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Using Scientific Methods to Enhance Early Childhood Students' Geometry Thinking

Erken Çocukluk Öğrencilerinde Geometrik Düşünceyi Geliştirmek için Bilimsel Yöntemleri Kullanma

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Abstract: The main purpose of this study is to describe the geometry learning process using the scientific method in learning the concept of geometry for early childhood. The series of learning activities were conducted using four stages of scientific methods. Participants were 46 children (4-5 years) and a teacher in some of the kindergartens in Banda Aceh, Indonesia. This study used explanatory sequential mixed methods design research to achieve the purpose, where the researcher first carries out a quantitative method and then uses a qualitative method to follow up and refine the quantitative findings. The geometry test and student activities observation sheet were used as data collection instruments (through a process of validity and reliability), whereas for analyzing the data, descriptive statistics, and gain-N-gain were performed. Based on the hypothesis testing (sig.000, df 45, t-test 14.574) and the N-gain percent score (45,39%), the result shows that conducting scientific methods in geometry learning can improve children's thinking of geometry especially in recognizing the shape of geometry (in the medium category N-gain=0.453). Observations and tests held during learning activities using scientific methods also show that children to be more imaginative and creative in thinking of geometry.
Keywords: Early childhood, geometry thinking, scientific method

Öz: Bu çalışmanın temel amacı, erken çocukluk dönemi için geometri kavramını öğrenmede bilimsel yöntemi kullanarak geometri öğrenme sürecini tanımlamaktır. Öğrenme etkinlikleri serisi, bilimsel yöntemlerin dört aşaması kullanılarak gerçekleştirildi. Katılımcılar Endonezya'nın Banda Aceh kentindeki bazı anaokullarında 46 çocuk (4-5 yaş) ve öğretmendi. Bu çalışmada, araştırmacının önce nicel bir yöntem uyguladığı ve ardından nicel bulguları takip etmek ve hassaslaştırmak için nitel bir yöntem kullandığı amaç için açıklayıcı sıralı karma yöntemler tasarım araştırması kullanılmıştır. Veri toplama aracı olarak geometri testi ve öğrenci etkinlikleri gözlem kâğıdı (geçerlilik ve güvenilirlik süreci ile) kullanılırken, verilerin analizinde tanımlayıcı istatistik ve kazanç-N-kazanımı uygulanmıştır. Hipotez testine (sig.000, df 45, t-testi 14.574) ve N-kazanç yüzdesi puanına (% 45,39) dayanarak, sonuç, geometri öğreniminde bilimsel yöntemlerin uygulanmasının çocukların özellikle geometri düşüncesini geliştirebileceğini göstermektedir. Geometri şeklini tanıma (orta-N-kazanım kategorisinde = 0.453). Bilimsel yöntemleri kullanarak öğrenme etkinlikleri sırasında yapılan gözlemler ve testler de çocukların geometri düşüncesinde daha yaratıcı ve yaratıcı olduklarını göstermektedir.

Anahtar Sözcükler: Erken çocukluk, geometri düşünme, bilimsel yöntem

INTRODUCTION

Early Childhood Education must be integrated with the environment, which provides many direct experiences for the children. Facing children with direct experience in learning is very important because it will help in childhood development and growth process (OECD, 2015; Hassan et al., 2018; UNICEF, 2018). Direct experience can be done by connecting learning with the environment or integrating learning in science education, because science education in early education has the potential to lay an essential foundation for children's knowledge and interest not only in science but also in as well as reinforcing and integrating critical language, literacy,

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and math readiness skills (Gerde et al., 2013; Beckmann, 2009). Besides that, the learning process in early education must also be conditioned in the activities of playing, singing, moving freely, and can be creative and explore to develop imagination in a good, comfortable and enjoyable way (Campbell, & Evergreen, 2013; Triharso, 2013; UNICEF, 2018). These conditions are related to the developmental period of early childhood (Holt, 1995; BCYF, 2015).

At an early age of 0-6 years, it is a period in which all aspects of the child are experiencing development according to their growth, especially at the age of 4-6 years which is the golden age (Uce, 2017). The golden age of childhood development is a time when children begin to be sensitive to receive various stimulations and various educational efforts from their environment either intentionally or unintentionally, during this vulnerable period, children are so easy to receive stimuli from their environment (Yuliani, 2009). Therefore, the development of the potential possessed by the child should be carried out with various creative and fun learning activities for early childhood.

