International Journal of Progressive Education, Volume 15 Number 3, 2019

Children's Geometric Understanding through Digital Activities: The Case of Basic Geometric Shapes

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Abstract

Early mathematics education bases a foundation of academic success in mathematics for higher grades. Studies show that introducing mathematical contents in preschool level is a strong predictor of success in mathematics for children during their progress in other school levels. Digital technologies can support children's learning mathematical concepts by means of the exploration and the manipulation of concrete representations. Therefore, digital activities provide opportunities for children to engage with experimental mathematics. In this study, the effects of digital learning tools on learning about geometric shapes in early childhood education were investigated. Hence, this study aimed to investigate children progresses on digital learning activities in terms of recognition and discrimination of basic geometric shapes. Participants of the study were six children from a kindergarten in Kırşehir, Turkey. Six digital learning activities were engaged by children with tablets about four weeks in learning settings. Task-based interview sessions were handled in this study. Results of this study show that these series of activities helped children to achieve higher cognitive levels. They improved their understanding through digital activities.

Keywords: Digital Learning Activities, Early Childhood Education, Basic Geometric Shape, Geometry Education

DOI: 10.29329/ijpe.2019.193.8

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INTRODUCTION

Mathematics has an important place in educational curricula through kindergarten to college levels (National Council of Teachers of Mathematics [NCTM], 2000). Learning mathematics is considered as subject specific for elementary, secondary and college levels of education while it is taken into consideration as a cognitive skill for kindergarten in Turkey (Ministry of National Education [MoNE], 2013, 2018). Therefore, it was aimed to gain cognitive skills and intuitions about mathematical contents by combining with skills related other areas as science, literacy or social science, for preschool, rather than posing it as separate subject area as in higher school (MoNE, 2013). They have education as more concrete and in a multidisciplinary way in Turkey. The early childhood education curriculum in Turkey underlines the importance of integrated activities in learning phases. Furthermore, it is strongly advised that all activities should be play-based since it is stated that play based learning is one of the most efficient ways of learning for children in preschool (MoNE, 2013). Therefore, the curriculum offers activities which are child-centered, hands-on and engaging.

Digital devices have quickly become the tools of the culture at home and school (Rideout, 2013). Therefore, investigation of digital technology use in early childhood education has become a necessity as there is a dramatic increase in the interaction of children with the technology (Eryaman, 2007; Blackwell, Lauricella, & Wartella, 2014). Some educators have conducted research to integrate digital technologies into early childhood education and utilize from them for learning of preschool children (Baroody, Eiland & Thompson, 2009). Researchers seek to answer how children best benefit from digital technologies as there are some concerns about children's use of digital technologies such as developmental issues (American Academy of Pediatrics, 2016). Accordingly, this study focuses on children's learning geometric shapes through digital activities. It is aimed to investigate how children improve their understanding of geometric shapes via digital activities.

Early Mathematics Education

Early mathematics education could provide the foundation for later academic success in higher levels of education. Studies show that introducing mathematical contents in preschool is beneficial for children during their progress-in other school levels (Gormley, 2007; Ludwig & Phillips, 2007). Children encounter with situations related mathematical contents as an informal ways through their first steps to school life, such as directions for spatial intuitions like up and down, quantities like more or less, geometrical information like shape, size, location and so on. This type of getting mathematical information in life situations is defined as everyday mathematics (Ginsburg, Lee & Boyd, 2008). These informal ways learning is different between individuals. Thus, children begin their school life with individual differences in terms of informal mathematics since they had different experiences for everyday mathematics. Therefore, their readiness for learning formal mathematics are affected from these individual differences. Everyday mathematics is an inevitable concept for learning mathematics as an informal way. This informal way of gaining skills for doing mathematics is a foundation of learning formal mathematics (Baroody & Ginsburg, 1986).

