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METAPHORS FORMED BY 6TH AND 7TH GRADE STUDENTS REGARDING THE DIFFICULTIES THEY EXPERIENCED IN THE PROCESS OF LEARNING THE SUBJECT OF CIRCLE

Research Article

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Abstract

In this study, the purpose was to make use of metaphors to determine the difficulties experienced by secondary school 6th and 7th grade students in the process of learning the subject of circle. In the study, the phenomenological research design, one of qualitative research methods, was used. The research data were collected from a total of 140 secondary school students (80 6th grade, 60 7th grade), who were asked to fill in the blanks in the statement of "While learning the geometric shape of circle, I experience the biggest difficulty in …. because …". For the analysis of the data, content analysis method was used. The results revealed 42 different valid metaphors. These metaphors were gathered under seven categories. Among these categories, the most frequently produced ones were *problems related to the shapes drawn in a circle* and *tangent problems with circles*. Moreover, in the study, it was found that when compared to the 6th grade students, the 7th grade students produced more metaphors related to the difficulties experienced in the teaching process of circle. Based on all these results and the students' perceptions, suggestions were put forward regarding the development of students' positive perceptions and understanding of geometry teaching.

Keywords: geometry, circle, difficulties, secondary school students, perceptions, metaphor.

1. Introduction

Mathematics is one of the main courses involving the use of mathematical language and abstract concepts in processing and producing the information, and geometry constitutes the observable aspect of this basic course full of abstract concepts (Aydın & Monaghan, 2011; Hacısalihoğlu, Mirasyedioğlu & Akpınar, 2004). Obviously, most of the objects in nature like trees, flowers, fruits, playgrounds, buildings and classrooms, which are all found in the physical world of an individual, are associated with geometric shapes (Aydın & Monaghan, 2011). Geometry, which cannot be limited to geometric shapes, not only helps understand the nature and define our world systematically (Yolcu, 2008) but also is a sub-discipline which helps students give meaning to their physical world throughout their development processes. In this respect, students can develop upper-level meanings by associating the physical world (which they begin to give meaning to at early ages) with geometric thinking at later ages. In addition, this developing upper-level understanding will allow students to anticipate the axiomatic structure of geometry, to develop positive attitudes (Altun, 2000; Ubuz, 1999) and to understand the characteristics of the geometric structures in their environment and the relationships between these structures (National Council of Teachers of Mathematics [NCTM], 2000). In this respect, students recognizing the importance of viewing a geometric shape from

different perspectives could be said to envisage how that shape would look in two-dimension or three-dimension; in other words, they would be able to develop their spatial visualization skills. The purpose of geometry teaching is to give meaning to the shapes in their own physical and intellectual worlds (Özkeleş-Çağlayan, 2010) and to develop their thinking and reasoning processes regarding the space (Van de Walle, Karp & Bay-Williams, 2010). In the process of achieving these goals, it is important to consider not only the way geometric models and shapes are perceived and but also the difficulties experienced in relation to the teaching of these shapes.

When the importance of geometric shapes in mathematics teaching (Sherard, 1981) is taken into account, the importance of geometric shapes and geometry, which features the axiomatic structure of mathematics (Ersoy, 2003), cannot be denied. In this respect, with the help of the subjects covered by geometry, a sub-branch of mathematics, which is of great importance among all other basic sciences, it would not be wrong to say that geometry sheds light on the abstract side of mathematics. Certain difficulties are likely to be experienced in understanding geometric concepts due to a number of factors influential on the learning process despite its observable aspect. Considering the fact that these difficulties are related to the geometric shapes found in the sub-learning of geometry, one of the best ways to reveal the difficulties experienced by students while learning these shapes is to make use of their metaphors because metaphors are regarded as a mental tool which reflects and concretizes our thoughts about difficult, abstract and complex concepts or phenomena and which makes use of simile and allows basing an unknown difficult-looking thing on our previous experiences (Balcı, 2003; Saban, 2004; Saban, Koçbeker & Saban, 2006).

The word "metaphor" originates from the Old Greek word "metaphrein" and has a meaning such as conveying, transferring and transmitting, and it etymologically derives from "metaphora", which is considered to be a combined word (meta+ phora) (Kılcan, 2017). To sum up, with the combination of the words "meta" meaning "replacement" and "phrein" meaning "conveying", "metaphor" is a Greek-origin word meaning "changing" (Kılcan, 2017; Levine 2005). With the contemporary metaphor theory, the concept of metaphor gained a new dimension (Lakoff & Johnson, 1980), and it was defined as individuals' expressing their thoughts with the help of similar concepts found in their intellect related to the concept in question (Lakoff, 1993). In our language, the word metaphor, which is used in a meaning different from its actual meaning as a result of a simile, is now used to mean 'borrowing' (Turkish Language Society [Türk Dil Kurumu], 1998). Parallel to this definition, in some studies, metaphors are referred to as a way of thoughts or viewpoints regarding how individuals perceive the concepts, phenomena or processes within the framework of their own knowledge, skills and attitudes (Inbar, 1996; Kurt, 2010 cited in Otyzbayeva, 2006; Saban, 2009). Similarly, according to Jensen (2006), who attributed the concept of metaphor to Plato, metaphors are words used to explain the meaning of abstract concepts difficult to understand, and Aslan (2013) defines metaphor as statements that allow explaining a concept by resembling it to another one within the context of their common features. In addition, metaphors are regarded as a tool that allows individuals to explain, with the help of similes, how they view the life, circumstances, phenomena, concepts and objects (Cerit, 2008); as a mechanism of mental mapping in the process of individuals' giving meaning to the circumstances in their lives (Arslan & Bayrakçı, 2006); and as words that allow individuals to use different aspects of a situation which they can normally explain with the help of linguistic and mental processes (Cebeci, 2013). Whether defined as a viewpoint about a situation or a phenomenon or as a way of thinking, metaphors could be regarded as strong mental concepts and tools that individuals can use to perceive, understand and explain the abstract and complex phenomena and processes they meet (Cerit, 2008; Inbar, 1996, Lakoff & Johnson, 2005; Saban, 2009; Yob, 2003). From

this point of view, in the present study, metaphors were taken as a tool used by individuals to explain the difficulties with the help of a concrete concept while teaching the concept of circle, which is an abstract and complex concept among the geometric shapes found in the sub-learning domain of geometry.

