that *“Geometry is similar to the English class. I always took the classes, but I could not go beyond the basic concepts. It is very difficult for me to grasp it completely”*. Considering the metaphors used by pre-service primary school teachers and their explanations regarding these metaphors, it can be said that many of them had negative perceptions.

There were four different metaphors in the **entertaining** category. However, among these, “puzzle” metaphor was used three times in this category. One of the participants using the puzzle metaphor said *“Geometry is like a puzzle because you have fun while solving both. While I’m solving geometry, I have fun as if I am solving puzzles”*. Another participant said that *“Geometry is entertaining like a puzzle because it becomes more fun as we work on it”*. Another pre-service primary school teacher, using the concept of “mosaic cake”, responded *“Geometry is similar to a mosaic cake because it is enjoyable and fun”*. A feature that distinguished the mosaic cake metaphor from other metaphors was that it was the only metaphor that expressed geometry as a type of food. The metaphors used in this category reveal positive perceptions about geometry.

Three different metaphors were created under the **unlimited** category, among which the “space” metaphor was used four times. One of the teacher candidates said that *“Geometry is like the space because the end of the space is an unknown void. Geometry is also similar for me. It is like an unseen and unknown universe”*. Another participant expressed his/her feeling about geometry using “space” metaphor as *“Geometry is like the space because space means infinity for me. Geometry reminds me of eternity with shapes and concepts”*. Other metaphors used in this category were “uncertainty” and “sky”. These metaphors were used in the following expressions, respectively, as follows; *“Geometry is like uncertainty because there is no end”* and *“Geometry is like the sky because when you look at it, it is so wide and endless”*.

Five different metaphors were used in the **requiring extra effort** category. From the metaphors used by the participants, explanations using the metaphors of “understanding a deaf person” and “factorization” are provided below. The pre-service primary school teacher preferring the metaphor of “understanding a deaf person” said that *“Geometry is like understanding a deaf person because we do not understand anything at the beginning, but as we strive to understand, we begin to understand”*. The teacher candidate using the “factorization” metaphor explained his/her feeling in the sentence as *“Geometry is like factorization because it is necessary to succeed and strive to learn them because*

both contain many things". This reflects the perception that one has to make an extra effort to learn geometry.

Four different metaphors were used in the **complex** category. These metaphors are "spider web", "tangled yarn", "space" and "human" metaphors. Each of these metaphors has been used once. The explanation including the "tangled yarn" metaphor was *"Geometry is like a tangled yarn because it is entangled and insoluble"*. The pre-service primary school teacher using the "spider web" metaphor stated that *"Geometry is like a spider web because it is very complicated for me"*. The teacher candidate using the "human" metaphor said that *"Geometry is like human because it is complex and incomprehensible like human"*.

The last category, **easy**, contained only one metaphor of "Prejudiced friend". The teacher candidate's explanation about the "prejudiced friend" metaphor was *"Geometry is like a prejudiced friend because when people see geometry, they act biased and set up a barrier but when they get in touch with it, they love it and see that they can do it, and it is easy"*. Based on this, it can be said that only one pre-service primary school teacher finds geometry in fact easy.

4. Discussion

The perceptions of pre-service primary school teachers about the concepts and subjects related to geometry are as important as their knowledge of geometry itself. Metaphors are important in revealing the perceptions and beliefs of individuals (Mahlis & Maxson, 1995; Mahlis, Massengill-Shaw & Barry, 2010; Marshall, 1990) and also people can reveal their experiences through metaphors (Nye, Faskey & Edwards, 2014; Mahlis, Massengill Shaw & Barry, 2010; Lin, Shein & Yang, 2012). It is important for many elements of education to determine the metaphorical perceptions of pre-service teachers about subjects or concepts related to their topics. In this study, which aimed to examine the pre-service teachers' perceptions of geometry through metaphors, 71 different metaphors in total were created by the participants. Among these metaphors, "puzzle", "space", "solving puzzle", "picture", "universe", "life", "living", "nature", "intelligence cube" and "landscape" metaphors were produced more than once. The "puzzle" metaphor was the most commonly used one ($f=10$). Similar results were observed in other studies aiming to reveal the metaphorical perceptions of geometry (Bahadır, 2016; Çöl, 2018; Horzum & Yıldırım, 2016). The "puzzle" was the most commonly used metaphor in the study conducted with prospective mathematics teachers (Çöl, 2018). In addition, in both studies, there are many common metaphors such as "picture", "intelligence cube", "game", "maze", and "life". The metaphors produced in the study are similar to the metaphors produced by high school students (Horzum & Yıldırım, 2016), and the metaphors produced by gifted and non-gifted secondary school students (Bahadır, 2016). Additionally, in other studies examining the pre-service teachers' perceptions on the concept of mathematics (Kılıç & Yanpar-Yelken, 2013; Kuzu et al., 2018; Şahinkaya & Yıldırım, 2016; Şengül & Katrancı, 2012; Tarım et al., 2017), "life", "play", "puzzle", "intelligence cube" metaphors are frequently encountered and they are similar to the metaphors produced in the present study related to geometry. This similarity stems from the fact that geometry is a sub-branch of mathematics.