Children prior experiences with the geometrical concept embody the concept image (Vinner & Hershkowitz, 1980). In other words, since they have informal experiences of geometric figures before kindergarten, and these informal experiences give a basis for learning basic geometric shapes (Clements & Battista, 1992). According to van Hiele geometric thinking theory, in the kindergarten, children may know and recognize some geometric shapes by their names via their experiences with and manipulation of them (Clements & Battista, 1992). However, this recognition mostly consists of the prototype images. Many students have problems in recognizing different geometrical shapes in non-standard orientation, for example, a square is not a square if its base is not horizontal (Mayberry, 1983; Clements & Battista, 1992) since they classify geometric figures with visual information.

Studies emphasized unfavorable effects of the prototype image in identifying and recognizing a geometric shape (Clements, 2002). According to studies children focus on the resemblance of figures and form a concept about these figures from similarity with their prototype images (Fischbein, 1993; Hershkowitz, 1993; Tall & Vinner, 1981). They form some concept families in regarding with their central member of the prototype images. These central members generally consist basic representation of a geometric shape such as a figure resemble equilateral or isosceles triangle for triangle family, a rectangle with a base horizontal to a plane, a trapezoid having the larger bottom base, etc. (Hansen, Drews, Dudgeon, Lawton, & Surtees, 2005). These type of lack of knowledge about geometric figures could lead children difficulties in learning and understanding basic geometric concepts and solving problems about them (Clements, Swaminathan, Hannibal & Sarama, 1999). Providing children activities rich with multiple representations of concepts and opportunities for investigating relationships between these representations could be helpful to overcome prototype images and extend concept image families with different orientation of geometric figures (Clements & Battista, 1992; Mooney, Briggs, Hansen, McCullouch, & Fletcher, 2014). With the help of the digital learning tools, children could have the opportunity of investigating different and numerous multiple representations in the instructional phase.

Digital Activities in Early Mathematics Education

Digital technologies can facilitate access to mathematical concepts by means of the exploration and the manipulation of concrete representations. Therefore, they can provide opportunities for children to engage with experimental mathematics by giving them an understanding of and practice in mathematics (Bottino & Kynigos, 2009). Many researchers have focused on the effect of digital technologies on children's learning of mathematical concepts, including on quantity and the position of objects (Çankaya, 2012), numbers (Alabay, 2006; Baroody, Eiland & Thompson, 2009; Obersteiner, Reiss & Ufer, 2013), geometric shapes (Kesicioğlu, 2011), and problem solving (Fessakis, Goul & Mavroudi, 2013). These research projects were either experimental or quasi-experimental studies and reported the positive effects of digital technology use on early mathematics education. Kesicioğlu (2011) investigated in detail the effect of computer-assisted instruction on young children's learning of geometric shapes (the triangle, circle, square, rectangle) in a pretest-posttest control group design study. The researcher reported a significantly positive effect of computer use in the learning of geometric shapes.

In parallel with innovations in technology, the effect of new forms of technology on children's cognitive learning has become an area of interest for researchers. The researchers emphasized the support role of the teacher during the implementation and the specific role of the digital technology in supporting young children's learning (Fletcher, 2015; Hsiao & Chen, 2016; Ng & Sinclair, 2015). As with other tools, the role of the teacher is key to the enhancement of digital learning materials, in particular with regard to the capacity to understand the classroom situation, make decisions and possibly modify the initial plan during the process, select appropriate examples and orchestrate a discussion in order to allow students' insights and shifts in their personal perspectives to emerge (Biza, 2011). Therefore, the teachers' decisions to use and about how to implement digital learning materials are important. NAEYC (2012) underlines that the appropriate use of technology is related to the age, developmental level, needs, interests, linguistic background, and abilities of children. Students' perspectives, their capacity and knowledge of how to use technology are important while making these decisions.

