Osmangazi Journal of Educational Research **Volume 7(2), Fall 2020**

RESEARCH Open Access

Suggested Citation: Karakarçayıldız, R. Ü., & Yenilmez, K. (2020). Investigation of geometrical thinking levels and polygons classification skills of 7th grade students. *Osmangazi Journal of Educational Research, 7*(2), 39-59.

Submitted: 16/07/2020 **Revised:** 09/10/2020 **Accepted:** 12/10/2020

Investigation of Geometrical Thinking Levels And Polygons Classification Skills of 7th Grade Students

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Abstract. The aim of this study was to investigate the relationship between level of geometrical thinking and classification skills of polygons of 7th grade students. Relational survey model was used in this study. The sample of the study consists of 318 7th grade students from a public school in a city in Central Anatolian region. Data were collected by Geometrical Thinking Levels Determination Test, developed by Özcan (2012) and Polygon Perception and Classification Scale, developed by Ergün (2010). The obtained data were analyzed by using nonparametric tests as Kruskall Wallis-H, Mann Whitney-U and Spearman Brown correlation analysis. According to results of the study, it was found that 7th grade students' geometrical thinking levels are mainly 1st level; more than half of the students are in the 2nd level and upper level. Students' classification skills of polygons were at medium level. It was stated that there is a positive and meaningful relationship between classification skills of polygon and geometrical thinking levels of students. It was seen that the students with high level of geometrical thinking were successful in classifying of polygons and finding relations between polygons.

Keywords. Teaching geometry, geometrical thinking levels, classification skills of polygons.

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Note: This study is a part Reyhan Ümit Karakarçayıldız's master's thesis named "Geometrical Thinking Levels and Polygons Classification Skills of 7th Grade Students and Relationship Between Them" completed in Eskisehir Osmangazi University in 2016.

Mathematics is a numerical and spatial science that is based on values and measurements such as arithmetic, algebra or geometry and that examines the properties of quantities (Altun, 2010). The importance of geometry, which provides basic skills such as analyzing, comparing and generalizing and offers cognitive skills such as examining, studying, criticizing, presenting what has been learned as a schema, being organized, careful and patient or reflecting ideas clearly and purely, is undeniable for mathematics (Baykul, 2014). With the perspective created by geometry, students can analyze and solve problems more comfortably and establish a connection between mathematics and life. Moreover, geometrical forms can help understand the abstract concepts better (Duatepe, 2000).

The report issued by the National Council of Mathematics Teachers [NCTM] in the United States of America (USA) to determine the principles and standards in school mathematics emphasized the importance of improving students' skills of mathematical questioning and proving a point (NCTM, 2000). According to Turğut and Yılmaz (2009), geometry helps students get to know the world better. Serving as an instrument in helping students like the mathematics, geometry enables them to utilize the skills and information which they gained in schools in their daily lives. Being considered as a form of mathematical thinking, geometric thinking has a specific structure. Efforts should be made to determine which skills, information and experiences students should gain in terms of geometry and to reveal students' geometric thinking levels which they will gain at the end of this process. Therefore, how the students' geometric thinking processes work and the levels of geometric thinking should be known.

It is fair to state that the examination of geometric thinking among children has started with Piaget (Aktaş-Arnas, 2009). Pierre Marie Van Hiele and Dina Van Hiele-Geldof, two Dutch pedagogues, performed studies in regard to the development of geometric concepts and thoughts among children in 1957, with concepts different to the ideas of Piaget, and they created their own theories in the end (Baykul, 2014). This theory known as "Van Hiele's Concept" is still utilized today. The knowledge, skills, thinking levels and general success of Turkish students from primary, secondary and other schools in geometry are low. The classification of geometrical figures, which is one of the basic mental processes, has an important role in the development of advanced geometric thinking skills in relation to the geometric classes at secondary school level (Okumuş, 2011).

