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Investigation of 4th Grade Students' Geometric Thinking Levels and Success Scores in Terms of Different Variables

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Abstract: The aim of this study is to investigate the 4th grade students' geometric thinking levels and achievement scores in terms of some demographic variables by using the Geometric Thinking Level Test. The data has been collected with 429 elementary school students at 10 elementary schools in Amasya employing the Geometric Thinking Level Test. The collected data has been analyzed by SPSS22 program. Based on analyzing the collected data, it is found that 4th grade students' geometric thinking level is low. Furthermore, participant students' geometric thinking success score has been examined. As a result; even though gender, parents' education level, parents' occupation, and using computer at home are statistically significant, whether or not getting pre-elementary education is not statistically significant on students' geometric thinking success score.

Keywords: Elementary school, student achievement, geometric thinking level, geometric thinking success score.

INTRODUCTION

Geometry studies have improved students' critical thinking and problem solving skills; as a result, contributed to teaching other topics in Math (Baykul, 2005). In this regard, teaching of geometry at elementary education level is more important than other education levels (Develi & Orbay, 2003). Since, at that time, students learn basic concepts such as triangle, square and all these basic concepts are important for teaching more comprehensive concepts in the next years. That is why; the determining of factors that affecting students' geometric success might be beneficial to developing curriculum for elementary education.

One of the well-known studies regarding developing geometric thinking of students has been conducted by Van Hiele and Pierre Marrie Van Hiele (Olkun & Toluk, 2003). According to that, the model of Van Hiele on geometric thinking consists of five hierarchical steps. To be able to be at next step, passing of the previous steps is necessary. All these steps are related to intellectual development. In this context, an elementary school student might be at the same level with a high school student (Van de Walle, 2004). The five steps at van Hiele (1986) theory are following: 1. Visual level, 2. Analysis level, 3. Previous of reasonable deduction level, 4. Reasonable deduction level, and 5. The highest level. What kind of geometric skills people should have at these levels are below (Usiskin, 1982):

Visual Level: Children at this level recognize figures as whole and name them. They start to understand classification of figures.

Analysis Level: Children at this level start to analyze the properties of figures and think all of them together. For instance, instead of thinking just a rectangle, children think all squares.

Previous of Reasonable Deduction Level: At this level, children can build up connection among figures. Children can follow a geometric proof; however, they cannot prove by themselves.

Reasonable Deduction Level: Children at this level can be successful on reasoning process and prove all process steps. Children also understand the relationships of features of figures.

The Highest Level: Children at this level can recommend theories, analyze among systems and compare them.

Turkey has participated in the Trends in International Mathematics and Science Study (TIMSS) in 1999 as the first time. In the first attending, Turkey is 34th country among 38 participant countries on Geometry [the Ministry of National Education (MoNE), 2004]. At the second attending, Turkey is the 30th country among 51 participant countries in the world. Even though the mathematics average of all 51 participant countries is 500, Turkey's score is 432. Also, Turkey's geometric score is 411 (Şişman, Acat, Aypay, & Karadağ, 2011). In a similar vein, Turkey is the 33rd country among 40 participant countries in the Programme for International Student Assessment (PISA), 2003. When all sub-learning dimensions have been examined, it is found that students are less successful on space and figure dimensions (MoNE, 2004). When the literature have been examined, many researcher have found that students face a bunch of difficulties on Geometry learning (Akkaya, 2006; Erdoğan, 2006; Ç. Kılıç, 2003; Öztürk, 2012). One of these difficulties is to try to teach Geometry without concerning of students' geometric thinking levels (Fidan, 2009; İlhan, 2011; Kılıç, 2003; Usiskin, 1982).