Ideas and concepts about geometric have formed and learned by children before they enter school (Clement & Sarama, 2011; Cross et al., 2009; Clement et al., 2007 & 2004). The concept of geometry is essential to be taught to children from an early age (Clement, 2008; Clement & Sarama, 2011; Cheng & Mix, 2014; Cross, Taniesha, & Heidi, 2009), because it is closely related to various things in everyday life, besides mastering the concept of geometry is also the basis for mastering the subsequent mathematical concepts (Rustam, 2019; Lestari, 2011; Darragh, 2006). Freudenthal in Principles and Standards for School Mathematics defined geometry as "Geometry is grasping space…that space in which the child lives, breathes, and moves. The space that the child must learn to know, explore, conquer, to live, breath and move better in it" (Clements & Sarama, 2007). In early childhood, understanding of geometry is the ability of children to recognize, point, mention, and collect objects around based on geometric shapes (Lestari, 2011; Yuliani, 2009). The Indonesia standard curriculum of early childhood education also described the indicators of geometry learning achievement for children aged 4-6 years (Novita, 2018). It expected that children could know and show geometric shapes based on the size of the objects; classify more objects into similar groups, or groups in pairs; classifying objects by color, shape, and size; sorting objects from the smallest size to the largest or vice versa. Furthermore, National Council of Teachers of Mathematics (NCTM)'s Curriculum Focal Points (2006) also describe the areas of geometry that children should learn by age and education level from pre-kindergarten (Pre-K) to kindergarten, which the children can Identify shapes and describing spatial relationships (describe shapes in their environments using their own words; build and design pictures by combining two- and three-dimensional shapes, discuss the relative positions of objects), and describe shapes and space (interpret the physical world with geometric ideas and corresponding vocabulary; identify, name, and represent a variety of shapes; model objects in their environment and construct more intricate shapes).

Introducing the concept of geometry can be done with various methods. One of the methods that can be implemented in geometry learning is scientific methods. Scientific is a way to provide learning experiences by confronting children with everyday problems that are solved in groups (Budiyanto et al., 2016; Beckmann, 2009; Conezio and French, 2002). Why use everyday issues? It aims to provide meaningful learning for children and try to close the often-perceived gap between formal mathematics and authentic experience (Kaput 1994, Watters et al., 2001; Beckmann, 2009). So, learning in meaningful contexts is designed to contribute to an intuitive mathematical understanding and allow students to experience the versatility of mathematical terms (Sackes et al., 2013; Michelsen & Beckmann, 2007).

Sitiatava (2013), put forward scientific simplicity is the way specific methods obtain science. More specifically, Gerde et al. (2013) said that the Scientific Method is a process for asking and answering questions using a specific set of procedures. This process can be used as a guide to creating comprehensive and meaningful learning experiences for young children. Engaging, children in scientific inquiry using all steps of the scientific method supports children to construct conceptually-related knowledge (Doğan and Boz, 2019; CDE, 2016; DPAUD, 2014; Sackes et al, 2013; Eshach and Fried, 2005; Gelman and Brenneman, 2004), this was due at each step-children use a variety of skills to discover new information about the concept of study.

Using scientific methods is expected that the cognitive aspects of children in recognizing the concept of geometric forms will increase according to the stages of the child's development (DPAUD, 2014; Hosnan, 2014).

The scientist method generally involves: ***Observing*** including reading, seeing, and listening. Observing means using all the senses (sight, hearing, craving, feeling, and taste) to recognize an object that is observed. The more senses used in the process of observing, the more information is received and processed in the children's brain; ***Questioning***, including asking and answering questions, then discussing information that has not been understood. Questioning can be interpreted as one of the processes of finding out or confirming or matching the knowledge that a child already has with the new knowledge being learned; ***Generating hypotheses and predictions*** about the answer to children's questions before hypothesis can define as a clear statement of what children expect the answer to the question to be. The hypothesis will represent the best "educated guess" based on observations and what children already know; ***Experimenting*** or Engaging in Experimentation and Testing including trying, demonstrating, imitating, collecting data from sources, reading other sources, and modifying. Experimenting occurs when children engage in activities that help them answer their questions, in this process children conduct activity "trial and error"; ***Summarizing and Analyzing Results to Form Conclusions*** or termed as associating (including processing information that has been collected, analyzed, connecting phenomena related to the discovery of a form, and concluding). In associating process, children begin linking the knowledge they already have with the new experience that they have or is around them; ***Communicating***, including compiling reports about process, results, and conclusions. Communicating is the process of strengthening knowledge of new knowledge that children get.; ***Identifying an New Question***, this is the final step of the scientific method which aim to extend the findings from the experiment into a new study, but it does not rule out other questions will arise after the children complete their search for one answer to the previous question (Gerde et al., 2013; DPAUD, 2014, Hosnan, 2014).

In this sense, previous research has contributed to discuss the capability of young children to associate what they do to space, considered a fundamental part of geometry, and centered on visualization. Some research (Novita et al., 2018; Tsamir et al., 2015, Keren et al., 2014; Zaranis, 2012; Clement & Sarama, 2011; Clement & Sarama, 2009) discussed the necessity to learn the concept of shape in Early Education with an excellent instructional tool, and the way children can describe different forms depending on their basic properties. On the other hand, a lot of research also discussed the geometry's role for children and the difficulties in geometry and the spatial sense that students with a variety of disabilities encounter, and offer examples of instructional Techniques and modifications to meet the needs of students (Hasan et al, 2018, Dinuţă, 2015; Cheng et al, 2014; Gerde, 2013; Clement & Sarama, 2007; Sarama et al., (2006). The use of scientific methods in mathematics learning has also been carried out by several other studies such as Jazuli (2017) & Quinn (2011) who focus the application of scientific methods on learning mathematics in higher grades and advanced mathematics material. If we continue to look more specifically at the implementation of scientific methods in early childhood learning (indeed it is still minimal), it has been done by Gerdeet al (2013) and Suryana (2017) where their research tries to explain how to teach science (application scientific method) that supports children's development across domains in early childhood education.