In preschool settings, mathematics can be understood through concrete materials, hands-on activities, paper-pencil activities and stories. Digital technologies can give visually rich opportunities in early childhood mathematics. It can provide challenging activities for exploration and discovery (Hatzigianni & Margetts, 2012), and enhance student achievement by helping students in developing a strategy and improving mathematical understanding (Clements, 2002; Wu, Choiu, Kao, Hu & Huang, 2012). Hence, this research focuses on the use of digital learning materials in children's learning of basic geometric shapes. The purpose of this case study was to investigate possible contributions of digital activities to the understanding of children. Therefore, in parallel with the purpose, this study seeks an answer to "How children's understanding of geometric shapes are improved through tablet-based digital activities?". In this research, the basic geometric shapes are defined as the circle, square, rectangle and triangle with regarding current Turkish kindergarten curriculum (MoNE, 2013).

METHODOLOGY

This study was designed considering qualitative research methodologies since for the purpose of answering the research question, it was necessary to gain in-depth knowledge about children learning and to find out how the children interacted with digital learning activities. Qualitative methodologies of inquiry are powerful and useful tools for enhancing one's understanding of teaching and learning processes (Creswell, 2007).

Participants

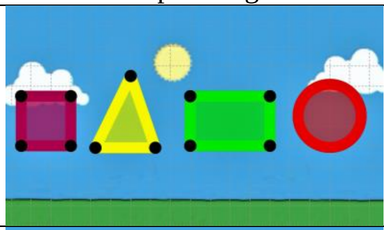
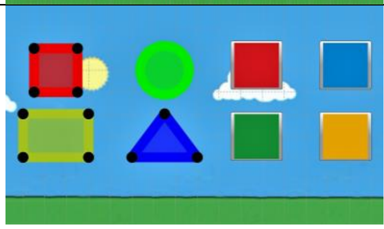
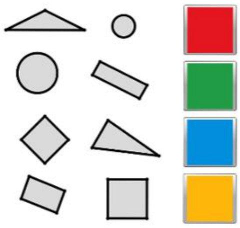
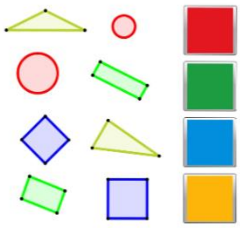
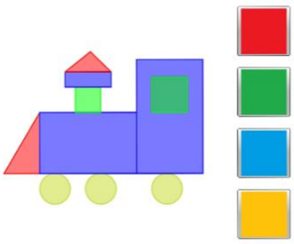
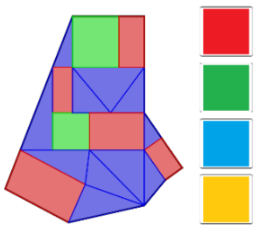
Participants of this study were six children in a kindergarten. The kindergarten in which this study was conducted was located in an outer district of Kırşehir, Turkey. The class was selected for convenience since we had a limited number of tablets and this class included only six children. In addition, the classroom itself fitted the requirements of this study, having a separate room in which the children could be interviewed and interactive whiteboard in order to present required information about tablets and digital activities. These participants of the study were six five-year-old children. One of the children was female and five were male. All children had low economic status, however, they had experiences of using tablets and mobile phones. In data analysis, pseudonyms were used to ensure the confidentiality of the participants.

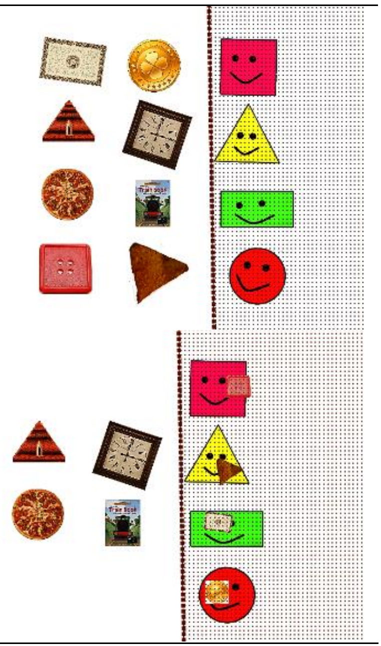
Procedure

In Turkey, early childhood curriculum includes geometry contents as a process of cognitive development (MoNE, 2013). Three objectives were considered for this study from this curriculum. These objectives were; (i) identifying names of geometric figures, (ii) recognizing basic properties of geometric figures, and (iii) matching geometric figures with real objects. The regarded geometric figures in this research were square, rectangle, triangle and circle.