Parallel to the fact that the metaphor used in various disciplines in the scientific world is viewed as an effective tool for giving meaning to educational processes (Balcı, 1999), it is seen in educational studies that metaphors are used in the processes of increasing the comprehensibility of difficult subjects or certain abstract concepts and collecting related data. In addition, it is also seen in educational studies that metaphors are used as a data collection tool in the process of revealing participants' perceptions regarding a concept or subject and that metaphors are generally based on qualitative research methods (Kılcan, 2017). When metaphor studies conducted in the field of education are examined, it is seen that metaphors are used to determine the perceptions regarding *curricula and learning/teaching; educational technologies; various teaching methods; school and ideal school; and teacher and the profession of teaching* (Adıgüzel, 2009; Akkaya, 2012; Aktürk, Mihçi & Çelik, 2015; Arslan & Bayrakçı, 2006; Aydoğdu, 2008; Balcı, 1999; Cerit, 2008; Çoklar & Bağcı, 2010; Dönmez-Usta, Durukan & Hacıoğlu, 2016; Kabadayı, 2008; Ocak & Gündüz, 2006; Saban, 2004; Semerci, 2007; Taşdemir & Taşdemir, 2011). Besides all these studies, there are several other metaphor studies conducted in the field of mathematics education to examine the *concept of mathematics* (Cassel & Vincent, 2011; Erdoğan, Yazlık & Erdik, 2014; Güner, 2013; Gür, Hangül & Kara, 2014; Güveli et.al., 2011; Keleş, Taş & Aslan, 2016; Oflaz, 2011; Özgün-Koca, 2010; Sam, 1999; Sam & Ernest, 1998; Schinck et.al., 2008; Sterenberg, 2008; Şahin, 2013; Şengül & Katrancı, 2012; Toluk-Uçar et.al., 2010); *mathematics course; mathematics teacher; mathematician concepts* (Ada, 2013; Fleener, Pourdavood & Fry, 1995; Güler, Öçal & Akgün, 2011; Picker & Berry, 2000; Şahin, 2013; Şengül, Katrancı & Gerez-Cantimer, 2014; Toluk-Uçar et.al., 2010); *learning mathematics; concepts of teaching mathematics* (Allen & Shiu, 1997; Güner, 2012; Reeder, Utley & Cassel, 2009); *mathematics problem; concepts of mathematics problem solving and problem posing* (Kılıç, 2014; Turhan-Türkkan & Yeşilpınar-Uyar, 2016; Yee, 2012); and *concept of proving* (Cansız-Aktaş & Aktaş, 2013). In addition to these concepts, it is also seen that the *concept of geometry* (Bahadır, 2016; Horzum & Yıldırım, 2016) and the geometry-related metaphors owned by students were examined. Consequently, a number of metaphors and conceptual categories were obtained in relation to the concepts or phenomena examined in all these studies. In this respect, Yob (2003) pointed out that the variety of the perceptions of the participants was effective in obtaining numerous metaphors and conceptual categories.

Parallel to all these studies, there are a number of studies on the use of metaphors in mathematics teaching, yet there is not enough research on metaphors in literature regarding geometry, geometric concepts or geometric shapes. However, geometric models, samples and shapes obviously have an important place in mathematics teaching. Undoubtedly, geometric models and shapes play an important role in students' own physical world as well as in the process of understanding the phenomena related to the universe (Özkeleş-Çağlayan, 2010). In this respect, in the Secondary School Mathematics Curriculum revised in 2018, the learning domain of Geometry and Measurement was included in all the class grades (5th, 6th, 7th and 8th grades) (Ministry of Education [MoNE], 2018). In relation to this learning domain, 6th and 7th grade students are expected to achieve the following outcomes related to circle: "can solve problems requiring calculation of the circle length" (problems related to drawing a circle are included); and "can determine the features of a circle" (exercises requiring the calculation of the length of a circle piece and exercises requiring the calculation of the area of a circle and circle slice are included; making use of ratio while relating the central angle to the area of the

circle slice (MoNE, 2018). On the other hand, it is seen that in the process of acquisition of these gains, several difficulties are experienced while teaching the sub-learning domain of circle (Cantimer & Şengül, 2017) and that the metaphors owned by students regarding these difficulties have not been evaluated sufficiently. Therefore, within the scope of the present study, it was necessary to examine the metaphors produced by the secondary school 6th and 7th grade students in relation to the difficulties they experienced in the process of acquiring the gains related to the sub-learning domain of circle. In this respect, with the help of metaphors, the present study aimed to determine the secondary school 6th and 7th grade students' perceptions (for in-depth understanding) regarding the difficulties they faced while achieving the outcomes found in the sub-learning domain of circle. In line with this purpose, the following research questions were directed in the study:

1) What are the metaphors that secondary school 6th and 7th grade students have regarding the difficulties they experience in the process of learning the sub-learning domain of circle?
2) What are the categories formed on the basis of the common features of the metaphors obtained?