In our country, a test has been developed to determine 5th grade students' geometric thinking levels (Fidan, 2009). Moreover, some researchers have used a test which has been developed Usiskin in 1982 and adapted to Turkish by Duatepe in 2000 (Akkaya, 2006; Erdoğan, 2006; Ç. Kılıç, 2003; Öztürk, 2012). In this study, a test has been developed for determining the 4th grade students' Geometric thinking levels in Amasya and employed with these students. When the literature has been scrutinized, there is no any test to determine the 4th grade students' Geometric thinking levels; therefore, this developed test is the first test at this topic. This test has been developed

based on the 4th grade acquisition and focuses on how people think about Geometric concepts and thinking types (Van de Walle, 2004) instead of acquiring what kind of Geometrical concepts.

The aim of this study is to investigate 4th grade students' geometric thinking levels and success scores in terms of some demographic variables by using the Geometric Thinking Level Test which is developed based on the 4th grade Geometry acquisitions on Mathematics. It is thought that middle school Mathematics teachers will both determine the 5th grade students' Geometric thinking levels with this test and reorganize lesson plans according to the levels of students.

Problem Statement

What are the levels of 4th grade students' Geometric thinking levels in Amasya?

Sub-problems

1- Which level of students is on Geometric thinking?

2- Are there any differences on students' Geometric thinking achievement scores according to gender?

3- Are there any differences on students' Geometric thinking achievement scores according to parents' education levels?

4- Are there any differences on students' Geometric thinking achievement scores according to parents' occupations?

5- Are there any differences on students' Geometric thinking achievement scores according to getting pre-elementary education?

6- Are there any differences on students' Geometric thinking achievement scores according to using computer at home?

Participants

This study is a kind of cross-sectional study that has examined 4th grade students' Geometric thinking levels and success scores in terms of some demographic variables.

The population of this study constitutes 4th grade students in center district of Amasya in 2013-2014 academic years. According to the record of the Directorate of National Education of Amasya, there are 18 elementary schools and 1331 students at these schools in 2013-2014 academic years. Krejcie and Morgan (1970) offered a formula for calculating sample size and according to that the sample size of this study should be 297 students. The sample of this study has been randomly selected from different socio-economic levels. The most important feature of randomly sampling method is to provide equal selection chance to the all participants (Cohen, Manion, & Morrison, 2007). This study has been conducted with 429 students in10 elementary school. 225 of the participant students of this study is female (% 52.4) and 204 of the participant students of this study is male (% 47.6).

Data Collection Tools

In order to determine students' Geometric thinking levels, the researchers have developed a scale. In the process of scale development, six steps, which have been offered by Anderson and Arsenault (1998) has been followed. First, Mathematics curriculum of 4th grade has been examined. At this point, the features Van Hiele's levels have been taken into consideration (Usiskin, 1982) and determined the level of markers defined properties. After that, the items of test - which has been developed by Fidan (2009) - have been checked up by considering all acquisitions on Geometry learning area at Elementary Education Curriculum (1-4). 14 items of that test has included to the prepared test. Since, the researchers have thought that all these included items are appropriate for the 4th grade. Also, scales have been arranged in accordance with experts' opinions. By this way, the test has been prepared with 61 questions on the first, second, and third levels. The pilot study has been conducted with 48 female and 57

male students at two elementary schools in city center of Amasya. As a result of analyzing the collected data from pilot study, some items- which item discrimination index is lower than .20- has been deleted from the test. Finally, 16 of 61 items have been emitted from the test and the final version of the test with 45 questions is prepared. Then, the final version of the test has been employed. In this context, it can be said that the scope and validity of test have found as high level.

For the reliability study, the test has been employed with 429 4th grade students. At this test, there are 20 questions on level 1, 15 questions on level 2, and 10 questions on level 3. It is found that corrected item-total correlation changes between 0.20 and 0.50 ranges for the first level; corrected item-total correlation changes between 0.24 and 0.54 ranges for the second level; and corrected item-total correlation changes between 0.20 and 0.46 ranges for the third level.