In this study, researchers were designed and developed six activities for these objectives. These activities were included basic information and describing tasks, painting tasks, and matching tasks about geometric figures with real objects. The learning activities in this study were designed to allow children to achieve these objectives in a technology-supported learning environment. In designing processes, Geogebra, which is a dynamic geometry software, was used as the tool for design the tasks since this dynamic geometry software supports analytic and logical functions in mathematics so that allows a mathematician program and design a learning task with mathematical knowledge in a dynamic environment. Therefore, researchers designed and developed these digital learning tasks without using any programming language except their knowledge about mathematics. These learning activities were designed as edutainment activities for children. For this reason, these activities included multimedia items such as audio, colourful shapes and animations. These activities were checked by three experts; one of them had a doctoral degree from the field of mathematics education, other one had a doctoral degree from early childhood education and the last one had a doctoral degree from instructional technologies, in order to provide appropriate learning tasks for intended curriculum and children's level. These activities were designed to be very basic for usage so on any individual could use these learning tasks without any technical knowledge. These digital activities were described in Table 1, briefly. The children were thus able to use the tablets and carry out the activities with little support required. The study was carried in a kindergarten and lasted about four weeks. The six children participating carried out digital activities on tablet computers.

Table 1. Description of digital learning activities

Content	Description	Sample images
1. Basic information about geometric figures	There were four geometric figures – a square, a triangle, a rectangle and a circle. When children touched one of these shapes an audio file played and described the shape in the first-person voice.	
2. Coloring basic geometric figures	Children were asked to color in one of these figures and try to explain the basic properties of that figure, in this activity. In this activity, firstly, children were asked to find a figure, define its some basic properties and color it in any color that they want.	
3. Coloring in groups of basic geometric figures	In this activity, geometric figures in different orientations were given to children in order to engage them in learning task to generalize their definitions about these figures to figures with unusual positions, such as slightly rotated triangle, square in traditional representation of a rhombus, etc. In the process of learning, children were asked to color in similar shapes with the same color and to say the names of these figures by explaining similarities of them.	 
4. Coloring in a group of basic geometric shapes which formed a locomotive	Students were asked to color in similar figures with the same color and to say the name of these figures by explaining why they were similar. There are some figures over another and in different sizes.	
5. Coloring a group of geometric figures in a complex figure	There were some complex figures like rectangles which were formed using triangles and multiple representation of figures in different orientations. Children were asked to color in similar figures with the same color and to say the names of these figures with explaining why they were similar.	

6. Matching representatives of real objects with the geometric figures	There were eight pictures of different real objects. These were a rug, a coin, a gable, a clock, a pizza, a book, a button and a corn chip. The main purpose of this task was to match these pictures with the four geometric figures according to their views. In the activity process, children allowed to drag and drop these pictures onto the geometric figures. If a child dragged one of these pictures correctly, the picture correctly took its place on its resembling one at the right of the screen and if he failed to drag correctly, this picture was refused and would return to its original places.	

These developed activities were handled by the children in this study by tablet computers in learning processes. The children did not have any difficulties while using tablet computer with these activities. Hence, these activities were in successful to be appropriate to targeted children's level of understanding and also they were easy to use by these children.

Data Collection and Analysis

Qualitative data collection procedures were used in the study. Observational notes, video recordings, and task-based interviews were employed to collect data during the study. Two documentary cameras were used to record the children's interaction with their tablets. A video camera was also used to record children's behaviour and speech during the activities. The task-based interviews were handled by teacher through digital activities to understand children's actions within the activities.