2. Method

2.1. Research Model

In the study, the phenomenological method, one of qualitative research designs, was used. Qualitative studies allow the researcher to examine the phenomena found in natural environment with all their complexities (Fraenkel & Wallen, 2000). By focusing on individuals' past experiences which they are aware of or which they fail to understand fully, phenomenological studies based on the qualitative research approach aim to describe how these individuals can problematize their own conditions (Marshall & Rossman, 2006; Yıldırım & Şimşek, 2011). The definitions obtained regarding the phenomenon examined in phenomenological studies are divided into categories to reveal what individuals think (Çekmez, Yıldız & Bütüner, 2012). With the help of metaphors, this qualitative study was carried out to determine the secondary school 6th and 7th grade students' perceptions regarding the difficulties they experienced in the process of learning the sub-learning domain of circle, and the study further aimed to categorize the metaphors obtained. For this purpose, the study was designed using the descriptive research design and metaphorical data analysis. Moreover, the phenomenological design was used for in-depth examination of the meanings attributed by the secondary school 6th and 7th grade students to the difficulties they faced in the process of learning circle.

2.2. Study Group

The present study was conducted with a total of 140 students from two different secondary schools in the city of Van in Eastern Anatolia in Turkey in the academic year of 2019-2020. The participants in the study were selected on voluntary basis and with the purposeful sampling method. In this respect, the participants were secondary school 6th and 7th grade students who had knowledge regarding the outcomes related to the sub-learning domain of circle. Among the 140 participants, 80 of them were 6th grade students (57.14%), and 60 of them were 7th grade students (42.86%).

2.3. Data Collection

In order to reveal the perceptions of the secondary school 6th and 7th grade students with the help of metaphors regarding the difficulties they experienced in the process of learning the sub-learning domain of circle, each of them was asked to complete the statement of "While learning the geometric shape of circle, I experience the biggest difficulty in …. because …". These descriptions provided by the students with their own handwritings constituted the basic data source as "document" for the researcher. In the first blank, the students were asked to write down a metaphor related to the difficulty they experienced while learning circle. In the second blank after the word 'because', the students were asked to explain the reasons for the metaphor they produced and wrote. The logical reasons for the metaphors can be identified via responses to the question of "why?" as different individuals could attribute different meanings to the same metaphors (Yıldırım & Şimşek, 2011). In the data collection process in the study, the students were informed about metaphors and asked to define the difficulties they experienced while learning circle and to explain for what purposes they provided these descriptions. It took the students about 15 minutes to complete the statements in the document.

2.3. Data Analysis

The qualitative data collected in the study were examined using content analysis to clarify the data within a certain framework and to obtain the related codes and categories (Silverman, 2000). The data analysis process was completed in the following phases (Saban, 2009).

2.3.1. Phase 1: Labelling

In this phase, all the statements written down by the students in the documents (all the metaphors regardless of whether they were valid or invalid were listed temporarily. In this process, the students' statements which were unclear were revised without changing the meaning and coded as metaphors. It was seen that almost all the students produced metaphors and that some of the metaphors were put forward by more than one student. Furthermore, in this phase, the documents which did not include any metaphor or which were left blank were marked for "elimination".

2.3.2. Phase 2: Elimination

In this phase, the metaphors produced by the students were revised with respect to the "subject of the metaphor, its source and the relationship between its subject and its source" (Fordcenville, 2002). The responses without any source, those belonging to more than one category, those inappropriate to the purpose of the study and the documents left blank were eliminated from the data collected. For example, "While learning the geometric shape of circle, I experience the biggest difficulty in doing laces placed on the edge of a circle because the circle reminds me of those difficult laces done by my mother and reminds me of a Turkish song named '*çemberimde gül oya*' (which includes the word circle in its name). As can be seen, although the subject of the metaphor was a circle and a difficult job, the student reported his/her thoughts irrelevant to the subject for the metaphor source. In this way, the responses like this one, which did not serve the purpose of the study or which included inappropriate and irrelevant relationships, were excluded. In this respect, 20 responses of the 6th grade students and 16 responses of the 7th grade students were not included in the analysis because they lacked a metaphor source, because they belonged to more than one category or because they were not appropriate to the purpose of the study. In addition, 33 documents of the 6th grade students and 9 documents of the 7th grade students were excluded from the analysis because they were left blank partially or completely. Consequently, a total of 78 responses (36 invalid and 42 left blank) were not subjected to analysis, and 62 responses were analyzed.

2.3.3. Phase 3: Code and category development

In this phase, the 42 remaining metaphors produced by the students were gathered under seven categories with respect to the common features of the difficulties experienced by the students in the process of learning the sub-learning domain of circle. These categories were named as follows: *Difficulty in drawing a circle for which standard and open equations are given; difficulty related to the arc-length measurements; difficulty related to the degree and radian; difficulty related to the concepts of interior, exterior, central and peripheral angles; difficulty related to the angles in shapes drawn in a circle; difficulty of problems related to the shapes drawn in a circle; and difficulty of tangent problems with circles*.

2.3.4. Phase 4: Ensuring validity

An important criterion for validity is the detailed explanation of how the results have been obtained after detailed reporting of the data collected in qualitative studies (Yıldırım & Şimşek, 2013). Therefore, in order to ensure validity in the present study, the data collection and analysis processes and the way the participants were determined were explained in detail. Moreover, in the section of findings, the categories formed in line with the common features of the metaphors obtained were supported with direct quotations from the examples of the metaphors written in the documents by the students, and the categories were explained in detail.

2.3.5. Phase 5: Ensuring reliability

For the reliability of the study, the metaphors and the categories determined by the researchers were presented to expert view, and the expert was asked to reassign the metaphors to the categories formed. Following this, by using the reliability formula of [Reliability=Agreement/(Agreement+Disagreement)*100] suggested by Miles and Huberman (1994), the percentage of the agreement between the researchers and the expert regarding the metaphors they assigned to the categories was calculated. As a result, the agreement ratio was found to be 96%.

3. Findings

The metaphors produced by the 6th and 7th grade students in relation to the difficulties they experienced in the process of learning circle were gathered under seven categories, and for the presentation of the findings, these categories were used. The categories were as follows: *drawing a circle for which standard and open equations are given; arc-length measurements; degree and radian; the concepts of interior, exterior, central and peripheral angles; the angles in shapes drawn in a circle; problems related to the shapes drawn in a circle; and tangent problems with circles*. Figure 1 shows the frequencies and the total frequency distribution of the metaphors produced by the 6th and 7th grade students regarding the categories obtained.