Table 1. KR-20 Reliability Coefficients of Geometric Thinking Levels

	n	**Number of Item**	**KR-20**
Level 1	429	20	.80
Level 2	429	15	.80
Level 3	429	10	.64
All test	429	45	.91

As can be seen in Table 1, KR-20 reliability coefficients have been found as 0.80 for the first level, as 0.80 for the second level, and as 0.64 for the third level. It has been found as 0.91 for the whole test.

Determining of Geometric Thinking Level and Geometric Achievement Level

At the determining process of students' geometric thinking levels, Usiskin (1982)'s procedure have been revised and used. The researchers have organized the

criteria level of determining because of the differences on question numbers and sample of this study. According to that, the criteria of evaluation have been explained below:

0. level; for a student who is answering not correctly 16 or less out of 20 questions at the first level.

1. level; for a student who is answering correctly more than 16 questions out of 20 questions at the first level.

2. level; for a student who is answering correctly more than 16 questions out of 20 questions at the first level and more than 12 questions out of 15 question at the second level.

3. level; for a student who is answering correctly more than 16 questions out of 20 questions at the first level, more than 12 questions out of 15 question at the second level and more than 8 questions out of 10 questions at the third level.

At the same time, 1 score has been given for each correct answer to be able to make all statistical analysis on Geometric thinking achievement scores. By this given score, the differences on students' Geometric thinking have been tested in terms of some demographic variables.

The Data Collection, Analysis, and Evaluation

The application has lasted around 60 minutes. Five students have been deleted from the study because of not completing at least one of the forms. The collected data has been analyzed by using SPSS 22 program. The frequency and distribution of percentage have been examined for the participant students' Geometric thinking levels. Also, t-test and one-way variance analysis have been run. Before analysis, all assumptions have been addressed and the researchers have come to the conclusion that all of them have met with all assumptions (Ho, 2013). For testing of all hypotheses, 0.05 has been accepted as the highest level of tolerance.

RESULTS

225 of participants (% 52.4) are female and 204 of participants (% 47.6) are male. Furthermore, when the participant students' mothers' education level have been examined, it is understood that 120 of them (% 28.0) have elementary school diploma, 101 of them (% 23.5) have middle school diploma, 133 of them (% 31.0) have high school diploma, and 75 of them (% 17.5) have university diploma. Also, when the participant students' fathers' education level have been examined, it is understood that 52 of them (% 12.1) have elementary school diploma, 86 of them (% 20.0) have middle school diploma, 145 of them (% 33.8) have high school diploma, and 146 of them (% 34.0) have university diploma. When the participant students' mothers' occupation have been examined, 319 of them (% 74.4) is housewife, 28 of them (% 6.5) is worker, 62 of them (% 14.5) is civil servant, and 20 of them (% 4.7) is self-employment. Additionally, when the participant students' fathers' occupation have been examined, 2 of them (% 0.5) is unemployed, 130 of them (% 30.3) is worker, 157 of them (% 36.6) is civil servant, and 140 of them (% 32.6) is self-employment. When the participant students have been examined in terms of whether or not getting pre-elementary education, it is understood that 397 of them (% 92.5) have gotten pre-elementary education; however, 32 of them (% 7.5) have not gotten pre-elementary education. In addition to all, when the participant students have been examined in terms of whether or not using computer at home, it is reached that 317 of them (% 73.9) have used computer at their home; however, 112 of them (% 26.1) have not used computer at their home.

Table 2. Geometric Thinking Levels of Participant Students

Thinking Level	Frequency	Percent
Level 0	226	52.7
Level 1	88	20.5
Level 2	67	15.6
Level 3	48	11.2
Total	429	100.0

As can be seen in Table 2, 226 of the participant students (% 52.7) is at level 0, 88 of them (% 20.5) is at level 1, 67 of them (% 15.6) is at level 2, and 48 of them (% 11.2) is at level 3.

Table 3. Results Related to Geometric Thinking Success by Gender

Gender	Average	Standard Deviation	df	t	p
Female	32.72	8.15	427	2.23	.027*
Male	30.88	9.00			

Note: *p< .05

As can be seen in Table 3, there is a statistically significant differences between female and male students in terms of Geometric thinking achievement. According to that, female students' Geometric thinking achievement is higher that male students' Geometric thinking achievement.