Classification is a process of grouping and collecting objects based on their qualities. Through classification, a relationship can be established between the similar objects, or similar events and objects can be reviewed in similar manners (Hohmann and Weitart, 2000; Ford and Crew, 1991). It is fair to state that classification is an important skill for geometric thinking. With relation to the curriculum of mathematical classes, students of primary schools should name the geometric figures based on their qualities and group them considering the straight sides, while the students of secondary schools should classify the geometric figures based on their qualities and establish a relationship between them. Students of the first grade are expected to classify the figures based on the numbers of corners and sides, and to name, define and model triangle, square, rectangle and circle upon their gains in the subfield of Geometric Objects and Figures within Mathematics. They are also expected to classify the geometric figures with the examples from the daily life (without mentioning the mathematical titles of them). Students of the second grade are expected to classify the geometric figures based on the number of sides and corners. The achievements of the fourth grade include the ability to classify the triangles by the length of their sides (Ministry of National Education -[MNE], 2018). Explanation of the properties of geometric figures and objects along with the relationships between them, and use of these in classifying the geometric figures and objects contributes to the process of solving mathematic problems regarding other fields and the problems of the real life (NCTM, 2004; Martin and Strutchens, 2000; Cited by: Fidan, 2009). The achievements from the curricula indicate that classification activities start in the primary school years and that the activities of defining, building, drawing, comparing and grouping the geometric figures based on certain properties are important for students to establish a relationship between the polygons.

Students of the secondary school examine the geometric figures based on their appearances or properties without comparing or correlating them, which constitutes a problem in the development of mental skills (Choi, 1996; Cited by: Okumuş, 2011). Significant differences were found between the geometric concepts known by the students and their skills of defining and classifying these concepts (Yanık, 2013). Results of different studies from the literature indicated that students knew the geometric figures (Aktaş and Aktaş, 2012), that they could not use the geometric concepts with activities of ordering from general to specific or specific to general, and that they could not understand the relationships between the figures (Akuysal, 2007). The hierarchical classification of rectangles is regarded as a field that will improve students' development in geometric thinking (Fujita and Jones, 2007). In addition, establishing relationship between the geometric figures is believed to be important for the development of geometric thinking (Van Hiele, 1986).

There are numerous studies performed with teachers, preservice teachers and students from different grades to determine the geometric thinking levels and to reveal the relationship between these levels and different variables in the relevant literature (Şahin, 2012; Kılıç, 2013; Akay, 2013; Oral, İlhan and Kınay, 2013; Çakmak and Güler, 2014; Viglietti, 2011; Napitipulu, 2001). Certain studies indicate that the geometric thinking levels of secondary and high school students are not how they are supposed to be (Fidan and Türnüklü, 2010), and geometric thinking levels of preservice teachers are below the expected threshold. The number of studies conducted with teachers, students and preservice teachers to examine the polygons and the skills of classifying them is quite limited. However, the relevant literature has many studies on rectangles (Ubuz and Koç, 2008; Başışık, 2010; Yanık, 2013; Türnüklü, 2014; Özdemir-Erdoğan and Dur, 2014; Ergin, 2014; Fujita, 2012; Fujita and Jones, 2007; Pickreign, 2007). A review of the literature also indicated that the number of studies on classifying the polygons is quite limited. Although the participants of these studies knew the geometric concepts, they had difficulties in making definitions. Moreover, they mentioned what they knew about polygons while answering the questions, and the prototype images about the polygons adversely affected them. They were also found to lack the perception toward the hierarchical relationship between the rectangles and to prefer the fragmented classification. The participants were believed to have considered the particular rectangles as independent from one another.

As understood from the studies conducted in Turkey and from the reports regarding the international tests, Turkish students' achievements in geometry are quite limited, meaning students' knowledge, skills and geometrical thinking levels are not sufficient. This study aimed to examine the relationship between the geometric thinking levels of seventh-grade students and their skills of classifying polygons, and it has a significant role in terms of reviewing the advanced geometric thinking skills such as classifying the geometrical figures. This study is believed to be important in terms of contributing to the processes of learning about the polygons, improving students' geometric thinking levels, and revealing the deficiencies experienced in teaching geometry. Accordingly, it reviews the relationship between the geometric thinking levels of seventh-grade students and skills of classifying the polygons. The sub-problems of this study are as follows:

1) How are the geometric thinking level of seventh-grade students?

2) Do the weighted scores regarding geometric thinking of seventh-grade students vary by gender, experience of preschool education, grade from mathematics in the report card, and maternal and paternal educational status?