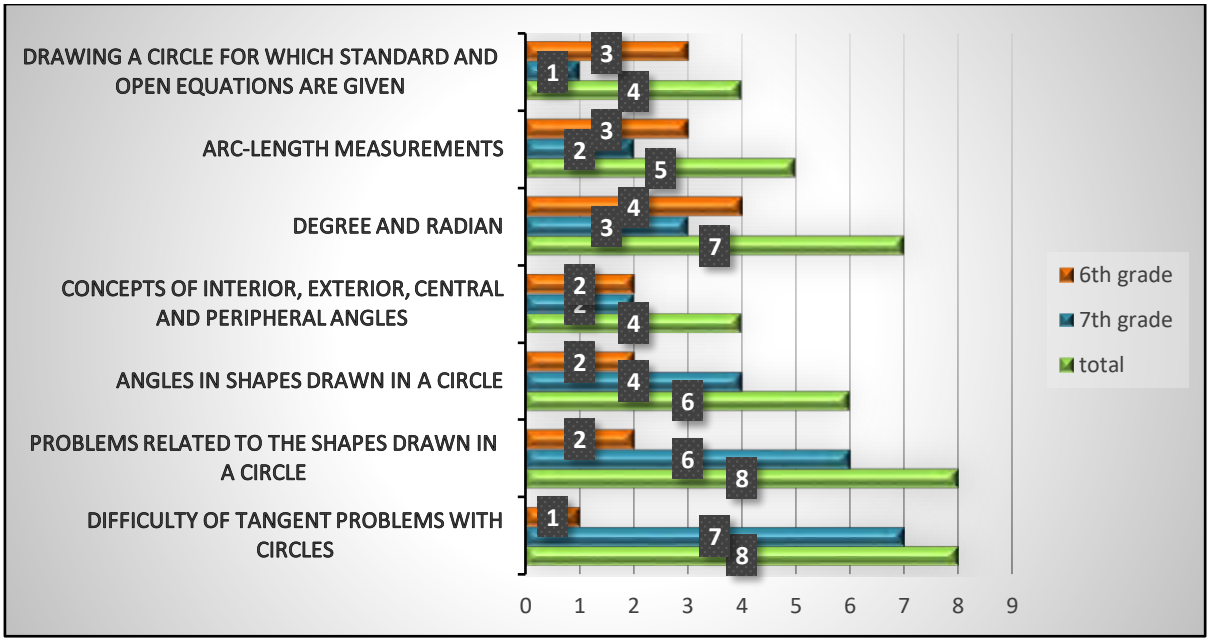

Figure 1. Frequency distribution of the metaphors with respect to the class grades and the total

According to Figure 1, the 6th grade students produced more metaphors than the 7th grade students in relation to the categories of *drawing a circle for which standard and open equations are given (6th grade =3; 7th grade=1), arc-length measurements (6th grade=3; 7th grade=2) and degree and radian (6th grade=4; 7th grade=3)*. In addition, the 7th grade students produced more metaphors than the 6th grade students regarding the categories of *angles in shapes drawn in a circle (6th grade=2; 7th grade=4), problems related to the shapes drawn in a circle (6th grade=2; 7th grade=6)* and *tangent problems with circles (6th grade=1; 7th grade=7)*. When Figure 1 is examined in general, it is seen that the metaphor produced most belonged to the categories of *problems related to the shapes drawn in a circle (total=8)* and *tangent problems with circles (total=8)* and that the 7th grade students *(total=25)* produced more metaphors when compared to the 6th grade students *(total=17)*. Table 1 presents the findings obtained in relation to the metaphors produced by the students with respect to the categories; the distribution of the student frequencies with respect to the metaphors and class grades; and the total frequency and total percentage values with respect to the categories.

Table 1. *Frequency and distribution of the students' metaphors with respect to the categories*

Categories	**Metaphors produced**	**6th grade frequency**	**7th grade frequency**	**Total frequency (f)**	**(f) and (%)**
Drawing a circle for which standard and open equations are given	point M and distance r	1		1	5 (8.06%)
	numbers and letters	2		2	
	standard equation	1		1	
	discriminant in the circle equation		1	1	
Arc-length measurements	eyebrow	1		1	7 (11.30%)
	tyre		1	1	
	alpha angle		1	1	
	arrow-arc	1		1	
	pie piece	3		3	

Degree and radian	ring		2	2	12 (19.35%)
	pi and arc angle		2	2	
	transformation	2		2	
	degree and radian	3		3	
	angle opposite the intersection of the olympic circles		1	1	
	measurement	1		1	
	degree×(π/180)	1		1	
Concepts of interior, exterior, central and peripheral angles	hour-hand and minute-hand	1		1	4 (6.45%)
	tangents and chords		1	1	
	wheel rim		1	1	
	practical slicer for melon and watermelon	1		1	
Angles in shapes drawn in a circle	slice of baklava on a tray	1		1	8 (12.90%)
	tortoiseshell		1	1	
	triangle cheese		1	1	
	butterfly drawn in a circle	2		2	
	square of chords		1	1	
	interior triangles and squares		2	2	
Problems related to the shapes drawn in a circle	manhole cover		1	1	11 (17.74%)
	twisting disc		1	1	
	frisbee		1	1	
	tennis racket		2	2	
	polygons in circle	1		1	
	basketball hoop		1	1	
	circle slices and area	2		2	
	target board		2	2	
Tangent problems with circles	pilates circle		1	1	15 (24.20%)
	nutcracker		1	1	
	roundabout		1	1	
	radius and tangent		3	3	
	point and tangent	2		2	
	exterior shapes tangent to the circle		2	2	
	square formed by the exterior tangent with the radius		4	4	
	square of tangents		1	1	
TOTAL	**42**	**26**	**36**	**62**	**100%**