Table 4. The Mean and Standard Deviation of Students' Geometric Thinking Achievement in terms of Mother Education Level

Education Level	Mean	Standard Deviation
Elementary School	30.77	8.34
Middle School	29.37	8.66
High School	32.48	8.66
University	35.77	7.38

As can be seen in Table 4, the average of students'- who mothers' education level is elementary school- Geometric thinking achievement is 30.77 (8.34), the average of students'- who mothers' education level is middle school- Geometric thinking achievement is 29.37 (8.66), the average of students'- who mothers' education level is high school- Geometric thinking achievement is 32.48 (8.66), and the average of students'- who mothers' education level is university- Geometric thinking achievement is 5.77 (7.38). In order to understand whether or not these scores are different according to the participant students' mothers' education level, one way variance has been employed and found that there is a statistically significant differences among students on students' Geometry thinking achievement by mothers' education level. Also, to better understand this difference, Post-Hoc Scheffe test has been run and found that the participant students'- who mothers' education level is university- Geometric thinking achievement is higher than the participant students' – who mothers' education level is elementary school and middle school- Geometric thinking achievement. Besides, the researchers have come to know that the participant students'- who mothers' education level is high school- Geometric thinking achievement is respectively higher than the participant students' – who mothers' education level is middle school- Geometric thinking achievement.

Table 5. The Mean and Standard Deviation of Students' Geometric Thinking Achievement in terms of Father Education Level

Education Level	Mean	Standard Deviation
Elementary School	28.94	7.44
Middle School	29.30	8.40
High School	31.17	8.97
University	35.05	7.75

As can be understood in Table 5, the average of students'- who fathers' education level is elementary school- Geometric thinking achievement is 28.94 (7.44), the average of students'- who fathers' education level is middle school- Geometric thinking achievement is 29.30 (8.40),, the average of students'- who fathers' education level is high school- Geometric thinking achievement is 31.17 (8.97), and the average of students'- who fathers' education level is university- Geometric thinking achievement is 35.05 (7.75). It is found that there is a statistically significant difference among students on students' Geometry thinking achievement by fathers' education level. Furthermore, to better understand this difference, Post-Hoc Scheffe test has been run and found that the participant students'- who fathers' education level is university- Geometric thinking achievement is respectively higher than the participant students' – who fathers' education level is elementary school, middle school, and high school- Geometric thinking achievement.

Table 6. The Mean and Standard Deviation of Students' Geometric Thinking Achievement in terms of Mother Occupation

Mother Occupation	Mean	Standard Deviation
House wife	31.16	8.67
Worker	29.46	8.19
Civil servant	36.15	7.31
Self-employed	32.80	7.96

As can be seen in Table 6, the average of students'- who mothers are housewife- Geometric thinking achievement is 31.16 (8.67), the average of students'- who mothers are worker- Geometric thinking achievement is 29.46 (8.19), the average of students'- who mothers are civil servant- Geometric thinking achievement is 36.15 (7.31), and the average of students'- who mothers are self-employed- Geometric thinking achievement is 32.80 (7.96). It is found that there is statistically significant difference among students on students' Geometry thinking achievement by mothers' occupation. To better understand this difference, Post-Hoc Scheffe test has been used and found that the students'- who mothers are civil servant- Geometric thinking achievement is respectively higher than the students' – who mothers are house wife and worker- Geometric thinking achievement.