The metaphors created by the pre-service primary school teachers about the concept of geometry were gathered under eleven conceptual categories. In terms of metaphors and explanations related to geometry, the categories were classified under the "feature" and "feeling" themes. Under the title of "feature", the category of "looking and seeing", which included 33 metaphors was the top place category. This conceptual category is a perception supporting the concept of learning geometry, which begins with seeing the physical world around us and continues with knowing and understanding (Ubuz, 1999). With this category, it can be said that teacher candidates mostly refer to a general feature of geometry. In the study of Çöl (2018), there is a category named "visuality in geometry" and this category has similarities with the "looking and seeing" category in our study.

The pre-service primary school teachers expressed that geometry includes the "part/whole relations" in its content. The "part/whole relations" category, represented by a significant number of metaphors, is similar to the category of "part-whole relationship" revealed in the study of Horzum and Yıldırım (2016). In the metaphor analysis studies (Güveli et al., 2011; Şahinkaya & Yıldırım, 2016) in which

the perceptions about mathematics are revealed, the categories of “life” and “life itself” are similarly included. It can be said that pre-service primary school teachers perceive geometry, which is one of the sub-learning areas of mathematics, as a concept intertwined with life, as in the concept of mathematics. The “rules and order” and “being abstract” categories in our study revealed the perception that geometry is an abstract concept having rules, similar to the perceptions about mathematics (Tarım et al., 2017).

Conceptual categories in which the metaphors produced by teacher candidates regarding the concept of geometry collected under the title of “feeling” were classified under the “having difficulty”, “entertaining”, “unlimited”, “requiring extra effort”, “complex” and “easy” categories. Of these categories, the “having difficulty” was the first category involving the highest number (11) of metaphors. In the study investigating the perceptions of mathematics teacher candidates towards geometry (Çöl, 2018), some of the teacher candidates stated that geometry was difficult. The “having difficulty” category is also encountered in the studies determining the perceptions about the concept of mathematics (Güveli et al., 2011; Şahinkaya & Yıldırım, 2016). It can be said that the most commonly expressed feeling under the theme of “feeling” was “having difficulty”, and the teacher candidates found geometry hard to learn. The “unlimited” category obtained as a result of this study is similar to the “infinity” category included in the study of Bahadır (2016). It can be said that perceptions that the geometry is a very large field in these studies are common. The “complex” category is similar to the complexity category defined in the study by Şengül and Katrancı (2011). Few teacher candidates have reflected geometry as “requiring extra effort”. The “demanding effort” is also a common category for the concept of mathematics (Güveli et al., 2011).

The category of “entertaining”, under which pre-service primary school teachers stated that they find geometry enjoyable, is the common category in some of the studies (Çöl, 2018; Bahadır, 2016; Horzum & Yıldırım, 2016). Similar categories related with the entertaining feature of the geometry were also stated in the mathematics related studies (Şengül & Katrancı, 2012; Kuzu et al., 2018; Şahinkaya & Yıldırım, 2016). In addition, the “puzzle”, “solving puzzle” and “intelligence cube” metaphors included under the category of “entertaining” were also similar to the studies in the literature. Although, some candidates find geometry “entertaining” and “easy”, many of them think geometry is difficult and complex.

5. Conclusion and Suggestions

A total of 71 valid metaphors of pre-service primary school teachers about geometry were gathered under eleven conceptual categories. The most commonly used metaphor by the pre-service teachers was the “puzzle”. The “looking and seeing” category is the “feature” category containing the highest number of metaphors. The pre-service primary school teachers perceived geometry as a concept that is mostly associated with the visual field, includes the part/whole relations and requires looking from different perspectives. When the metaphors produced by pre-service teachers are considered, it can be said that their perceptions towards geometry are mostly related to the meaning, definition and function of geometry. It is thought that pre-service teachers who know the meaning and function of geometry can make a positive contribution to teaching geometry while performing their teaching profession. In addition to this study, it is thought that it will be useful to examine the basic geometry knowledge and skills of the pre-service teachers.

Metaphors and explanations were categorized under the “feature” and “feeling” themes. When the metaphors and the conceptual categories represented by these metaphors are examined, it can be concluded that geometrical concepts were not used to create metaphors. For this reason, studies are needed to reveal both the perceptions and geometry subject knowledge of pre-service teachers. It may also be useful to reveal metaphorical perceptions of geometric concepts. Metaphors, understanding is the the main function of them (Lakoff & Johnson, 1980), play a key role in revealing how pre-service teachers perceive the world and what is happening in the world (Perry & Cooper, 2001). From this point of view, the importance of the studies trying to reveal perceptions through metaphors is understandable.

In terms of negative perceptions of geometry, two conceptual categories emerged that indicated geometry were “having difficulty” and “complex”. For positive perception, two categories emerged were “easy” and “entertaining” but the number of candidates who think geometry is easy and entertaining was very few. The number of teacher candidates who think that geometry is difficult and complex was more than the number of candidates who find geometry as easy and entertaining. The interview technique can be used to better identify the negative perceptions of the pre-service primary school teachers and an in-depth examination of the views on these negative perceptions can be conducted. Studies that use qualitative and quantitative data collection methods can reveal factors that may cause these negative perceptions.

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