According to Table 1, the results of the analysis of 62 responses considered to be valid revealed that a total of 42 different metaphors were produced. Of all these metaphors, 26 of them were produced by the 6th grade students, and 36 of them were produced by the 7th grade students. The frequency of the metaphors ranged between 1 and 4. The most frequent metaphor was *"square formed by the exterior tangent with the radius"* produced by 4 7th grade students, which was followed by the metaphors of *"pie piece"*, *"degree and radian"* and *"radius and tangent"* produced by 3 6th grade students and 3 7th grade students; and by the metaphors of

"numbers and letters", "ring", "pi and arc angle", "transformation", "butterfly drawn in a circle", "interior triangles and squares", "tennis racket", "circle slices and area", "target board", "point and tangent" and *"exterior shapes tangent to the circle"* produced by 2 6th grade students and 2 7th grade students. In this respect, it could be stated that the 6th and 7th grade students produced various metaphors regarding the difficulties they experienced in the process of learning circle. In addition, considering the number of the metaphors produced and the number of the participants, it was seen that the 7th grade participants produced more metaphors *(25 metaphors)* with a higher frequency *(36 students)* though the number of the participants in the 7th grade *(60 students)* was lower than that of the participants in the 6th grade *(80 students)*.

Within the scope of the study, while assigning the metaphors to the categories presented in Table 1, the explanations referring to the source of the metaphor were taken into account. For example, in relation to one 7th grade student's response of *"While learning the geometric shape of circle, I experience the biggest difficulty in finding the perimeters of shapes on a manhole cover because it is very difficult to find the perimeters of shapes drawn in a circle, which looks similar to a manhole cover",* the explanation referring to the source of the metaphor revealed that the student experienced difficulties in dealing with the problems related to the shapes drawn in a circle.

Moreover, according to the categories in Table 1, when the total frequency and percentage values were examined, it was seen that the total frequency and percentage values *(15 participants, 24.20%) were highest* for the category of *"tangent problems with circles"*, for which most metaphors (8) were produced as well. This category was followed by the category of *"degree and radian"* with 7 metaphors *(12 participants, 19.35%)*, by the category of *"problems related to the shapes drawn in a circle"* with 8 metaphors *(11 participants, 17.74%),* by the category of *"angles in shapes drawn in a circle"* with 6 metaphors *(8 participants, 12.90%), and by the category of "arc-length measurements"* with 5 metaphors *(7 participants, 11.30%)*. In addition, the total frequency and percentage values for the category of *"concepts of interior, exterior, central and peripheral angles"* with the fewest metaphors (4) were lowest *(4 participants, 6.45%)*, and the total frequency and percentage values for the category of *"drawing a circle for which standard and open equations are given"* with 4 metaphors were low as well *(5 participants, 8.06%)*. Below are the categories formed and the 6th and 7th grade students' descriptions for the related difficulties they experienced in the process of learning circle.

Category 1: Drawing a circle for which standard and open equations are given

In this category, there were 4 metaphors produced by a total of 5 students (8.06%), 4 of whom were 6th grade students and 1 of whom was 7th grade student. In the category, the metaphor of "numbers and letters" (f=2) produced by the 6th grade students was prominent. Below are sample statements forming the metaphors in this category:

"While learning the geometric shape of circle, I experience the biggest difficulty in finding the circle equation in the case of a given point M and a distance r because I cannot understand the relationship between the circle and forming an equation with a point and distance"

"While learning the geometric shape of circle, I experience the biggest difficulty in forming an equation with such numbers and letters because I don't understand how we can form an open or closed equation with them, and I thus memorize them."

"While learning the geometric shape of circle, I experience the biggest difficulty in finding the discriminant of that circle because it is already difficult to find the circle equation. It is

difficult to cope with the coefficients of x and y to find whether that equation is a circle or not, and it is even more difficult to memorize them all."

When these metaphors were examined, it was seen that according to the students' statements, they experienced difficulties in forming the circle equation for which certain descriptions were provided in the process of learning circle (central point, radius length, a point on the circle) or in examining a circle whose equation was given. In addition, they focused on memorizing certain theoretical information to overcome these difficulties.

Category 2: Arc length measurements

In this category, there were 5 metaphors produced by 7 students (11.30%) 5 of whom were 6th grade students and 2 of whom were 7th grade students. In the category, the metaphor of "pie slice" produced by the 6th grade students was prominent (f=3). Below are sample statements forming the metaphors in this category:

"While learning the geometric shape of circle, I experience the biggest difficulty in thinking about how long the math teacher's eyebrow might be because our teacher, who has arc-like but knitted eyebrows, always knits his eyebrows when he asks us to find the length of an arc with a given angle, and his knitted eyebrows cause me to think about the length of his eyebrows."

"While learning the geometric shape of circle, I experience the biggest difficulty in finding not the peripheral length of a car tyre but the length of a part of it because I cannot conceive how much distance a tyre will cover when it rotates with a 53-degree angle although I know that a tyre can cover a distance which is as long as the peripheral length of its one cycle"

"While learning the geometric shape of circle, I experience the biggest difficulty in solving problems related to pie slices because we have to deal with the perimeter of the pie and with the angles of the slices so that we can slice the pie for people a lot in number and get equal slices for everyone."

When these metaphors were examined, it was seen that according to the students' statements, they experienced difficulties regarding certain question types related to arc length associated with daily life. In addition, strikingly, the students focused on interesting visible objects (e.g. pie slice, tyre, arc-arrow, eyebrow).

