Evaluation of Pre-school Children's Development of Geometric Thought in the UK and Turkey according to Van Hiele Model

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Abstract

This is a study that has applied descriptive survey model. Descriptive survey model is a research approach which aims at describing a past or present phenomenon, an object or a person as realistically as it is. Convenient sampling was applied to specify the study group. Within the scope of the study, 56 pre-school children from Turkey (28) and the UK (28) were reached. A Geometric Shape Form was used by the researchers as an instrument to collect data. In accordance with the focus questions, the children's oral responses and the geometric shapes they drew were analyzed by the researchers. The analysis of data, which included percentages, frequency values and q-square tests, was conducted through SPSS 15 for Windows. The results showed that Turkish and English pre-school children both had similar characteristics in drawing and perceiving geometric shapes, in general. However, in recognizing rectangles and shape-corner perceptions, there was statistically significant difference.

Key words: Pre-school education, Geometry, Van Hiele

INTRODUCTION

In recent years, the interest in teaching Math to pre-school children has gradually increased (Saracho & Spodek, 2009); since mathematical skills are one of the basic ones in pre-school education. As Geometry focuses on concrete objects and shapes, and contributes to learning Mathematics, it is important to start teaching Geometry as early as pre-school ages (Toluk & Olkun, 2001). In order to teach Geometry effectively, it is necessary for experts to know how geometric thinking develops. Consequently, many researchers have been interested in the development of geometric abilities of children in the pre-school period. Van Hiele is one of the most prominent researchers who have conducted research on the development of geometric thinking among children. He tried to observe and understand the difficulties his students underwent while he was a Math teacher (Van Hiele, 1986). As a result of his studies, Van Hiele concluded that students have differentiated levels of geometric thinking, and he designed and developed the Van Hiele's Model that still remains to be influential.

At the end of his research, Van Hiele divided children’s development of geometric thinking in five consequent levels in which children are required to accomplish several assignments. These levels are: visualization, analysis, informal deduction, deduction and rigor. Visualization, which is the first level of geometric thinking development, is observed among pre-school children, and it starts with non-verbal thinking and the shapes are evaluated with their appearance (Van Hiele, 1999). Van Hiele asserts that a child sees a shape as a whole rather than as a sum of its part in the visualization level. It is theoretically stated that children are interested in whether a shape looks like a prototype rather than its characteristics. Hence, they may not perceive a stretched triangle as a triangle since the stretched triangle is very different from the prototypical triangle in their minds. They can recognize squares and rectangles at this level; however, it does not mean that they are aware of the characteristics of these squares and rectangles (Trouthman & Lichtenberg, 1991). At the visualization level, children are not interested in geometric features. For them, it is more essential to observe the physical environment they are in. They are able to comment on the shapes based on these observations. At this level, several activities are recommended for children; these activities include a) the identification, description and categorization of shapes, b) playing with toys that have certain geometric shapes such as seek-and-find, c) matching, drawing, building, inserting, extracting of geometric shapes, d) the comprehension of different angles and sizes of different shapes, e) the differentiation of appearance features related or unrelated with certain shapes, f) the creation of patterns from different shapes, and g) finding real-life examples of geometric shapes (Pesen, 2003). Clements and Sarama (2000) remark that children need guidance to comprehend the characteristics of these shapes such as their colours, sizes and dimensions during these activities.

In parallel, Palha, Dekker, Gravemeijer and Hout-Wolters (2013) point out the significance of geometric shapes and tools in comprehending the geometric concepts, analyzing their structures, and making mathematical deductions. This study, by examining the participant Turkish and English children’s levels of geometric thinking via Van Hiele’s approach, first aims at answering whether there are any similarities and differences between these two groups, and then discussing what the differences are. In this respect, answers to the following research questions are sought:

1. Are there any differences in the levels of drawing geometric shapes between Turkish and English pre-school children?

2. Are there any differences in the levels of distinguishing geometric shapes between Turkish and English pre-school children?

3. Are there any differences in the levels of recognizing the shape-edge relationship between Turkish and English pre-school children?

4. Are there any differences in the levels of recognizing the shape-side relationship between Turkish and English pre-school children?

METHODOLOGY

Research Model

This study follows a descriptive survey model. Descriptive survey model is a research approach which aims at describing a past or present phenomenon as it is. The researcher tries to describe the topic, which may either be an object or a person, as realistically as possible while he or she avoids changing or having an effect on the subject (Karasar, 2002). In descriptive survey model, answers to research question(s) are sought through the analysis of data collected from a number of subjects in a set period of time (Arseven, 2001).