These audial and visual data transcribed into verbatim and analyzed through content analysis regarding themes, categories and codes derived from Marzano and Kendall's Taxonomy (Marzano & Kendall, 2007). The taxonomy has six levels for the mental processes; retrieval, comprehension, analysis, knowledge utilization, metacognitive system and self-system. The categories of each level were considered as iterative as stated by Marzano and Kendall (2007). The considered objectives for this study from early childhood curriculum in Turkey are at very basic level of cognitive development. Therefore, children's progress was supposed to occur from within the first to the second level of mental processes. Correspondingly, first two levels of the taxonomy were considered for this study in order to serve as themes for data analysis procedure (Table 2). For this study, the recognize, recall and integrate sublevels were focused on since children were not expected to demonstrate, draw or symbolize geometrical shapes during the activities. Therefore, executing and symbolizing categories were excluded from the coding procedure of the study. In addition,

Table 2. The taxonomy's first two levels as a codebook for data analysis

Themes	Categories	Codes
Retrieval	Recognize	Recognize, select, identify (from a list)
	Recall	Name, list, describe, state
	Executing	Demonstrate, show, make, draft
Comprehension	Integrating	Summarize, describe the key parts, describe how or why, describe the effects, paraphrase, describe the effects
	Symbolizing	Use models, symbolize, represent, draw, diagram, chart, depict, illustrate

The data were separately coded by the researchers. Then, the coded data were merged on by agreements in discussion sessions. To ensure reliability of the analysis, Miles and Huberman's (1994) formula was used to determine interrater reliability which was calculated as .94. Therefore, the reliability level of the analysis was considered as acceptable (Creswell, 2007).

RESULTS

Children's progresses on digital activities related to geometric shapes in kindergarten were coded in terms of two main themes regarding levels of Marzano and Kendall's (2007) Taxonomy. Thus, children's understanding processes via digital activities were reported in terms of retrieval and comprehension procedures. Table 3 presents a general outline of the children's progress during the activities.

Table 3. Summary of children's progresses with digital activities (F: Failure; R: Recognize; RC: Recall; I: Integrating)

Child	Activity 1	Activity 2	Activity 3	Activity 4	Activity 5	Activity 6
A..	R	RC	I	I	I	I
B..	R	RC	RC	RC	I	I
C..	R	RC	RC	I	I	I
D..	R	RC	RC	RC	I	I
E..	R	RC	RC	RC	I	I
F..	F	RC	RC	RC	RC	I

This table gives a piece quick summary information about the results of the study. As seen on the table, students had basic preliminary knowledge about geometric figures at the beginning of the study and all of them achieved to reach integration sublevel of the comprehension cognitive level of the Marzano and Kendall's (2007) Taxonomy.

Retrieval Procedures through Digital Activities

Children's understanding processes related to recognizing information or recalling of it when asked but without understanding their rationale, were briefly described in this part. Children's understanding processes were extracted through their works on digital activities.

First of all, Child A (pseudonym), successfully pointed square, rectangle, triangle and circle when names of them asked to her in the task-based interview session for the first activity, so that her works for this activity had clues for recognizing names of these geometric shapes. She also repeated the basic description of these shapes after she touched on shapes and listened descriptions of them in this activity. However, she could not point all geometric shapes while asking with descriptions not only with names. For instance, she could point circle while asking her "which one of these shapes has no corner", but she could not give any response for other shapes. Since her actions were only limited to pointing all shapes with their names and pointing circle with its description, her actions were noted on recognizing sublevel. In the second activity, she identified the geometric shapes by their names and correctly colored these shapes without any distractions. Moreover, she also correctly discriminated some of these shapes by asked properties such as corners or sides. However, she confused to determine and discriminate rectangle and square from each other while asking "which shape has four equal sides". She could not give any answer and stated "this one triangle has three sides, this (circle) has no side and these (rectangle and square) have four sides and they are rectangle". In fact, from a mathematical point of view, the child was correct since a square is also a rectangle. In this situation, this child could not give any explanation about differences among a square and a rectangle. This situation was overcome with scaffolding student in order to understand that these both shapes had four sides, but their difference was about the length of these sides. Hence, her works in the second activity showed clues about the recall category.