3) How are the skills of seventh-grade students in classifying polygons?

4) Do the weighted scores regarding the polygon classification skills of seventh-grade students vary by gender, experience of preschool education, grade from mathematics in the report card, and maternal and paternal educational status?

5) Is there a relationship between the weighted scores regarding geometric thinking of seventh-grade students and their scores regarding the polygon classification skills?

Method

This section provides information about the study model, population and sample, data collection tools and data analysis.

Research Model

This quantitative study used the correlational model to determine students' geometric thinking levels, measure their skills in classifying polygons, and examine the relationship between their geometric thinking levels and skills. The correlational model is defined as the approach aiming to examine the relationship between two or more variables. It examines whether the variables change collectively and how the change occurs if there is one (Karasar, 2011).

Study Group

The population of this study consisted of seventh-grade students who were studying in public schools that serve in a Central Anatolian district under the authority of Ministry of National Education during 2013-2014 school year. The sample was formed using convenience sampling method – a selective sampling method. Using the convenience sampling method, researchers can determine the group they can conveniently access for their studies and can collect the data from that group. The main purpose in this sampling method that is also known as accidental or opportunity sampling method is to prevent the losses in time, money and labour force. Researchers work on a case that can provide the maximum amount of saving in the process of accessing the group with the required size (Büyüköztürk et al., 2014), which enables researchers to perform sampling through their close acquaintances (Balcı, 2013). Accordingly, 318 seventh-grade students who were studying in a secondary school of a Turkish district constituted the sample. The main idea behind the selection of this group was that the school of the participating students was one of the most crowded schools in the city, that the school had different students with different profiles from various neighborhoods, and that the basics of polygons are generally learned in the seventh grade.

The percentage and frequency values regarding the participating students' demographic characteristics are present in Table 1.

Table 1.

Demographic Characteristics of the Sample Group

		f	%			f	%
Gender	Female	151	47.5	**MES***	Primary School	88	27.7
	Male	167	52.5		Secondary School	95	29.9
Grade in Mathematics	Poor	38	11.9		High school	102	32.1
	Pass	55	17.3		University	33	10.4
	Moderate	73	23.0	**PES****	Primary School	34	10.7
	Good	78	24.5		Secondary School	71	22.3
	Excellent	74	23.3		High school	143	45.0
Preschool Education	Yes	195	61.3		University	70	22.0
	No	123	38.7				

Note: *MES; Maternal Educational Status, **PES; Paternal Educational Status.

Table 1 indicates that male and female participants in this study were distributed to groups homogeneously. Students' achievements in mathematics showed that they were not successful in mathematics, that the number of students with passing grades was limited, and that students with moderate, good and excellent grades showed a homogeneous distribution. The number of students who received preschool education was higher than the number of those who did not receive such an education. Regarding the maternal educational status, the number of mothers with a bachelor's degree was limited, and graduates of primary, secondary and high schools displayed a homogeneous distribution. The number of fathers who were high school graduates was quite higher than that of fathers who graduated from other schools.

Data Collection Tools

The study data were collected using three different data collection tools: Personal Information Form, Test for Determining the Level of Geometric Thinking, and Polygon Perception and Classification Scale.

Personal information form. This form was prepared by the researchers and consisted of demographic variables believed to be related to students' geometric thinking levels (gender, preschool education experience, maternal and paternal educational status, and mathematics grade in the report card).

Test for determining the level of geometric thinking. This test was developed by Özcan in 2012 and used to determine students' level of geometric thinking. The validity and reliability studies were conducted by Özcan. The reliability coefficient regarding the 54-item trial form was found to be 0.89 while the mean difficulty index regarding the test items was 0.56. This test had five items for Level 1 while it has ten for Level 2, another ten for Level 3 and five for Level 4, meaning 30 items in total. Five items in Level 4 were derived from the test prepared by Usiskin (1982). Items from Level 5 were not included considering the status of the participants as secondary school students (Özcan, 2012). Van Hiele geometric thinking levels range from 0 to 4 or 1 to 5 in the literature, the latter of which was used in this study. Students who were not assigned to any levels were graded as Level 0.