Table 7. The Mean and Standard Deviation of Students' Geometric Thinking Achievement in terms of Father Occupation

Father Occupation	Mean	Standard Deviation
Unemployed	28.50	6.36
Worker	29.95	8.56
Civil Servant	34.85	7.34
Self-employed	30.28	9.10

As can be seen in Table 7, the average of students'- who fathers are unemployed- Geometric thinking achievement is 28.50 (6.36), the average of students'- who fathers are worker- Geometric thinking achievement is 29.95 (8.56), the average of students'- who fathers are civil servant- Geometric thinking achievement is 34.85 (7.34), and the average of students'- who fathers are self-employed- Geometric thinking achievement is 30.28 (9.10). It is understood that there is statistically significant difference among students on students' Geometry thinking achievement by fathers' occupation. Moreover, to better understand this difference, Post-HocScheffe test has been employed and found that the students'- who fathers are civil servant- Geometric thinking achievement is

respectively higher than the students' – who fathers are worker and self-employed- Geometric thinking achievement.

Table 8. Results Related to Geometric Thinking Success by Getting Pre-elementary Education

Pre-elementary Education	Mean	Standard Deviation	df	t	p
Yes	31.93	8.58	427	.726	.468
No	30.78	9.10			

As can be seen in Table 8, while the average of students'- who has gotten pre-elementary education- Geometric thinking achievement is 31.93 (8.58), the average of students'- who has not gotten pre-elementary education- Geometric thinking achievement is 30.78 (9.10). According to this finding, it can be said that there is no a statistically significant difference on students' Geometric thinking achievement by getting pre-elementary education.

Table 9. Results Related to Geometric Thinking Success by Using Computer at Home

Computer at home	Average	Standard Deviation	df	t	p
Yes	32.80	8.47	427	3.94	.000**
No	29.13	8.43			

Note: **p< .001

As can be shown in Table 9, while the average of students'- who use computer at home- Geometric thinking achievement is 32.80 (8.47), the average of students'- who do not use computer at home- Geometric thinking achievement is 29.13 (8.43). According to that, it can be stated that there is a statistically significant difference on students' Geometric thinking achievement by using computer at home. It is found that the

students'- who use computer at home- Geometric thinking achievement is respectively higher than the students'- who do not use computer at home- Geometric thinking achievement.

DISCUSSION AND RESULTS

In this current study, the 4th grade students' geometric thinking levels and achievement scores have been investigated in terms of some demographic variables. The researchers have come to know that % 52.7 of the students is at level 0, % 20.5 of them is at level 1, % 15.6 of them is at level 2, and % 11.2 of them is at level 3. These results are consistent with the findings of some studies in the literature. For instance, Carroll (1998) found that the 5th grade students' % 58 is at level 1; Kılıç, Köse, Tanışlı and Özdaş (2007) found that the 5th grade students are level 1 and level 2, Fidan (2009) found that the 5th grade students' % 47.9 is level 0, % 27.3 of them is level 1; Akkaya (2006) found that the 6th grade students are level 1 and level 2; İlhan (2011) found that 8th grade students' Geometric thinking level is mostly level 1 with % 61.75. At the same time, Van de Walle (2004) affirmed that the most students at the 1st, 2nd, and 3rd grades are level 1, the 4th and 5th grade students are level 2, and just some of them is at level 3 in terms of Geometric thinking level.

When the students' Geometric thinking achievement scores have been examined in terms of gender, it is understood that female students' Geometric thinking achievement scores is statistically higher than male students' Geometric thinking achievement scores. This result is coherent with the findings of Linn and Kessel (1996) and Fidan (2009). On the other hand, some researchers found that male students' Geometric thinking achievement scores is higher than female students' Geometric thinking achievement scores (Duatepe, 2000; Halat, 2008; Haviger & Vojkůvková, 2014; Şahin, 2008). Besides, some researchers found that there is no any differences between female and male students on Geometric thinking achievement scores (Artut & Tarim,

2006; Bal, 2012; Hall, Davis, Bolen, & Chia, 1999; İlhan, 2011; Unutkan, 2007). The reason of why female students' Geometric thinking achievement scores are higher than male students' Geometric thinking achievement scores might be that even though girls are entering puberty approximately 10-11 years old, boys are entering their teens 11-12 years old (Kail & Cavanaugh, 2007). That is why, female students might be much better on abstract thought than male students; as a result, they can easily understand Geometric concepts than male students. When considering the age of 4th grade, students are mostly 10 or 11 years old. From this point of view, it can be affirmed that developmental features are the reason of why female students' Geometric thinking score is higher than male students.