In the case of using the scientific method in learning geometry (focus on geometric thinking), especially for early childhood, it is more difficult to find research on Childhood Education. For this reason, the purpose of this paper is to discuss the effectiveness of applying the scientific method in improving five-year-old children's geometry thinking related to recognizing the geometric shape. Then, this study also analyzes how children's efforts to think the geometry that they have learned when trying to explain various geometric space.

METHOD

This study uses mixed-method research of the following type by combining quantitative and qualitative methods to achieve the purpose. The kind of mix method research used is explanatory sequential design. In this design, the researcher first carries out a quantitative method and then uses a qualitative method to follow up and refine the quantitative findings (Creswell, 2014; Fraenkel et al., 2012). Therefore, to reach the research objectives, this research was conducted in two stages. The first stage of this research, a quantitative method, is performed to obtain measurable data about the ability of early childhood students to recognize the geometric shape. In the second stage by using a qualitative, this method is carried out to explore the findings obtained from the first stage.

The type of quantitative research method carried out in this study is a one-group pretest-posttest design where a single group is measured or observer before and after being exposed to a treatment of some sort (Creswell, 2014; Fraenkel et al., 2012). A diagram of this design is as **Figure 1** follows:

O_1	X	O_2
Pretest	Treatment	Posttest

FIGURE 1. *The one-group pretest-posttest design*

Description:
X: The treatment of learning by using the Scientific Method
O: Pretest-posttest the geometry thinking related to recognizing the shape

Then, after conducting a series of studies using the quantitative method (to obtain the effectiveness in the implementation of the scientific method on children thinking of recognizing geometry shape), the research was continued using the qualitative method. The qualitative way was more concerned with understanding situations and events from the viewpoint of the children. From this perspective, the researcher has been able to establish a holistic description of student's activities of geometry learning using scientific methods in early childhood students.

There are six steps in qualitative research method (Fraenkel et al., 2012), namely: (1) identification of the phenomenon to be studied - how can the scientific method be used in the geometry learning of early childhood students. At this stage, the researcher tries to design a series of learning, including devices and media for early childhood learning by using the scientific method. This design was carried out using a series of stages of research design (focus on the use of scientific methods and geometry thinking) conducted by researchers in previous studies (Novita et al., 2018); (2) identification of the participants in the study - this stage is done by selecting more participants with the aim of testing the implementation of the design that has been obtained to see the effectiveness of the learning design with the scientific method that has been prepared for the development of children's geometry thinking. Participants selected were participants who had the same characteristics as the participants who were the target of the study, namely early childhood aged 4-5 years; (3) generation of hypotheses - At this stage, the researcher summarizes the initial assumptions related to this study where the implementation of the scientific method in learning geometry can develop early childhood thinking of geometry and make it possible to develop other import foundation for children knowledge such as literacy, critical language, and creative thinking skills ; (4) data collection – researchers collected data using a number of instruments that had been compiled in the initial stages of this study (already through the stages of validity and reliability), instruments used in the form of observation sheets (containing a number of children's activities related to geometry thinking to be observed), geometry thinking test sheets (contains some things related to the geometry thinking of children that cannot be observed through observation directly), student work sheets that contain a number of geometry activities used by children in the learning process, and unstructured interview sheets to interviewing some students to get more in-depth information about their thinking process; (5) data analysis – analyzing the data involves a coherent description of what observed and discovered; and (6) interpretation and conclusion.

Participants

The participants in this study are 46 children (4-5 years) in the kindergartens in Banda Aceh, Indonesia. Of the total participants, 25 (54.3%) were female, and 21(45,6%) were male. Participants are in three classes from three different schools taken by random sampling techniques which were then given the same treatment of learning using the scientific method.

Instrument & Data analysis

Data collected in this study through the test instrument, student worksheets, and student activities observation sheet. The instruments test in this study were designed based on early childhood development, Snow et al (2008) said that young children need to be able to touch and move objects to give an accurate demonstration of their understanding of concepts, assessments using still pictures on a piece of paper is likely to underestimate their mathematical understanding, as they may be better able to solve problems when they are allowed to move actual objects around physically. So that the test conducted to obtain data about children's geometry thinking is then more focused on the child's direct experience, but the consideration of presenting some evidence related to the development of geometry thinking in this study, researchers also used several paper-based instruments tets.

To capture the ability of children to think geometry in this study is done in two ways, namely the use of paper-based tests and performance tests. İn paper-based tests, for example, when Identifying names and describing a variety of shapes with different sizes and orientations, children can work on paper sheets given by the teacher. While the performance tests, teachers do by asking students to directly carry out instructions given by the teacher, such as find shapes in the environments and describe them in children's own words. So, the test instrument contains the number of activities and mathematical problems related to geometry thinking in recognizing the geometry shape. The geometry tests were given at the beginning of treatment as the pretest and the end of treatment as the posttest while the observation sheet of student activities is used to observe the student activities related to the geometry thinking during the learning geometry process using the scientific method.