Child B (pseudonym) failed to recognize the square while asking to find square by its name, but he could find and showed the rectangle, triangle and circle, in the first activity. Additionally, he tried to describe the triangle by counting corners with his fingers. Since his works in this activity included pointing some shapes except square by their names and realizing one basic property of triangle, he was considered to be at the recognition sublevel for the first activity. In the second, third and fourth activities, he again had some difficulties to identify square either by name or from its basic properties. It was discovered that this child also confused to discriminate rectangle and square similar to child A. This situation was tried to be eliminated by giving some example shapes in order to show similarities and differences between two shapes. After this scaffolding process, he could find all geometric shapes including rectangle and square while asking their basic properties about the number of sides or corners and by their names. After completing the first four activities, however, he cannot describe these geometric shapes with his own terms, yet. Therefore, his works limited to give clues for the recall category in these activities.

Child C (pseudonym) found geometric shapes but the circle with asking by their names, in the first activity. Moreover, he could realize some basic properties of the rectangle and triangle by counting corners or sides with fingers. Therefore, he can be considered at the recognition sublevel. At the second and third activities, he could identify and point the square, triangle and circle by their names and properties, but he became confused when he was asked "which shapes had four sides". He pointed and colored in only the square after this question. After this action with a little support, he was able to point the rectangle as having four sides, also. Hence, Child C was considered to be in the recall category for these activities.

Child D and Child E (pseudonyms) followed similar progress throughout the study. In the first activity, they could find all geometric shapes by their names. Therefore, their works were scored at the recognition level. In the second activity, Child D and Child E confused to discriminate square and rectangle by asking to find four-sided shapes, similar to other children. They could point out either square or rectangle separately after this question. With some minor assistance from the teacher, they did work out how to identify the square and rectangle. At the third activity, they found and matched the basic geometric shapes while asking their names and descriptions. However, they could not describe these shapes by their own terminology, yet. Their works in the fourth activity showed that they still suffered to differentiate the square and rectangle. Moreover, Child C had difficulties to find triangles if it was given in different orientation than the usual triangle demonstration. They still need some helps to differentiate some shapes. However, they could define other basic geometric shapes with their own terminology at this activity. Therefore, they considered at the recall category according to their works in these activities.

Child F failed to point out and name the rectangle and triangle but could indicate which shape was square or circular, at the beginning of the study. Therefore, he failed to accomplish recognition sublevel for the first activity. In the second and third activities, Child F needed help to identify and colour in the circle after the question: "Is there a shape that has no corners?" However, he identified and coloured in the other shapes correctly. At the fourth activity, he confused to differentiate rectangle and square. He found and coloured both squares and rectangles when they were asked to colour only the rectangles. He had difficulty in differentiating squares and rectangles in the fifth activity, too. When he was asked to paint rectangles, he also painted squares. Thus, F could also be considered to be in the recall category for these activities.

Comprehension Procedures through Digital Activities

Children's understanding ways related to the second cognitive level of the New Taxonomy were explained in this part. According to objectives and designed activities, only integrating sublevel, which "involves identifying and articulating the critical or essential elements of knowledge" (Marzano & Kendall, 2007, p.43), was focused while describing evidences.

Child A was the first one who reached comprehension level. At the third activity, Child A successfully matched geometric shapes and described their properties in her own words without any mistake. Therefore, she was considered to proceed integrating sublevel of the New Taxonomy. Similarly, she was also complete all tasks in the fourth activity. Her works in the fourth activity showed that she could use some descriptions of the shapes while working on them. In other words, she could determine and discriminate shapes correctly even the shapes were given in different orientations by using their properties. Therefore, these works strengthened clues about being at integrating sublevel. In the last two activities, she could name all parts of the given shape in terms of known geometric shapes and she also defined these shapes with her own terms. Therefore, it can be said that Child A was able to reach integrating category at the end of the study, according to her works which pointed out some descriptions of integrating sublevel.

Child B was not successful in defining geometric shapes with his own terms in the fourth activity. However, in that activity, he achieved the goal of the activity by scaffolding. After the fourth activity, he started to recognize and discriminate square and rectangle without any help. For example, at the last two activities, he was able to identify, and paint asked all shapes either by names or basic properties. Moreover, he also defined these shapes with his own words by giving some basic properties of them, i.e. "square has four similar length sides and four corners", etc. Hence, Child B was able to achieve integrating category at the end of the study.