Study Group

Convenient sampling is applied to identify the study groups. In this method of data collection, the researcher chooses the most available subjects (Yıldır m & Şimşek, 2008). Likewise, the researchers of this study chose the nursery schools at their disposal. Within the scope of the study, 56 pre-school children from Turkey (28) and the UK (28) are involved.

Data Collection

The researchers used a ‘geometric shape form’ as the instrument of data collection. The form has five main sections. In the first section, the participant children were asked to draw geometric shapes. In the remaining four sections, they were asked subsequent questions to measure their skills in a) identifying various geometric shapes, b) recognizing the similarities between these shapes, and c) understanding the edges and sides of the geometric shapes. The geometric shapes in Clements, Swaminathan, Hannibal and Sarama (1999) scale were utilized in the design of the geometric shape form. In order to be quantitatively analyzed, the children’s right and wrong answers were scored as +1 or 0 respectively.

Data Analysis

In accordance with the items, the geometric shapes and the responses were analyzed by the researchers. To that end, the collected data was transferred into SPSS 15 for Windows for data analysis. Percentages and frequency values were calculated along with q-square tests.

FINDINGS

Findings regarding the first research problem: Are there any differences in the levels of drawing geometric shapes between Turkish and English pre-school children?

Table 1. Distribution of Turkish and English pre-school children's drawings of geometric shapes

	Triangle	Square	Circle	Rectangle
Turkish	12	24	26	20
English	14	24	26	18
Total	26	48	52	38

As seen in Table 1, Turkish children drew triangles, squares, circles and rectangles correctly with the scores of 12, 24, 26, and 20 respectively. Similarly, the number of the English children who correctly drew triangles was 14, squares 24, circles 26, and rectangles 18. The table shows that as the English and Turkish children drew square and circle in the same percentage, English children drew more correct triangle than Turkish children did, and the number of drawing rectangle correctly for Turkish children is higher than English children's.

Table 2. The results of the t-test regarding the drawing scores of Turkish and English pre-school children

Geometric shape	Country	N	$\bar{x}$	S	Sd	t	P
Triangle	Turkish	28	.57	.50	54	1.61	.11
	English	28	.35	.48			
Square	Turkish	28	.85	.35	54	.00	1
	English	28	.85	.35			
Circle	Turkish	28	.92	.26	54	.00	1
	English	28	.92	.26			
Rectangle	Turkish	28	.71	.46	54	.56	.57
	English	28	.64	.48			

As Table 2 indicates no statistically significant difference was found between the Turkish and English pre-school children in the drawings of triangles, squares, circles and rectangles ($p>0.05$).

Findings regarding the second research problem: Are there any differences in the levels of distinguishing geometric shapes between Turkish and English pre-school children?

Table 3. The distribution of Turkish and English pre-school children’s identification levels of geometric shapes

	Triangle	Square	Circle	Rectangle
Turkish	14	22	26	12
English	16	22	24	19
Total	30	44	50	38

As seen in Table 3, Turkish children identified triangles, squares, circles and rectangles correctly with the scores of 14, 22, 26, and 12 respectively. Similarly, the number of the English children who correctly identified triangles was 16, squares, 22; circles, 24 and rectangles, 19.

Table 4. The results of the t-test regarding the identification of geometric shapes among Turkish and English pre-school children

Geometric shape	Country	N	$\bar{x}$	S	Sd	t	P
Triangle	**Turkish**	28	.64	.48	54	1.61	.11
	English	28	.42	.50			
Square	**Turkish**	28	.92	.92	54	1.53	.13
	English	28	.78	.78			
Circle	**Turkish**	28	.71	.46	54	1.9	.57
	English	28	.64	.48			
Rectangle	**Turkish**	28	.42	.50	54	.56	.05*
	English	28	.67	.47			

*p<0.05

As seen in Table 4, there was no statistically significant difference between Turkish and English pre-school children in their identification of triangles, squares and circles (p>0.05). However, statistical significance was found in between when the identification of rectangles was concerned (p<0.05).

Findings regarding the third research problem: Are there any differences in the levels of recognizing the shape-edge relationship between Turkish and English pre-school children?

Table 5. The distribution of Turkish and English pre-school children's perception levels of shape-edge relationship

Country	Triangle	Square	Circle	Rectangle
Turkish	12	14	4	16
English	16	20	4	20
Total	28	34	8	36

When Table 5 is examined, it is seen that the number of Turkish children who correctly responded to the shape-edge relationship question for triangles was 12; squares, 14; circles, 4 and rectangles, 16. However, among the English children the numbers were 16, 20, 4, and 20 for triangles, squares, circles and rectangles respectively. It can be seen that English children's perception levels of shape-edge relationship is higher for triangles, squares and rectangles than Turkish children's, and there is a similarity in the shape-edge perception levels of circles.