The analysis of increasing children's geometry thinking related to recognizing geometry shapes used the results of pretest, posttest, gain, and N-gain. Gain is the difference between the value of the pretest and the posttest. This study uses the normalized gain average formula to show the quality of improvement in children's geometrical thinking. N-gain (normalized gain) is used to measure the increase in children's geometry thinking related to the introduction of geometry between before and after learning (Hake, 1999). To find out the N-gain value, this study used the formula as in **Figure 2** follows:

$$Normalized\ Gain\ (g) = \frac{G}{G\ max} = \frac{Sf - Si}{100 - Si}$$

FIGURE 2. *Normalized gain formula*

Description:
G: average gain
G max: maximum possible average gain
Sf: average the final (posttest)
Si: average the initial pretest

As for the categories, we can use the following normalized gain index interpretation (Hake, 1999):

Analysis of children's geometrical thinking skills related to recognizing geometry shape is presented in detail for each indicator to see the improvement. Scores of each indicator were obtained based on the results of the children's answers at the pretest and posttest.

Table 1. *Interpretation of normalized gain score*

Normalized Gain Score	Interpretation
-1.00 <g<0.00	Decrease
g=0.00	Stable
0.00 <g<0.30	Low
0.30 <g<0.70	Medium
0.70 <g<1.00	High

Design of the Teaching Experiment

At the beginning of the study, researchers had prepared geometry learning instruction using scientific methods that developed through a previous study (Novita et al. 2018; Lestari, 2011; NCTM, 2006). This study focuses on geometry competencies related to recognizing geometric shapes namely: (1) children can interpret the physical world with geometric ideas and describe it with corresponding vocabularies; (2) children can find forms in their environments and explain them in their own words; (3) children can identify names and describe a variety of shapes with different sizes and orientations; (4) children can classify more objects into similar groups, or groups in pairs; (5) children can build figures and designs by combining two-dimensional shapes.

The geometry learning instruction described each step of the scientific method and ways that teachers can scaffold children's participation in the stage. **Table 2** provides a brief explanation of the studied geometry related to recognizing geometry shape by using seven steps of the scientific method.

The second stage is to provide a pretest to the children before conducting an experiment using the scientific method. Then, after the experiment process was complete, the third stage, the student is given the posttest. The test given in this study provided contains a task related to geometry competences. The instrument test consists of paper-based tests and performance tests. Related to the development of early childhood geometry thinking, this study only focuses on the development stage at level 1 from the model of Van-Hiele's geometrical thinking (Van Hiele: 1986), namely: students recognize a shape by its appearance, they are not able to notice the components; they may estimate a given figure is a square because it looks like a table. So that, the assessment rubric that was compiled (using a Likert scale) to assess all the indicators of the geometry learning competence used was adjusted to the stages of thinking geometry at level 1of Van-Hiele. However, it does not rule out the possibility if in the learning process allows children to bring up the stages of geometry thinking that passes level 1 or even to level 2 of Van-Hiele so that it is considered as a finding later.

Furthermore, the last step is to conduct qualitative data analysis using formulas and quantitative decision making. At this stage also, the qualitative way is done by bringing up a holistic description of student's activities of geometry learning that has been done at the experimental stage.

Table 2. *Stage of Scientific Method to Recognize the Shape of Geometry: the first cycles*

Scientific Method	Description of Learning activities	Target Learning objectives/competencies
Make Observation	The teacher introduces a triangle-shaped animation (which she calls Tintin) to students. Because of their different shapes, the triangle animation wants to find a friend who has the same shape. Then, the teacher asks the children to go out to observe and look for objects around the school environment that have the same shape as the animation. Children find what geometry forms around the school environment	• Scientific skills of observation • Interpret the physical world with geometric ideas and describe it with corresponding vocabularies (describing & labeling) • Oral language development
Come up with a question	The teacher provides opportunities for children to ask questions about what the children have not understood about surrounding objects related to the geometry shape. Example: is it true that the shape of the building roof is rectangular?	• Scientific skills of generating a Question • Find shapes in their environments and describe them in their own words (Oral language development Vocabulary knowledge).
Making predictions and arriving at a hypothesis	The teacher calls on different student asking for their beliefs about "Why these objects are not the same as triangles?"	• Scientific skills of predicting and verbalizing ideas • Understanding of print/print Knowledge
Engaging in experimentation and testing	Teachers and children collect/show some objects around the environment related to geometry, then try to identify the base of the object on the angle they have.	• Identify names and describe a variety of shapes with different sizes and orientations (comparing skill).
Record results and draw conclusions	Children can do free drawing activities of objects observed around the school environment. The teacher tried to guide the children to explain what picture they were drawing and what geometry shapes were in the film.	• Scientific skills of summarizing results and drawing conclusions • Children can build figures related to the shape • Oral language is developed as they explain ideas
Communicating discovery / Share result	the child tells/shows the work of the drawing made to other students	• Science skills of communicating findings • Literacy developing their print knowledge
Identifying the new question	(to the next ***cycles)***	
The second cycles of the scientific method		
Make Observation	The teacher gives children pieces of color paper cut into basic shapes: circles, squares, triangles, and a rectangle. Then, Children are asked to observe and name each of geometry shape	• Scientific skills of observation • Identify names of geometry shape
Come up with a question	The teacher scaffold students to ask questions. As: "Do any of the shapes on the table have differences or similarities? " "Are these shapes bigger or smaller than the others?	• Scientific skills of generating a question • Oral language development • Vocabulary knowledge
Making predictions and arriving at a hypothesis	The teacher helps children to answer these questions by asking them to classify the object on their table into a similar group (similarity characteristics they have).	• Scientific skills of predicting and verbalizing ideas • Understanding of print/print knowledge
Engaging in experimentation and testing	Children classify more objects into similar groups. Children sort objects from the smallest to the largest or vice versa.	• classify more objects into similar groups, or groups in pairs
Record results and draw conclusions	After finding the same geometric shapes, the students glue the shape to a sheet of paper provided by the teacher	• Scientific skills of summarizing results and drawing conclusions
Communicating discovery / Share result	The teacher helps children to share their page with the class.	• Scientific skills of summarizing results and drawing conclusions