Child C was successful to identify and point the square, triangle and circle but the rectangle in the third activity. At the following activities, he was able to use some descriptions of the basic geometric shapes and recognize shapes at any direction and orientation by simply following their properties. Moreover, at the last activity, he could dissemble the given shape into parts in terms of known basic geometric shapes. Finally, he was considered as his works which showed clues for integrating category.

Although Child D and Child E had difficulty in differentiating square and rectangle in the first four activities, they started to differentiate all the geometric shapes correctly and also define all these shapes in their own terminology at the last two activities. Hence, they found and define geometric shapes even if they were given in different orientations and locations. They started to use descriptions of the shapes while working on them. Therefore, at last, they achieved integrating category.

Child F was unsuccessful in differentiating rectangle and square in the fifth activity. The teacher scaffolded him to discriminate those shapes. Then, during the sixth activity, he could define and discriminate all the shapes including rectangle and square without any mistakes along with other shapes. Hence, his works showed that he could use descriptions of the shapes and define them with his own terminology. Therefore, according to these clues in his works in the last activity, he could achieve the integrating sublevel of the second level of the New Taxonomy, at the end of the study.

DISCUSSION AND SUGGESTIONS

This study focused on preschool children's improvement in their understanding of geometric shapes through a series of digital activities. The results of the study showed that children developed their understanding of geometric shapes from the retrieval to the comprehension. However, each child had a different pace and path to reach the upper level. Besides, the activities which included rotated figures and real-life objects were effective on developing children's understanding. Furthermore, only one child did not require scaffolding while moving from the retrieval to the comprehension level. However, other children benefited from scaffolding to improve their understanding during the digital activities.

First of all, since this study was conducted with Turkish children it could be important what are the clues hidden within Turkish words for these geometric figures. For example, triangle means "üçgen" in Turkish. This word is formed with the unity of three (üç) and -gon (-gen) like in pentagon. Similarly, rectangle means "dörtgen" in Turkish and this word is formed with the unity of four (dört) and -gon (-gen). Therefore, names of these two geometric figures have clues about meaning of them although -gen (-gon) suffix has no meaning separately and only numbers as affix provide clues about figures. On the other hand, other geometric figures, which were circle (çember) and square (kare) have not clues in their meaning to imply their geometric properties like number of sides or corners.

In this study, it was seen that, the series of digital learning activities helped children to achieve higher cognitive levels regarding Marzano and Kendall's (2007) taxonomy. Although children were at recognize level in the beginning, they improved their understanding and reached integrating level through these digital activities. According to results, these improvements were occurred in different speed and in different ways. Children's task processes in the first activity revealed that nearly all students were in recognizing sublevel of retrieval cognitive level for the taxonomy except one child. This child also struggled to accomplished for recall sublevel of retrieval cognitive level and integrating sublevel of comprehension cognitive level. In fact, he could not achieve to reach integrating sublevel until the last digital activity. Other children eventually accomplished recall and integrating sublevels through digital learning activities but in different times and situation. To the best of our knowledge, these children had not have a formal learning experiences for basic geometric figures. They engaged learning phases for basic geometric shapes in a formal way of learning in our observation with digital activities. However, since at the beginning of the research some of them were more receptive than others. Even some of them had preliminary information about some basic properties such as having four sides for rectangle or three sides for triangle, in informal way. Their difference in encountered everyday of mathematics could lead these differences of readiness for formal mathematics as stated Baroody and Ginsburg (1986). Hence, their informal experiences about geometric shapes resulted with these learning differences (Clements & Battista, 1992; Ginsburg, Lee & Boyd, 2008). Therefore, they followed different routes for reaching higher sublevels of the cognitive levels of the Taxonomy.