Table 6. The results of the t-test regarding the geometric shape-edge relationship scores of Turkish and English pre-school children

Geometric shape	Country	N	$\bar{x}$	S	Sd	t	P
Triangle	Turkish	28	.46	.50	54	.79	.43
	English	28	.57	.50			
Square	Turkish	28	.50	.50	54	1.6	.10
	English	28	.71	.46			
Circle	Turkish	28	.14	.35	54	.00	1
	English	28	.14	.35			
Rectangle	Turkish	28	.57	.50	54	1.4	.16
	English	28	.75	.44			

As seen in Table 6, there was no statistically significant difference between the scores of shape-edge relationships for all of the four geometric shapes ($p>0.05$).

Table 7. The distribution of Turkish and English pre-school children's perception levels of shape-side relationship

	Triangle	**Square**	**Circle**	**Rectangle**
Turkish	24	15	8	12
English	20	18	6	19
Total	44	33	14	31

As shown in Table 7, it is seen that the number of Turkish children who correctly knew the shape-side relationship in triangles was 24; squares, 15; circles, 8 and rectangles, 12. The number of the English children who correctly answered the shape-side relationship in triangles was 20; squares, 18; circles, 6 and rectangles, 19.

Table 8. The results of the t-test regarding the geometric shape-side relationship scores of Turkish and English pre-school children

Geometric shape	Country	N	$\bar{x}$	S	Sd	t	P
Triangle	Turkish	28	.85	.35	54	1.2	.19
	English	28	.71	.46			
Square	Turkish	28	.53	.50	54	.80	.42
	English	28	.64	.48			
Circle	Turkish	28	.28	.46	54	.60	.54
	English	28	.21	.41			
Rectangle	Turkish	28	.42	.50	54	2.21	.03*
	English	28	.71	.46			

*p<0.05

As seen in Table 8, the difference between Turkish and English pre-school children in their identification of triangles, squares and circles was not statistically significant (p>0.05). However, there was statistical significance between the two groups when the scores of shape-side relationship in rectangles was concerned (p<0.05).

DISCUSSION AND CONCLUSION

When the findings of the first section of the research study is closely examined, it is seen that Turkish children can draw the geometric shapes with the scores 12, 24, 26 and 20 for triangles, squares, circles and rectangles respectively. The English children's scores are quite similar to that of Turkish children with 14, 24, 26 and 18 for the given geometric shapes. However, the statistical analysis of these scores reveals no statistical difference between the two groups.

As for the second section of the study, among the Turkish children, the number of those who can identify triangles is 14, squares 22, circles 26 and rectangles 12. For the English children, the scores are 16, 22, 24 and 19 for the triangles, squares, circles and rectangles. For the identification of three geometric shapes except rectangles, there is no statistical difference.

When the overall results of the research study are compared, it is obvious that both the Turkish and English children particularly have difficulty in drawing and recognizing triangles. In general, the participant children have a tendency in accepting the distracting triangles as well as the atypical ones as triangles. The relevant literature reveals similar findings. Clements and Sarama (2000) state that pre-school children are less successful in identifying triangles compared to other geometric shapes. It is also known that children do not accept folded, upside-down or stretched triangular shapes as triangles. A majority of pre-school children have expressed opinions that they think all triangles need a vertex, and they say they made mistakes in identifying triangles whose vertex is moved to one side (Clements, Swaminathan, Hannibal, and Sarama, 1999). According to Kesicioğlu, Alisinanoğlu and Tuncer's (2011) study, which they conducted with 123 children, only 63% of the children can identify triangles correctly. Furthermore, Aslan (2004) specify that kurtosis is an important element for children to identify triangles with similar shapes, and when the kurtosis of the triangles is changed, the rate of giving correct answers fall significantly. In order these errors to be corrected, Van Hiele (1999) asserts that the concepts provided to children need to be multiplied. The participant children of this study show similar characteristics with the depiction of children in the visualization level in Van Hiele's model. The children who are at this level do not recognize the upside-down triangles as triangles. They can classify the shapes only according to their basic appearances (Y lmaz, Turgut, Alyeşil & Kabakçı 2008). In the light of these explanations, it can be assumed that the findings of this study confirm the relevant literature.