RESULTS

Based on the results of the study, it showed that learning geometry by using a scientific method in early childhood education was effectively applied to improve the children thinking to recognize geometrical shapes. This condition was concluded based on a hypothesis test carried out on several data related to children's thinking to identify the geometry. Hypothesis testing of pre-test and post-test data was carried out after testing for normality. Based on the data analysis, it found that both data in the pretest and posttest were normality distributed (Sig value 0.083 and 0.104 more than the significance level $\alpha = 0.05$). Then, using the paired sample test, we found that the value of the t-test was 14,574 which means that there were significant differences in the value (sig value 0,00) between the average values of the pretest and posttest values.

In the final stage, N-Gain testing was carried out to see how effective the use of the scientific method was used in geometry learning, especially in improving children's thinking to recognize the geometry. Based on the average N-gain percent value obtained is 0.453, it can be interpreted that the scientific method is sufficient (in medium category) to be applied in geometry learning specifically to improve children's geometry thinking abilities. The detailed analysis is presented in **Table 3**.

Table 3. *Summary of t-test*

Aspect	***N***	**Mean**	**Sig of Normality test**	**Min Score**	**Max. Score**	***t*-value**	**sig**
Pretest	46	72,39	.083	55	95	-14.574	.000
Posttest	46	84,24	.104	65	100		
N-Gain %	46	45.39	.105				

Furthermore, the researcher analyzed children's scores at each indicator of the ability to recognize geometry shape. The score is based on student answers at the pretest and posttest. The following **Table 4** shows the percentage of students by category for each aspect of competences.

Table 4. Analysis of children's geometrical thinking skills in learning using the scientific method based on the early childhood rating scale.

No	Competences	Pretest Score				Posttest Score			
		1	2	3	4	1	2	3	4
1	Find shapes in their environments and describe them in their own words		9	4	33			12	34
			19.57 %	8.70 %	71.74 %			26.1. 4%	73.9 %
2	Identify names and describe a variety of shapes with different sizes and orientations.			9	37			3	43
				19.57 %	80.43 %			6.5%	93.5 %
3	Classify objects into similar groups, or groups in pairs		4	10	32			12	34
			8.70 %	21.74 %	69.57 %			26.1 %	73.9 %
4	Build figures and designs by combining two-dimensional shapes		18	16	12		3	18	25
			39.13 %	34.78 %	26.09 %		6.5%	39.1 %	54.3 %

The percentage for each competency showed from **Table 4** indicates an increase for each level of development of students' geometric thinking. So henceforth, based on the results of the t-test (N-gain) and also an increase in percentage, it can be said that the scientific method has a positive impact on learning to recognize geometric shapes.

DISCUSSION and CONCLUSION

This study was carried out by applying the seven-steps of scientific method; namely, observation, questioning, Generating hypotheses and predictions, data collection (Experimentation or testing of a hypothesis), associating (Summarizing or analyzing data to conclude), communicating in geometry learning at early childhood education and Identifying a new question.

At the observation stage, activities are carried out by inviting children out of the classroom to observe objects that are around the school environment and linking the geometrical shapes known to the children (based on their child's fundamental knowledge). The children were very enthusiastic about mentioning the objects in the school environment. This activity also equating them with the geometric shapes they knew, such as "there is a triangle on the roof of building, there is around (meaning the child wants to mention a circle) in the tire of the car, there is a side of four (the meaning of the child wanted to mention the rectangle) in the window, and other".

(a). Children explore the school environment

(b). triangle in the roof

FIGURE 3: Children in the observation stage

Figure 3 shows the activity of natural exploration, and the following is one transcript of the conversations that took place between teacher and Children (CM):

The teacher starts the activity by inviting students to walk on the school grounds to find what geometry forms around the school environment

Teacher	*: "children, let you all observe in our school environment, are there any geometric shapes that you are familiar with?"*
All children	*: there is Mom! (while pointing one by one the objects they see)*
Some children	*: There is a triangle on the roof of the building! (triangular roof)*
CM	*: there is also a triangle on the roof. (point to the shape of the roof, as shown in* ***Figure 3b****.)*
Teacher	*: "why do you say it is a triangle? Does he look like a triangle?"*
CM	*: it is right because it is like this...! (CM shows a triangle shape using his fingers and also his hands as if they resemble sloping sides on both sides of the roof)*

Based on the conversation from the CM, it was identified that the CM and other children were able to recognize the triangular shape of the objects they saw, specifically for the triangle by remembering two sloping sides and a one-pointed angle. On the other hand, in the same activity, it was found that some children easily recognize geometric shapes by calculating the angles possessed by the objects they see even though the term angles are very unfamiliar to them (they call "angles" as corners). If the object or shape has three edges (or three corners according to them), then the child will immediately recognize that the object or shape is a triangle, as well as a rectangle.