In this study, all the children had their own informal explanations about basic geometric shapes such as, "It looks like a watch", "It's like a door", "It's like a wheel", etc. However, it can be seen that this recognition of basic shapes from their own previous experience generally consisted of prototype images with specific properties as Battista and Clements (2000) stated. In the study, some children had difficulties recognizing rotated or extended shapes. For example, a child was not able to recognize all the squares in the fourth activity and another had difficulties finding all the rectangles during this activity. When a rectangle which had been rotated 90 degrees from its usual position was given to children some of them identified it as a square. This study revealed that the digital learning activities helped the children to overcome with these types of prototype images, as it was seen that in the last two activities the children were able to recognize even rotated geometric figures when given descriptions or their names. These improvements showed that providing multiple representation of same figures in different orientation helped children (Hansen, et al., 2005). At the end of the study, all the children were able to recognize figures from their names or simple definitions, and they were able to name the figures or describe at least one property of each figure such as, “It has four sides”, “It has no corners”, “One side is long, one side is short”. Children had some similar ways for learning process with these digital learning activities as well as they had differences. Results enlightened that half of the children presented some indicators about that they accomplished integrating sublevel of the comprehension cognitive level at the end of the fifth activity. This digital activity included multiple figures in different orientations. Therefore, this digital learning activity provided children to interact with geometric figures in different orientations. This opportunity could lead children to realize interdependence of concept for a geometric figure from its orientation or representation (Mooney, et al., 2014). Since, they were provided with multiple representations for the geometric figures, they could reform their concept image for families of geometric figures (Clements & Battista, 1992; Fischbein, 1993; Fujita & Jones, 2007; Hansen, et al., 2005). As a result of this fifth digital activity, it was revealed that figures represented in different orientations helped children to accomplish integration sublevel of the comprehension cognitive level.

The study showed that children actively participated in the activities and engaged in decision-making processes during the digital activities. Children controlled their tablets and practised identifying, matching and labelling geometric shapes. Although the teacher provided a tablet for each child and the children used them individually, children displayed social behaviours such as helping, explaining ideas and observing their peers while engaging in the activities. Lim (2013) has stated that working in pairs is a factor that supports children’s social interaction when integrating technology into education. Further investigations along these lines could provide more information in order to determine which factors most influence children’s social interactions in which situations. In addition, the teacher supported children in achieving the goals of these activities. These points of the study are in accordance with NAEYC’s (2012) principles that, “Effective uses of technology and media are active, hands-on, engaging, and empowering; give the child control; provide adaptive scaffolds to ease the accomplishment of tasks; and are used as one of many options to support children’s learning” (p. 6). The activities that were used in this study are available for researchers and developers to make them more developmentally appropriate (NAEYC, 2012) for young children.

It was also seen that when the digital activity included a link to the real life of young children, the activity was effective on engaging children and supporting their learning. When children encountered with the objects which they could be familiar in the real life, they used their prior information about the objects to improve their understanding during the digital activities. Bishop (1988) labelled mathematics as a cultural phenomenon. He conceived mathematics as a cultural product which was developed as a result of various experiences. He included geometric figures in designing activities which was defined as creating a shape or design for an object or for any part of one’s spatial environment. Thus, children’s learning of mathematics through digital activities cannot be separated from the culture of children. Furthermore, NAEYC (2009) emphasizes key role of culture within the framework of developmentally appropriate practice (DAP). Therefore, appropriateness of the digital activity to the social and cultural contexts in which children live. This construct is also inline with everyday mathematics phenomena (Ginsburg, Lee & Boyd, 2008).

In the light of the result of this study, it could be specified that digital activities could help children learning through the content familiar to their experiences in real life with scaffolding as they need. Therefore, future studies with digital activities should be conducted by considering transforming children’s informal mathematics to formal learning by providing teacher or peer supporting environment. Since children’s informal mathematics could include some prototype images which cause difficulties for them to identify figures in unusual orientations, learning activities should provide multiple drawings to illustrate concepts. Therefore, children can focus on not only the visual aspects of shapes but also its essential aspects like properties which remain unchanged by altering drawings. Varying in pictures and diagrams is a need to overcome to form misconceptions.

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