Category 3: Degree and radian

In this category, there were 7 metaphors produced by a total of 12 students (19.35%) 7 of whom were 6th grade students and 5 of whom were 7th grade students. In the category, the metaphors of "degree and radian" (f=3) and "transformation" (f=2) produced by the 6th grade students and the metaphors of "pi and arc angle" (f=2) and "ring" (f=2) produced by the 7th grade students were prominent. Below are sample statements forming the metaphors in this category:

"While learning the geometric shape of circle, I experience the biggest difficulty in understanding the subjects of degree and radian because I cannot understand how a radian can be a length"

"While learning the geometric shape of circle, I experience the biggest difficulty in relation to the transformation procedures because we take the angle as length."

"While learning the geometric shape of circle, I experience the biggest difficulty in subjects like the pi and arc angle, in which we transform 360° into length, because I always do memorization to find the arc length corresponding to the angle degree, and I really hate memorizing formulas."

"While learning the geometric shape of circle, I experience the biggest difficulty in finding the perimeter of a ring as radian; well, yes you may find this funny, because at the end of that lesson, my girlfriend asked me: 'When you buy a ring for me, a 1-cm ring corresponding to a 120-degree angle will fit my finger. If so, what is the radian value? and I still couldn't find the answer!"

When these metaphors were examined, it was seen that according to the students' statements, they experienced difficulties in transforming a degree into radian or a radian into degree. Based on the explanations regarding the metaphors in this category, it could be stated that the students failed to understand that "the measure of the central angle across the arc with the radius is 1 radian"; furthermore, it could be stated that they had difficulty in relating the length to the angle and that they memorized 2π radian = 360°'to overcome this difficulty.

Category 4: Concepts of interior, exterior, central and peripheral angles

In this category, there were 4 metaphors produced by a total of 4 students (6.45%) 2 of whom were 6th grade students and 2 of whom were 7th grade students. In the category, each of the students produced 1 metaphor (f=1), and none of the 4 metaphors was prominent. These metaphors were "hour-hand and minute-hand of a clock", "tangents and chords", "wheel rim" and "practical slicer for melon and watermelon". Below are sample statements forming the metaphors in this category:

"While learning the geometric shape of circle, I experience the biggest difficulty in finding the angles between two tangents or between the tangent and the chord because I cannot figure out whether it is a peripheral angle or an interior angle"

"While learning the geometric shape of circle, I experience the biggest difficulty in determining the correct angle for placing the watermelon slicer to have equal slices of watermelon for everyone because we have such a slicer at home; my mother is a teacher, and when she asks me such questions, I can't give an answer. Therefore, I become upset, and I don't like that slicer."

"While learning the geometric shape of circle, I experience the biggest difficulty in finding the angle between the hour-hand and minute-hand of the clock because I can't solve questions involving different angles in a circle-shape clock with the minute-hand past 2 and the hour-hand past 3"

When these metaphors were examined, it was seen that according to the students' statements, they experienced difficulties in not only understanding the concepts of interior, exterior and peripheral angles formed in circle-like shapes but also finding these angles. In addition, it was striking that while expressing the difficulties they experienced in relation to the concept of angles in circles, the students used the tools they met in their daily lives (watch, wheel rim, practical slicer for melon and watermelon).

Category 5: Angles in shapes drawn in circle

In this category, there were 6 metaphors produced by a total of 8 students (12.90%) 3 of whom were 6th grade students and 5 of whom were 7th grade students. In the category, the metaphor of "butterfly drawn in a circle" (f=2) produced by the 6th grade students and the metaphor of "interior triangles and squares" (f=2) produced by the 7th grade students were prominent. Below are sample statements forming the metaphors in this category:

"While learning the geometric shape of circle, I experience the biggest difficulty in finding the angle of triangular baklava slices on a huge tray because some slices are so big that I wonder whether they have equal angles or not."

"While learning the geometric shape of circle, I experience the biggest difficulty in finding the angles of the square shapes on a tortoiseshell because these shapes resemble the squares we draw in a circle in class. I wonder whether these angles and the ones on the tortoiseshell are similar or not, but I can't find it!"

"While learning the geometric shape of circle, I experience the biggest difficulty in calculating the interior angles of the butterfly shape drawn because these angles are not always the same as in similar triangles."

"While learning the geometric shape of circle, I experience the biggest difficulty in finding the interior angles drawn in triangles and squares because I confuse whether to use my knowledge about circles or my knowledge about triangles and squares."

When these metaphors were examined, it was seen that according to the students' statements, they experienced difficulties in finding the angles of the shapes drawn in a circle. Based on the explanations regarding the metaphors in this category, it could be stated that the students were indecisive about whether to benefit from the features of geometric shapes or from the features of a circle to find the angles drawn in a circle.

Category 6: Problems related to shapes drawn in a circle

In this category, there were 8 metaphors produced by a total of 11 students (17.74%) 3 of whom were 6th grade students and 8 of whom were 7th grade students. In the category, the metaphor of "circle slices and area" (f=2) produced by the 6th grade students and the metaphors of "tennis racket" (f=2) and "target board" (f=2) produced by the 7th grade students were prominent. Below are sample statements forming the metaphors in this category:

"While learning the geometric shape of circle, I experience the biggest difficulty in finding the areas of shapes which become smaller on round things like the Frisbee because I can't solve the problems related to the areas of shapes drawn in a circle."

"While learning the geometric shape of circle, I experience the biggest difficulty in finding the perimeter of the foot shape formed of points on a round twisting disc that I use while doing physical exercises because when our teacher asked us to prepare a problem related to a circle, I prepared such a question, but I can't solve it now!"

"While learning the geometric shape of circle, I experience the biggest difficulty in finding the measures of the wires in a good-quality tennis racket and in calculating the spaces between the wires because I like playing tennis a lot, and I wanted to find the wire measures of my tennis racket after I solved questions related to the shapes drawn in a circle, but I had a great difficulty in doing so."