In the second stage, *come up with a question*, the teacher allows children to ask questions about geometry. Sometimes, this stage is a little more challenging to do if the teacher expects students to ask questions. So, in this study, if students do not ask, the teacher tries to direct students to ask questions, or maybe items are given by the teacher to find answers together with students. In this study, several student questions often did not appear related to learning, such as: “why did the ball have a round shape?”. For such problems, the teacher tries to answer by giving an explanation that is a little logical and readily accepted by the child, for example: "the ball is shaped like a circle, while the circle is round, so the ball is round."

In the third stage, *making predictions and arriving at a hypothesis*, the teacher tries to guide the child to make a hypothesis of the problems raised by the teacher such as giving the question "Why are the objects not the same as triangles?". These activities allow students to communicate with their ideas and language to describe the mathematical concept. Communication skills are critical to be developed by teachers in the learning process as an effort to improve children's literacy abilities (Gedre et al., 2013; Blank, 2012). At this stage, the children try to convey ideas in his language about the questions given by the teacher, such as this object is not the same as a triangle because he is round, or because he has many boxes. This stage is also done by asking students to describe the forms they have seen, then explain the forms they have made. For example, children describe the stone at the schoolyard **(Figure 4a)** were similar to round (which they mean is a circle), or the broom equipment they said was related to a triangle **(Figure 4b).** **Figure 4** shows the children's contribution to drawing activity.

(a) stone in circle-shaped

(b) broom in triangle-shaped

(c) (d) there are various geometric shapes (triangles, circles, rectangles) at home

FIGURE 4: *Children’s contributions*

However, although the child can already identify shapes using corner (as angles), it still has doubts when mentioning triangles or squares on trapezoidal objects (Figure 4b and Figure 4c) compared to other rectangular objects such as square, rectangles or parallelogram. This does not apply equally to rectangles or squares, in this study shows that children can show squares and rectangles in a variety of different shapes and orientations, this is also supported by other related studies (Halat et al., 2016). In build picture or drawing activity, the teacher asks some questions to the CS (who create Figure 4a) and CM (who create Figure 4c).

Teacher : *"Your picture is great ...! what object are you drawing?"*
CS :*" I drew a broom."*
Teacher : *“very cute brooms, what shape is it?”*
CS : *“it is like a triangle, and this top is round” (*he wants to show the broom handle*),*
“but I cannot draw it.”

Then with CM

Teacher : *"Your picture is great ...! what object are you drawing?"*

CS : *"I drew a terraced house."*
Teacher : *"What shapes are in your drawing!"*
CS : *"There are circles; there are rectangles; there are triangles. This is a long triangle like a rectangle."*
*(*He wants to say one of the roofs is triangular but not the same as a triangle, a long triangle like a rectangle*)*

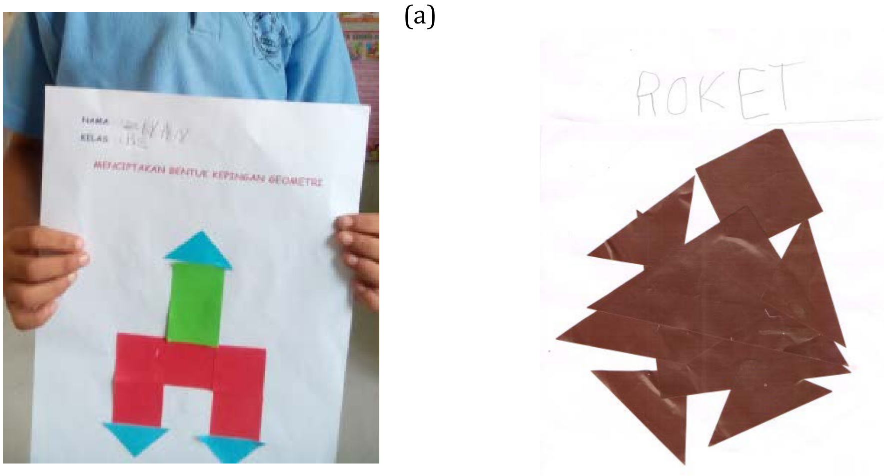
In this study, it was found that students had difficulty and doubt in determining the forms of the trapezoid as in **Figure 3c, 3d, 3d** (maybe because it was never introduced to them at all). If objects are shaped like Figures 3c and 3d, then the children tend to call them as triangles, but if they are shaped like F**igure 3d** picture, the children call them rectangles. They ignored if there was one more side at the top which caused the object to be not at all triangles but rectangles or more precisely called trapezoid. This understanding, still requires further recognition because indeed at that time the children were not yet introduced to the term trapezoid, but what needed to be noticed that some children are more familiar with triangles because of their two sloping sides and sharp angles rather than counting the number of angles (in some instances). Forcing children to communicate what they are thinking is very important. So communication is essential to be involved in the learning process because it is not only literacy (Blank, 2012) even to explore and improve the process of thinking, reasoning (since reasoning is an underlying mathematical thinking skill), and problem solving (Tambunan, 2019; Bozkus & Ayvaz, 2018; Ayele , 2017; Roheni et al, 2017; Rigelman, 2007; Allen et al., 1999). Besides, the observation activities in the school environment (natural exploration activity) can also develop children's creativity not only in recognizing geometric forms contextually, communicating them but also in drawing objects that have geometric shapes (see **Figure 3).**