Polygon perception and classification scale. This scale was developed by Ergün in 2010 to determine students skills in classifying polygons and used in this study. Ergün performed the validity and reliability studies of this scale in 2010 and found the reliability coefficient as 0.835. The mean difficulty index of test items was 0.49 while the mean discrimination index of test items was 0.47. This scale consisted of 40 items that aimed to determine students' perceptions toward polygons and their skills in classifying them. The highest and lowest scores to obtain from this scale was 40 and 0, respectively.

Data Analysis

The weighted score regarding geometric thinking and polygon classification skill score were calculated, and difference analyses were performed on these scores based on various variables. The data obtained at the end of the study were analyzed using Statistical Package for the Social Sciences (SPSS) version 21.0 by IBM. Kolmogorov-Smirnov test was used to examine the normality of distribution, and it indicated that the data were not distributed normally. Whether the students' geometric thinking levels and polygon classification scores varied by variables was examined using Mann-Whitney U test and Kruskal-Wallis H test – two non-parametric tests. Moreover, Spearman-Brown Correlation of Prophecy Formula was used to examine the relationship between the weighted scores of geometric thinking and polygon classification score.

Results

The distribution of the sample group based on geometric thinking levels was examined, and the results are provided in Table 2.

Table 2.

Distribution of Sample Group by the Levels of Geometric Thinking

Levels		**Level 0**	**Level 1**	**Level 2**	**Level 3**	**Level 4**
	f	10	134	70	92	12
	%	3.1	42.1	22.0	28.9	3.8

According to Table 2, only a few students were within Level 0 and Level 4, while almost half of them were within the Level 1. Moreover, more than half of the participants were within Level 2 and above.

Mann-Whitney U test was used to see whether the weighted scores of seventh-grade students based on geometric thinking level varied by gender, and the results are presented in Table 3.

Table 3.

Difference of Weighted Scores Regarding the Geometric Thinking Level by Genders

Score	**Gender**	**n**	**Σ_{rank}**	**x_{rank}**	**U**	**Z**	**p**
	Female	151	24396.50	161.57	12296.50	-0.39	0.70
	Male	167	26324.50	157.63			

Table 3 indicates that no statistically significant difference was present between the genders in terms of the weighted scores regarding students' geometric thinking levels.

Kruskal Wallis -H test was used to see whether the weighted scores of seventh-grade students based on geometric thinking levels varied by the success in mathematics, and the results are presented in Table 4.

Table 4.

Difference of Weighted Scores Regarding the Geometric Thinking Level by the Success in Mathematics

Score	**Grade**	**n**	**x_{rank}**	**χ^2**	**sd**	**p**
	1	38	117.13	42.615	4	0.00
	2	55	122.75			
	3	73	149.14			
	4	78	168.62			
	5	74	209.18			

As understood from Table 4, a statistically significant difference was present between the mean assessment values of groups as a result of Kruskal-Wallis H test performed to determine whether students' weighted scores regarding geometric thinking showed a significant difference in terms of their grades in mathematics. Following the additional comparison made to determine where the significant difference found after the Kruskal-Wallis H test arose from, a significant difference was found between the groups of 1-4, 1-5, 2-4, 2-5 and 3-5. The difference was in favor of those who had higher grades in the report card in all groups.

Mann-Whitney U test was used to see whether the weighted scores of seventh-grade students based on geometric thinking levels varied by preschool education experience, and the results are presented in Table 5.

Table 5.

Difference of Weighted Scores Regarding the Geometric Thinking Levels by the Experience of Preschool Education

Score	**Preschool Educatio**	**n**	**Σ_{rank}**	**x_{rank}**	**U**	**Z**	**p**
	Experience	195	32399.00	166.15	10696.00	-1.67	0.09
	No Experience	123	18322.00	148.96			

Table 5 indicates that no statistically significant difference in terms of the weighted scores regarding students' geometric thinking levels was present between the students who received preschool education and who did not.

Kruskal Wallis -H test was used to see whether the weighted scores of seventh-grade students based on geometric thinking levels varied by maternal educational status, and the results are presented in Table 6.

Table 6.