"While learning the geometric shape of circle, I experience the biggest difficulty in solving the problems related to polygons drawn in a circle because I can't make use of the features of a circle while finding the lengths and angles of shapes drawn in a circle."

"While learning the geometric shape of circle, I experience the biggest difficulty in finding the areas of the triangular slices and the areas of the nested circles on my target board because I believe I will play dart better when I find the areas of the shapes in a circle."

When these metaphors were examined, it was seen that according to the students' statements, they experienced difficulties in solving the problems related to the shapes drawn in a circle. The explanations regarding the metaphors in this category revealed that the students tried to adapt the problems to their daily life objects (e.g. twisting disc, tennis racket, target board) but experienced difficulties in doing so.

Category 7: Tangent problems in circles

In this category, there were 8 metaphors produced by a total of 15 students (24.20%) 2 of whom were 6th grade students and 13 of whom were 7th grade students. In the category, the metaphor of "point and tangent" (f=2) produced by the 6th grade students and the metaphors of "square formed by the exterior tangent with the radius" (f=4), "radius and tangent" (f=3) and "exterior shapes tangent to the circle" (f=2) produced by the 7th grade students were prominent. Below are sample statements forming the metaphors in this category:

"While learning the geometric shape of circle, I experience the biggest difficulty in dealing with questions like 'Is the point where the nutcracker touches the walnut really perpendicular to the radius of the circle?' because at school, I can't understand and solve the questions related to tangents to circles, so I try to adapt these questions to my life."

"While learning the geometric shape of circle, I experience the biggest difficulty in establishing a relationship between shapes and radius formed of lines that are exterior tangents to the circle because I can't solve the questions related to tangents to circles."

"While learning the geometric shape of circle, I experience the biggest difficulty in thinking about why my father close-shaves a roundabout while turning around it because in class, we learned that the closet distance of a line to a circle should be the tangent, but I find it difficult to associate this with our car and with the roundabout."

"While learning the geometric shape of circle, I experience the biggest difficulty in finding the perimeter of squares that are tangent to a circle because I can't find the tangent distances to a circle."

When these metaphors were examined, it was seen that according to the students' statements, they had difficulties in solving the tangent problems with circles. Moreover, based on the explanations related to the metaphors, it could be stated that the students found tangent problems with circles difficult to understand and that they thought there were obstacles in front of associating these problems with daily life.

3. Discussion, Conclusion and Suggestions

In this study, the secondary school 6th grade and 7th grade students' perceptions regarding the difficulties they experienced in the process of learning the subject of circles. At the end of the study, it was found that the students' perceptions regarding the difficulties they experienced in the process of learning circle were gathered under 7 categories with a total of 42 valid Metaphors. When these categories were evaluated in general, it was seen that the most frequent metaphors belonged to the categories of *tangent problems with circles (24.20%), degree and radian (19.35%)* and *problems related to the shapes drawn in a circle (17.74%)* and that the least frequent metaphors belonged to the categories of *concepts of interior, exterior, central and peripheral angles (6.45%)* and *drawing a circle for which standard and open equations are given (8.06%)*. Similarly, studies conducted on the sub-learning domain of circle revealed that students experience several difficulties which are mostly related to examples and shapes drawn in a circle (Özerbaş & Kaygusuz, 2012; Özsoy & Kemenkaşlı, 2004; Tikekar, 2009). This result shows that in the process of learning the subject of circle, students experience difficulty mostly in relation to tangent problems with circles requiring conceptual knowledge as well as in relation to shapes drawn in a circle. Moreover, it could be stated that students have less difficulty in dealing with problems involving angles in circles and with circle equations requiring procedural knowledge. This result is thought to be due to the fact that students are better at making use of their procedure-based knowledge to overcome the difficulties they experience regarding circles. In relation to this, Bekdemir (2012) points out that students' procedural knowledge about the learning domain of circle is better than their related conceptual knowledge.

Within the scope of the study, when the number of the participants and their class grades were taken into account, it was seen that the 7th grade students produced more metaphors with a higher frequency than the 6th grade students although the number of the 7th grade students was lower than that of the 6th grade students. In addition, the 6th grade students produced more metaphors regarding the categories of *circle equation, arc measures* and *degree and radian, while the 7th grade students produced more metaphors regarding the categories of tangents to circle* and *problems and angles in shapes drawn in a circle*. This result could be associated with the fact that the outcomes related to the sub-learning domain of circle in the mathematics curriculum (MoNE, 2018) are different for the 6th grade and 7th grade students. Moreover, this result is consistent with the findings that individuals from different age groups and class grades will produce different metaphors (Allen & Shiu, 1997; Cassel & Vincent, 2011; Gowin, 1983; Horzum & Yıldırım, 2016; Levine, 2005; Özdemir, 2012; Yee, 2012; Yob, 2003) and that students from different class grades will experience different difficulties regarding the subject of circle (Cantimer & Şengül, 2017).

The frequencies of the metaphors considered to be valid within the scope of the study revealed that the frequencies ranged between f=1 and f=4 and that the most frequent metaphors were "square formed by the exterior tangent with the radius" (f=4); "pie piece", "degree and radian" and "radius and tangent" (f=3). In this respect, it could be stated that almost all the students produced different metaphors regarding the difficulties they experienced in the process of learning circle. This situation is parallel to the findings obtained in other studies which reported that different metaphors are favoured by different individuals in relation to a concept or a situation (Erdem, 2018; Erdoğan, Yazlik & Erdik, 2014; Horzum & Yıldırım, 2016; Yee, 2012).