Then, in the fourth and fifth stages, the teacher and children *conducted some experiments* related to the questions raised by the children and also the competencies to be achieved. Activities carried out at the experimental stage, are designed to answer children's problems at the observation stage. There are three experiments that have been carried out in the implementation of the scientific method on geometry learning in this study, namely (1) Identify names and describe a variety of shapes with different sizes and orientations (comparing skills); (2) classify more objects into similar groups, or groups in pairs; and (3) build figures and designs by combining two-dimensional shapes. Based on the three experiments conducted by the children, the third experiment was fascinating and challenging for them. In that experiment, the children tried to combine their imagination and geometric knowledge that they already had to create or design an object. So, at this stage, we can see original forms made by children. For example, **Figure 5** below shows a rocket in the kind imagined by each child.

For the last stage, *communicating discovery*, the teacher asks students to describe the experiment that they had conducted. At this stage, children are very enthusiastic about explaining and sharing in front of the class about the design or finding that they have made. The teacher asked the children to communicate the finding in the first experiment where the children told about the picture they had made in front of the class. For example, children describe the stone at the schoolyard (**Figure 4a**) were similar to circle, or the broom that they said was related to a triangle (**Figure 4b**)**,** nice rocket in a different form (**Figure 5a, 5b**)**,** or many other shapes that children draw**.** However, this communication activity, some children were still shy in sharing and conveying their ideas. This condition is typical; of course, it is not easy to invite children to tell what they are drawing even what they are thinking, the teacher must try to accompany some inducement questions.

Now, the development of children's geometric thinking abilities for each competency that has been set will be analyzed. Every stage of scientific learning that have designed is always equipped with the target of learning objectives/skills geometry that wants to be achieved. The first, discussion focuses on increasing the development of students' geometrical thinking through each competency of the children's score in pretest and posttest based on the rubric of geometry thinking that was compiled at the beginning of this study. Then the second, we will look at the effectiveness of each scientific method in developing the process of thinking geometry in children by using the significance of the N-Gain score.

(a) (b)



Children design the same object (the rocket) in a different form.

FIGURE 5: *Student activity in doing the experiment*

Based on Table 4, 76.9% of the children in pretest able to reach maximum score (4) to Find shapes in their environments and describe them in their own words, while in the posttest, there was an increase to 84.6% or there were 11 of children who have achieved score-4. The obstacle experienced by students to attain this competency at the time of the pretest is that the child is still upside down in determining triangular and rectangular objects. For the second competency, identify names and describe a variety of shapes with different sizes and orientations, there was also an increase in the number of children who reached the maximum scale (4) from 84.6% at the pretest to 92.3% at the posttest. The obstacle experienced by children in achieving this competency is when geometric forms are given in different orientations, and then the shape becomes a different shape for them.

Furthermore, the increase also occurred in the third competency, 84.6% (11) children had reached the maximum value. **Figure 6(a)** shows children's contribution, where they can determine the geometric shapes correctly, even though they can distinguish rectangle and square as both different shapes. Then, in **Figure 6(b),** we can also see that students already have a sense of form, where they can classify the same shape even though it is in different colors.

The last competence, build figures and designs by combining two-dimensional shapes, was also showed an increase in the number of students who received the maximum score (from 30.8% (4 children) to 53.8% (7 children). However, if the data on the percentage of students who get the maximum score in all four competencies were analyzed, it can be seen that the rate of children who score four on the fourth competency is deficient compared to the other three skills (just 53.8%). This condition is most likely due to the different levels of development of children's imagination. Children who still have limited vision then their ability to spark original ideas in creating or imitating existing forms will also have obstacles (Aljarrah, 2017; Widhiani et al., 2014).

(a) (b)

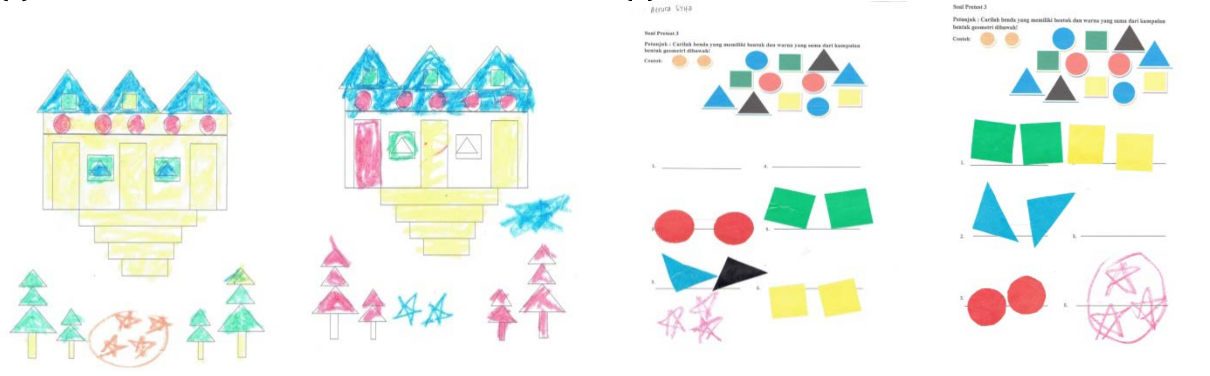


FIGURE 6 : *(a) Children give color to determine the image based on their shape; (b) Children Classify objects into similar groups or groups in pairs*