Difference of Weighted Scores Regarding the Geometric Thinking Level by the Maternal Education Status

Score	**Education**	**n**	**x_{rank}**	**χ^2**	**sd**	**p**
	Primary School	88	160.80	1.52	3	0.68
	Secondary School	95	155.36			
	High school	102	156.74			
	University	33	176.52			

As understood from Table 6, a statistically significant difference was not present between the mean assessment values of groups as a result of Kruskal-Wallis H test performed to determine whether students' weighted scores regarding geometric thinking showed a significant difference in terms of maternal education.

Kruskal Wallis -H test was used to see whether the weighted scores of seventh-grade students based on geometric thinking levels varied by paternal educational status, and the results are presented in Table 7.

Table 7.

Difference of Weighted Scores Regarding the Geometric Thinking Level by the Paternal Education Status

Score	**Education**	**n**	x_{rank}	χ^2	**sd**	**p**
	Primary School	34	135.81	7.28	3	0.06
	Secondary School	71	143.23			
	High school	143	166.52			
	University	70	173.16			

As understood from Table 7, a statistically significant difference was not present between the mean assessment values of groups as a result of Kruskal-Wallis H test performed to determine whether students' weighted scores regarding geometric thinking showed a significant difference in terms of paternal education.

The general analysis regarding the seventh-grade students' skills in classifying polygons is present in Table 8.

Table 8.

General Analysis of the Sample Group's Skill Scores from Classifying Polygons

	n	$\bar{X}$	**sd**
Skills Scores from Classifying Polygons	318	20.22	7.03

According to Table 8, students' skills in classifying polygons were at moderate level considering their scores in classifying polygons.

Mann-Whitney U test was used to see whether seventh-grade students' scores in polygon classification skills varied by gender, and the results are presented in Table 9.

Table 9.

Difference of Skill Scores from Classifying Polygons by Gender

Score	Gender	n	Σ_{rank}	x_{rank}	U	Z	p
	Female	151	24396.50	145.34	10243.50	-2.89	0.00
	Male	167	24271.50	157.63			

Table 9 indicates a statistically significant difference regarding the scores of polygon classification skills between the gender groups. This difference arose from female students' higher scores of polygon classification skills compared to those of men.

Kruskal Wallis -H test was used to see whether the seventh-grade students' scores in polygon classification skills varied by the success in mathematics, and the results are presented in Table 10.

Table 10.

Difference of Skill Scores from Classifying Polygons by The Success in Mathematics

Score	Grade	n	x_{rank}	χ^2	sd	p
	1	38	78.05	116.73	4	0.00
	2	55	93.73			
	3	73	144.26			
	4	78	189.31			
	5	74	233.82			

As understood from Table 10, a statistically significant difference was present between the mean assessment values of groups as a result of Kruskal-Wallis H test performed to determine whether students' scores regarding polygon classification skills showed a significant difference in terms of grades in mathematics. Following the additional comparison made to determine where the significant difference found after the Kruskal-Wallis H test arose from, a significant difference was found between the groups of 1-3, 1-4, 1-5, 2-3, 2-4, 2-5, 3-4, 3-5, and 4-5. The difference was in favor of those who had higher grades in the report card in all groups.

Mann-Whitney U test was used to see whether the seventh-grade students' scores in polygon classification skills varied by preschool education experience, and the results are presented in Table 11.

Table 11.

Difference of Skill Scores from Classifying Polygons by The Experience of Preschool Education

Score	**Preschool Education**	**n**	**Σ_{rank}**	**x_{rank}**	**U**	**Z**	**p**
	Experience	195	32930.00	168.87	10165.00	-2.29	0.02
	No Experience	123	17791.00	144.64			

As understood from Table 11, there was a statistically significant difference regarding the polygon classification skill scores between the students who received preschool education and who did not, which is believed to be in favor of those who received preschool education.

Kruskal Wallis -H test was used to see whether the seventh-grade students' scores in polygon classification skills varied by the maternal educational status, and the results are presented in Table 12.

Table 12.

Difference of Skill Scores from Classifying Polygons by The Maternal Education

Score	**Education**	**n**	**x_{rank}**	**χ^2**	**sd**	**p**
	Primary School	88	148.01	14.81	3	0.00
	Secondary School	95	145.95			
	High school	102	164.86			
	University	33	212.59			

As understood from Table 12, a statistically significant difference was present between the mean assessment values of groups as a result of Kruskal-Wallis H test performed to determine whether students' scores in classifying polygons showed a significant difference in terms of maternal education. The additional comparison methods were used to determine the groups as the source of the significant difference found at the end of Kruskal Wallis-H test. The difference was present between the groups of secondary school-university and high school-university, and it was in favor of those whose mothers were university graduates.