When the students' Geometric thinking achievement scores have been examined in terms of parents' education level, the researchers have come to the conclusion that as parents' education level go up, students' Geometric thinking achievement scores rise. When the literature has been searched, there are a bunch of study that have reached same result (Fidan, 2009; Howie & Pietersen, 2001; Özkan & Yıldırım, 2013; Wang, 2004). Previous research revealed that Parental education is not only positively affect psychological characteristics of students (E. Şahin, Barut, & Ersanlı, 2013a, 2013b; E. Şahin, Barut, Ersanlı, & Kumcağız, 2014; E. Şahin, Ersanlı, Kumcağız, Barut, & Ak, 2014) but also academic achievement. As parents' education level go up, there is no hesitation that students will get more support and opportunity. That is why; it can be stated that there is a positive relationship between parents' education level and students' Geometric thinking achievement scores.

In this current study, the effects of parents' occupation on students' Geometric thinking achievement have been also examined. The researchers have come to the conclusion that there is a statistically difference on students' Geometric thinking achievement scores in terms of parents' occupation. According to that the students' – who mother and/or father is civil servant- Geometric thinking achievement score is

higher than the students' – who mother and/or father is housewife, worker, or self-employed- Geometric thinking achievement scores.

The reason of this statistical difference can be thought that because civil servants' education level is higher than other occupations. Since, to be able to be a civil servant in Turkey, people in our country should have some high level education background ((Fidan, 2009). Many studies have found that family support is very important for students' Mathematics achievement (Biçer, Capraro, & Capraro, 2013; Gottfried, Marcoulides, Gottfried, & Oliver, 2009). In this context, parents -who are working as civil servant- understand the importance of necessary of high quality education on getting an occupation. Therefore, they provide more opportunity to their kids such as private lesson. This might positively affect students' Geometric thinking achievement scores.

When the students' Geometric thinking achievement scores have been examined in terms of getting or not pre-elementary education, the researchers have come to the conclusion that there is no a statistically significant difference on students' Geometric thinking achievement by getting pre-elementary education. This result is contrast with the findings of Fidan (2009). This reason of indifference might be that most participant students in this study have gotten pre-elementary education.

When the students' Geometric thinking achievement scores have been examined in terms of using computer at home, the researchers have come to know that there is a statistically significant difference on students' Geometric thinking achievement by using computer at home. This result is consistent with the findings of some researchers in the literature. According to them, using computer positively affects and increases students' Geometric thinking achievement scores (Efendioğlu, 2006; Fidan, 2009; Olkun & Altun, 2003).

This study has some limitations. First, this study has been conducted with the 4th grade students. Hence, the results of this study can be generalized to same groups. Even

though the Geometric Thinking Level Test has been developed based on elementary education curriculum, equivalent scales and contrary scales validity has not been made because of not having a similar test. The sample of this study has been randomly selected and limited students have participated in this study. Thus, the sample should be selected with different sampling methods and included more schools.

RECOMMENDATIONS

In this study, the Geometric Thinking Level Test has been developed and the 4th grade students' geometric thinking achievement scores have been investigated by the researchers. Based on the results of this study, the researchers have some recommendations:

1. The Geometric Thinking Level Test can be used for determining students' Geometric thinking levels. The results of this test can be used for supporting students' Geometry learning.
2. The results of this developed test also can be help teachers to use different teaching methods in Geometry lessons.
3. By using this developed test, students' Geometric thinking level can be determined and according to that teachers can organize their lesson based on students' level.
4. It is understood that gender, parents' education level, parents' occupation, and using computer at home affect students' Geometric thinking level. Therefore, there could be applications such as etudes, homework in-detail, extra study time and so on for students who are low Geometric thinking score.

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