In the study, when the metaphors produced by the participants were examined in general, it was seen that according to the explanations referring to the sources of the metaphors, the students made associations between their daily lives and the difficulties they experienced in the process of learning circle. These associations could be exemplified with the following metaphors produced by the students: "eyebrow, tyre, pie piece, ring, olympic circles, hour-hand and minute-hand of a clock, wheel rim, practical slicer for melon and watermelon, slice of baklava on a tray, tortoiseshell, triangle cheese, manhole cover, twisting disc, frisbee, tennis racket, basketball hoop, target board, pilates circle, nutcracker and roundabout." In line with these examples, the metaphors produced by the students could be said to be fairly rich and striking. Considering the fact that metaphors are produced with the help of similes (Kittay, 1989), it could be concluded that metaphors may involve the objects that people face in their daily lives. Based on this result, the metaphors produced by the students in relation to the difficulties they experienced in the process of learning the geometric concept of circle could be associated with the fact that geometry interacts with daily life. Moreover, in relation to this result, it was another striking finding that in relation to learning circle, the students tried to produce problems based on the objects they faced in their daily lives. This result is also evident in the following response of one of the students: *"While learning the geometric shape of circle, I experience the biggest difficulty in finding the perimeter of the foot shape formed of points on a round twisting disc that I use while doing physical exercises because when our teacher asked us to prepare a problem related to a circle, I prepared such a question, but I can't solve it now!*". This result might have occurred due to the fact that teachers refer to daily life while giving in-class examples in the process of teaching geometry. Therefore, if teachers associate geometric concepts with daily life in the process of geometry teaching, this association might contribute to the achievement of the intended outcomes. Similarly, in related literature, it was reported that the methods and techniques used in the teaching process contributed to the development of the students' research, practice and learning skills and had positive influence

on their learning (Aydın & Monaghan, 2011; Barnett et.al., 2011; Ebenezer et.al., 2012; Ertem-Akbaş, 2019; Majerek, 2014; Tüysüz & Aydın, 2007; Gök & Ertem-Akbaş, 2019; Yılmaz, Ertem & Çepni, 2010). In addition, it was seen in the present study that the metaphors produced by the students were made up of more than one word rather than a single word or concept (angle opposite the intersection of the olympic circles, hour-hand and minute-hand of a clock, practical slicer for melon and watermelon, butterfly drawn in a circle, slice of baklava on a tray, pilates circle, roundabout, basketball hoop, nutcracker, exterior shapes tangent to the circle and so on). The production of these metaphors could be associated with the nature of the research problem. Besides the basic concepts in geometry teaching, the relationships between these concepts and the problems posed are examined as well (Cantimer & Şengül, 2017; Tikekar, 2009). Therefore, it was a striking result that the students participating in the present study associated the difficulties in the process of learning circle with the difficulties they experienced in their daily lives rather than using a single word or concept to express the difficulties they experienced in the process of learning circle. This result could be associated with the fact that geometry is a way of portraying our world (Hacısalihoğlu et.al., 2004; Özkeleş-Çağlayan, 2010) and that students can make better use of their current skills and intellectual indicators while describing their real-life worlds. Based on this result, it could be stated that making associations with the abstract objects in students' environments could allow them to overcome the probable difficulties in the process of learning with the help of their current skills. This is also evident in the following response of one of the students: *"While learning the geometric shape of circle, I experience the biggest difficulty in finding the measures of the wires in a good-quality tennis racket and in calculating the spaces between the wires because I like playing tennis a lot, and I wanted to find the wire measures of my tennis racket after I solved questions related to the shapes drawn in a circle, but I had a great difficulty in doing so."*

In the study, it was found that 36 of the invalid metaphors produced by the students lacked a metaphor source, belonged to more than one category and lacked a relationship with the difficulties experienced in the process of learning circle. It was also seen that 42 of the metaphors were left either completely or partially blank. This result shows that the students had difficulty expressing the difficulties they experienced in the process of learning circle. Similarly, in one study, Bahadır (2016) concluded that the participants had difficulty expressing their thoughts and emotions regarding certain subjects. In this respect, it is important to provide participants with environments in which they can feel confident and freely express their thoughts. In addition, it is thought that the students had difficulty in expressing the difficulties they experienced in their learning process probably because they failed to internalize the information about the abstract concepts related to the subject of circle. This situation is supported with the finding of other studies that students lack background knowledge about circles and sometimes fail to envisage the abstract concepts related to circle (Cantimer and Şengül, 2017; Özsoy and Kemankaslı, 2004). Moreover, considering the fact that in geometry teaching, it is more important to see the relationships between concepts rather than just knowing the definition of the concepts, teachers could create learning environments in which geometric concepts are discussed and associated with daily life with the help of appropriate tools and activities.

The findings obtained in the present study demonstrate that secondary school 6th and 7th grade students experience various difficulties in relation to the subject of circle. Based on the results of this qualitative study involving metaphor analysis, it cannot be claimed that students' perceptions regarding the difficulties they experience in relation to the subject of circle are true for all secondary school geometry subjects. However, in the process of learning geometry subjects, especially the subject of circle, students could be said to have various perceptions

regarding the difficulties they experience in the process. Obviously, geometry-related outcomes, which are included in the scope of mathematics curriculum, have an important place not only in their education lives but in their daily lives as well. In this respect, rather than the difficulties related to geometric concepts, it is necessary to develop students' positive perceptions and understanding. For this purpose, teachers could associate geometry subjects with the problems students face in their daily lives so that students can develop positive perceptions. In this respect, a similar study could be conducted with preservice teachers and with teachers who teach geometry, and the results to be obtained could be compared with those reported in related literature. Metaphor is the way individuals present their perceptions and understanding regarding a situation (Lakoff & Johnson, 2005). Furthermore, in another study, an interview technique could be applied for in-depth examination of the findings to be obtained. In addition, considering the fact that the only focus subject was circle in the present study, future studies could focus on other concepts and subjects related to geometry. In this respect, these studies could not only help determine how geometry subjects are perceived and but also contribute to the correct perception and understanding of these subjects.

4. Conflict of Interest

The authors declare that there is no conflict of interest.

5. Ethics Committee Approval

The authors confirm that the study does not need ethics committee approval according to the research integrity rules in their country.

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