Kruskal Wallis -H test was used to see whether the seventh-grade students' scores in polygon classification skills varied by the paternal educational status, and the results are presented in Table 13.

Table 13.

Difference of Skill Scores from Classifying Polygons by The Paternal Education

Score	Education	n	x_{rank}	χ^2	sd	p
	Primary School	34	116.72	26.47	3	0.00
	Secondary School	71	137.19			
	High school	143	160.00			
	University	70	201.89			

As understood from Table 13, a statistically significant difference was present between the mean assessment values of groups as a result of Kruskal-Wallis H test performed to determine whether students' scores in classifying polygons showed a significant difference in terms of maternal education. The additional comparison methods were used to determine the groups as the source of the significant difference found at the end of Kruskal Wallis-H test. The difference was present between the groups of high school-university and primary school-university, and it was in favor of those whose fathers were university graduates.

The results of Spearman-Brown Correlation of Prophecy Formula used to determine whether there was a relationship between the polygon classification skill scores of seventh-grade students and their geometric thinking levels are present in Table 14.

Table 14.

The Relationship Between the Weighted Scores Regarding the Geometric Thinking Level and Skills Scores from Classifying Polygons

Score	Geometric Thinking Leve Weighted Scores	Skills Scores from Classifying Polygons	p
Weighted Scores Regarding the Geometric Thinking Level	1	0.42	0.00
Skills Scores from Classifying Polygons	0.42	1	

As understood from Table 14, there was a positive, significant and moderate-level difference between the polygon classification skill scores and geometric thinking levels of seventh-grade students.

Discussion and Conclusion

The geometric thinking levels of seventh-grade students were found to be as displayed in Level 1 (visual level). The students in Level 2 (analysis level) and 3 (pre-logical inference level) constituted approximately the half of students in the sample group. The number of students in Level 4 was interesting despite being low, and some students could not even be assigned to any groups. These students within Level 0 (pre-recognition level) were able to answer one or a couple of questions from each level but they could not answer enough questions to be included in Level 1. Accordingly, the reason for students' presence in different geometric thinking levels could be related to their personal skills and orientations, and to their educations. According to National Council of Teachers of Mathematics (NCTM) 2000 standards, the first and second-grade students are expected to be within Level 0 (pre-recognition level), while the third, fourth and fifth-grade students should be within Level 1 (visual level). Moreover, the sixth, seventh, and eighth-grade students are expected to be within Level 2 and 3. Approximately half of the students were within the Level 2 and 3, while the other half were below the expected thinking level. Fidan (2009) states that fifth-grade students are within the Level 0 while Özcan (2012) notes that seventh-grade students are expected to be within Level 1 (visual level). Similarly, Halat (2006) reports that sixth-grade students are within the pre-recognition level while Akkaya (2006) indicates that sixth-grade students are within the Level 1 and 2. Yılmaz et al. (2008) expresses that eighth-grade students are within the visual level considering their geometric thinking levels, which is below the expected level. Accordingly, the results of this study are substantially in parallel to the results of other studies examining students' geometric thinking levels. The presence of approximately half of the students in Level 2 and 3 was a different result compared to the results of other studies.

An examination toward the weighted scores of students by their gender indicated no significant difference between the gender groups in regard to geometric thinking levels. Accordingly, it is fair to state that geometric thinking levels of female and male students were close. According to Trends in International Mathematics and Science Study (TIMMS) data, students' success in geometry does not differ by gender until the third-grade in the primary school (Mullis, Martin, Fierros, Goldberg and Stemler, 2000, Cited by: Fidan, 2009). According to The Programme for International Student Assessment (PISA), gender has no effect on students' success. Moreover, Yılmaz et al. (2008) found that geometric thinking levels of secondary school students showed no difference by gender but female students' mean geometric thinking level was higher than that of male students. Moreover, Fidan (2009) indicated that there was a significant difference between the geometric thinking levels of students by gender. Mean geometric thinking levels of female students were higher than those of male students. Accordingly, there are studies indicating that geometric thinking levels differ by gender (Duatepe, 2000; Toluk, Olkun and Durmuş, 2002; Şahin, 2008; Fidan and Türnüklü, 2010). It is fair to state that the study result regarding the gender variable was in parallel to the results of certain studies.