When the participant children's comprehension levels of shape-edge relationship is concerned, the number of correct answers among Turkish children for triangles is 12; squares, 14; circles, 4 and rectangles, 16. For the English children, the scores are: 16 for triangles, 20 for squares, 4 for circles and 20 for rectangles. However, there is no statistical difference between the two groups.

For the participant children's comprehension levels of shape-side relationship, the number of the Turkish children who could correctly answer the question is 24 for triangles; 15, 8 and 12 for squares, circles and rectangles respectively. Among the English, the numbers were 20 for triangles, 18 for squares, 6 for circles, and 19 for rectangles. These findings, however, show no statistical difference, either. However, shape-side relationship scores for rectangles were statistically different between the two groups.

When the literature is reviewed, the findings of the research confirm Van Hiele's model. According to this model, in the visualization level, children are able to differentiate triangles from squares but when they identify a square, children focus only on its shape but not on the angle-edge relationship. At this level, children acquire the basic knowledge to classify the shapes (Y lmaz, Turgut, Alyeşil & Kabakçı 2008). Trouthman and Lichtenberg (1991) postulate that the fact that children are able to make a distinction in between squares and rectangles does not mean that they are aware of the characteristics of quadrangles. In other words, they claim that children, at this level, know what a triangle or a square is but they do not know why they are squares or triangles. On the other hand, the findings of Satlow and Newcombe's (1998) research study reveal the fact that age is an important factor in determining the children's development of geometric thinking among pre-school children. Since the scope of this study includes the pre-school period and encapsulates 3-6 year-olds, several differences in this study are in alignment with Satlow and Newcombe's (1998) study.

REFERENCES

Arseven, A. D. (2001). *Alan araştırma yöntemi*. Ankara: Gündüz Eğitim Yayıncılık

Aslan D, Aktaş Arnas. Y.,.(2007). Okul öncesi eğitim materyallerinde geometrik şekillerin sunuluşuna ilişkin içerik analizi. *Çukurova Üniversitesi Sosyal Bilimler Enstitüsü Dergisi*. 16 (1):69-80.

Clements, D.H. Swaminathan, S., Hannibal, M.A., Sarama, J. (1999). Young children's concepts of shape. *Journal for Research in Mathematics Education*. 30 (2), 192- 212.

Clements, D.H., Sarama, J. (2000). Young children's ideas about geometric shapes. *Teaching Children Mathematics*, 6(8): 482-488.

Karasar, N. (1999). *Bilimsel araştırma yöntemi* (9. Baskı). Nobel Yayınlar , Ankara.

Kesicioğlu, O.S., Alisinanoğlu, F., Tuncer, A.T. (2011). Okul öncesi dönem çocuklar n geometrik şekilleri tanıma düzeylerinin incelenmesi. *İlköğretim Online***.** 10(3):1093- 1111.

Palha, S., Dekker, R., Gravemeijer, K., & van Hout-Wolters, B. (2013). Developing shift problems to foster geometrical proof and understanding. *The Journal of Mathematical Behavior*, *32*(2), 142-159.

Pesen, C. (2003). *Eğitim fakülteleri ve sınıf öğretmenleri için matematik öğretimi*. Ankara: Nobel Yayın Dağıtım.

Saracho, O. N., & Spodek, B. (2009). Educating the young mathematician: The twentieth century and beyond. *Early Childhood Education Journal*, *36*(4), 305-312.

Satlow, E., & Newcombe, N. (1998). When is a triangle not a triangle? Young children's developing concepts of geometric shape. *Cognitive Development*,*13*(4), 547-559.

Trouthman, A.P., Lichtenberg,K.B.(1991). *Mathematics a good beginning trategies for teaching children fourth edition*. California: Brooks/Cole Pub.

Toluk, Z. ve Olkun, S. (2001). *İlköğretimde matematik öğretimi*. Ankara: Artım Yayınla ı

Yıldırım, A., Şimşek, H. (2006). *Sosyal bilimlerde nitel araştırma yöntemleri*. Ankara: Seçkin Yay nevi.

Yılmaz, S., Turgut, M., Alyeşil KabakçI, D. (2008). Ortaöğretim öğrencilerinin geometrik düşünme düzeylerinin incelenmesi: Erdek ve Buca örneği. *Üniversite ve Toplum*

Dergisi.http://www.universite-toplum.org/text.php3?id=354 adresinden 22.11.2009tarihinde alınmıştır.

Van Hiele, P. M. (1986). (1986). *Structure and insight. A theory of mathematics education***.** Orlando, Florida. Academic Pres. U.S.A.

Van Hiele, P. (1999). Developing geometric thinking through activities that begin with play. *Teaching Children Mathematics*. February 01, 5(6), 310-316.