Besides, children's motor development (fine motor) also plays a role when children try to arrange the pieces of paper into shapes or objects they imagine. There were 7.69% of children who just stick to the paper randomly and have not been able to explain the imagination design that they have made, while the other 38.5% have tried to hold and tell what form of imagination they are thinking (even though the paper taped does not resemble the form they mentioned).

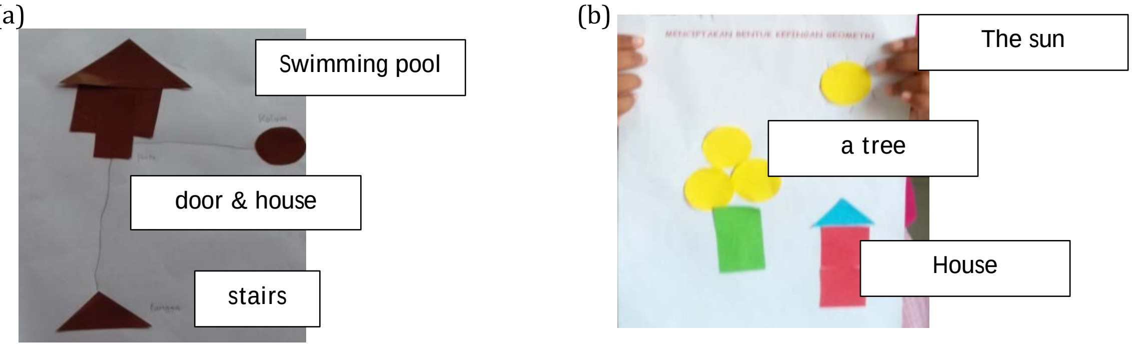


FIGURE 7: *Student Design to build pictures by combining two-dimensional shapes activity*

Furthermore, there were 53.8% of children, able to design the shapes that they imagined with a little bit the same as the real one. Based on the design they have made, it appears that observation activities in the school environment influence the childhood imagination. **Figure 7a, 7b** shows the children try to design a house (a combination of square and triangle) that has a door (using a rectangle), then there are the stairs symbolized by a triangle and a swimming pool symbolized by a circle. Then, from the design of two-dimensional shapes that have been made by the child shows that students can recognize geometric shapes and be more creative using these geometric forms.

If previously using descriptive analysis, we obtain the fact that the implementing scientific method is effectively applied to improve geometry thinking in early recognition for each geometry competency at the pretest and posttest. However, some things must be noted that in addition to developing geometry thinking and capabilities, the scientific method in this study also proves to provide space for child development in other aspects such as oral language development, vocabulary knowledge and also Literacy developing. This condition is in line with the results of Gerde et al. (2013), where is using the scientific method in early childhood learning processes can enhance learning across developmental domains. More than that, this study also found that the implementation of scientific methods developed by paying attention to how the mathematical domain concept was taught (in this case geometry) would allow for the development of other mathematical proficiency such as mathematical thinking, reasoning, and problem-solving. Furthermore, this study has contributed to the field of early childhood education, especially in strengthening understanding of mathematical concepts at an early age where the implementation of the scientific method seems to be following the processes and stages of geometry learning in early childhood. Then this can be concluded that the scientific method is one of the efficient techniques applied in geometry learning of early childhood. Pedagogically, this study would like to convey that introduction to geometry learning carried out with scientific methods is very helpful for teachers in teaching geometric concepts to early childhood in a meaningful and fun way. Then, practically, learning activities using the scientific method are also beneficial for young children in knowing geometry and linking them to everyday life. So, based on the learning activities that have been carried out, it can be concluded: *first*, it is crucial to start learning with contextual problems or real action that provide the problem to solve it, these ways to make the students understand more about the benefits of mathematical learning and its connection with daily life. *The second*, it is essential to carry out mathematics learning in fun and meaningful ways for early childhood to make children understand mathematical concepts better.

Based on the findings and some limitations in this study, for teachers or further researchers who want to develop geometry learning with scientific methods to children, it is recommended to do the following. (1) Planning learning activities following the stages of the scientific methods; (2) provide opportunities and motivate children to communicate their ideas; (3) it seems like how to introduce and teach some geometric shapes such as trapezoid, parallelogram, and several others are exciting to be further designed in early childhood learning. Furthermore, the contribution of this paper to the literature are: (1) the implementing of the scientific method seems to be in accordance with the processes and stages of geometry learning in early childhood; (2) it can be said that the scientific method is one of the efficient techniques applied in geometry learning in early childhood; (3) this study can have both pedagogical and practical impact on the introduction of mathematics and the development of mathematical proficiency starting from the preschool classroom.

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