Another result was that there was no significant difference between the students who received pre-school education and who did not, which is different compared to the results of certain studies from the literature. Fidan (2009) found that the geometric thinking levels of students who received pre-school education were higher than those of students who did not receive such an education, which can be reassessed through different samples.

An assessment on geometric thinking levels of students based on their families' educational levels indicated that students' geometric skills were not affected by the maternal and paternal educational statuses. Fidan (2009) found that students whose fathers were illiterate reached the Level 1 maximum while they were at the Level 3 in all other cases. It is fair to state that the results of this study differed from the results of other relevant studies in the literature.

The seventh-grade students' success in mathematics indicated that those who had higher grades had higher weighted scores regarding geometric thinking. The studies conducted by Çakmak and Güler (2014) with pre-service teachers found a positive but weak relationship between teachers' mean grades and geometric thinking levels.

The polygon classification skills of seventh-grade students were found to be moderate. Although the number of studies on classifying polygons is limited, the aforementioned result was in parallel to what Ergün (2010) found. An assessment on seventh-grade students' polygon classification skills indicated that the difference was in favor of female students, and that Ergün (2010) and Berkün (2011) found no difference in classification skills in terms of gender.

A difference was found between the polygon classification skills of seventh-grade students based on the experience of pre-school education, meaning those who received pre-school education had better skills of classifying polygons. Students of pre-school period generally classify the objects by their colors and shapes first, and by the sizes later. Younger children classify objects by a specific characteristic but they can perform complicated classifications in time. Classification is a period that starts in early periods and forms the basis of transactions and geometric thinking (Aktaş

Arnas, 2009). Accordingly, it is fair to state that pre-school education is important for the development of pre-school classification skills.

A review on seventh-grade students' polygon classification skill scores in terms of maternal education indicated that students whose mothers had higher educational status had higher skill scores. Moreover, another review on seventh-grade students' polygon classification skill scores in terms of paternal education indicated that students whose fathers had higher educational status had higher skill scores. The impact of family on students' development can be seen here, which is also the case for other fields.

A positive, moderate-level relationship was found between seventh-grade students' polygon classification skill scores and weighted scores regarding geometric thinking levels. Students with higher geometric thinking levels were found to be successful in polygon classification skills. According to van Hiele geometric thinking levels, seventh-grade students are expected to be within Level 2 and 3, and to classify the polygons. However, the results of this study indicate that students are below the expected levels in both cases. The geometric thinking levels of van Hiele indicate that classification of polygons based on van Hiele's afore-noted levels indicates Level 3 for students and approximately one-third of the students could reach the Level 3, which may be the reason why other students had difficulties in their skills of classifying the polygons.

Recommendations

Considering the results of this study, the following recommendations are presented to improve students' geometric thinking levels and polygon classification skills.

- The negative models (non-polygonal figures, non-square figures, or non-trapezoid figures…) can be adequately used to teach the geometric figures.
- The prototypes regarding geometric concepts are believed to have arisen from the figures presented in mathematic courses and books. Thus, students can be promoted to draw the geometric figures using materials. With the instruments and materials used within the class activities, students can be introduced to the various forms of geometric concepts.

- Following the early years of pre-school and school periods, the number of activities on classification and relationships between the polygons can be increased.
- Students' geometric thinking levels can be determined, and level classes can be formed to ensure an educational environment suiting students' needs.
- Teaching activities can be organized to ensure a transition from a current level to the higher thinking level, suiting the learning stages of "Van Hiele Theory" (information/inquiry, guided orientation, explication, free orientation and integration) within the teaching activities.
- Qualitative studies can be conducted with fewer students, and the reasons for the results can be examined.

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Conflict of Interest

It has been reported by the authors that there is no conflict of interest.

Funding

No funding was received.

Ethical Standards

We have carried out the research within the framework of the Helsinki Declaration. The participants are volunteers.

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