

EARLY CHILDHOOD EDUCATION TEACHERS' AND PROSPECTIVE TEACHERS' UNDERSTANDING OF GEOMETRIC SHAPES

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Abstract: *Children explore shapes in their daily lives. Understanding geometry is needed in children's daily life and help them to develop their ability in solving a problem. However, in Indonesia, learning math in the context of early childhood education merely focuses on learning numbers. Therefore, it is possible that teachers do not have sufficient knowledge of teaching geometry. For this reason, it is important to find out early childhood education teachers' and prospective teachers' understanding of geometric shapes. This study used a descriptive qualitative approach to answer the research question of how early childhood education teachers and prospective teachers understand geometric shapes. The data were collected using semi-structured interviews and then analyzed using thematic analysis. Findings showed that early childhood education teachers and prospective teachers have a lack of understanding of geometric shapes, particularly in their content knowledge of 2-dimensional geometry, and how to teach and assess children's learning in geometry. It is suggested that early childhood education teachers as well as prospective teachers improve their knowledge of geometry. Early childhood education schools and universities are also expected to provide professional development and explore further other areas of mathematics, such as geometry not just focusing on numbers.*

Keywords: *Early childhood education, geometric shapes, prospective teachers, teachers' understanding*

A. Introduction

Children explore shapes in their daily lives. For example, when they create building creations from blocks of various shapes, such as squares, circles, triangles, rectangles, and others. Teaching shapes to children is important to grow their spatial abilities and their logical thinking by associating shapes with one another (Markovits & Patkin, 2020). Understanding geometry is needed in children's daily life and help them to develop their ability in solving problem (Sa'ida, 2021).

Geometric shapes are divided into two; three-dimensional shapes which are characterized by having length, width, and height and two-dimensional objects which only have length and width. Surya (2009) as cited in Rachmat and Sumiati (2016) explains that although there are many types of 2-dimensional shapes, there are only 3 kinds of them that can be taught to children, namely rectangle, triangle, and circle. This opinion is in line with the statements from Hasbi and Rachmawati (2020) and Rachmat and Sumiati (2016) who state that in early childhood education, children can be introduced to 2-dimensional shapes such as squares, rectangles, circles, and triangles. The Ministry of Education and Culture Regulation number 146 of 2014 concerning the early childhood education 2013 curriculum states that one of the indicators of 3-4-year-old children's achievement is being able to group 2-dimensional shapes (triangle, square, and circle) whereas, for 4-5-year-old children, the indicator is that they should be able to distinguish the geometric shapes. For 5-6-year-old children, they are expected to sort things based on 5 series or more shapes, sizes, or colors (Ministry of Education and Culture, 2014). In order to help children developing those goals, preschool teachers need to possess sufficient knowledge about shapes.

Sa'ida (2021) explains that many young children still have difficulty in learning geometric shapes. They tend to be passive learners and less interested in learning shown by their less attention when learning in the classroom (Rachmat & Sumiati (2016); Sa'ida (2021). Schools, teachers, and parents do not acknowledge children's difficulties to recognize geometry. Children still have problem in grouping 2 dimensional

geometric shapes such as circle, square, triangle and rectangle while the teacher still depends on text book and work book (Rachmat & Sumiati, 2016).

However, in Indonesia, learning mathematics in early childhood education context still focuses on numbers (Zafirah, Sabdaningtyas, & Siswandi, 2017). One of the factors that plays role is parents' expectation to see their children to be able to read, write, and count after graduating from early childhood education school. As a result, other mathematics subject areas, such as geometric shapes, receive minimum attention. Learning geometric shapes is considered less important by early childhood education teachers (Clements & Sarama, 2011). As it is considered less important, it can be assumed that early childhood educators do not have significant understanding and knowledge of geometric shapes. This assumption is supported by Zafirah, et al. (2017) who argue that early childhood teachers still have lack of understanding in teaching early mathematics subjects to children. They only focus on teaching numbers, addition, and subtraction while other mathematics subjects, such as geometric shapes, pattern, size and measurement, and classification are overlooked (Zafirah et al., 2017).

Several studies have been conducted to improve children's understanding of geometric shapes. For example, a study conducted by Sa'ida (2021) which uses STEAM-based learning, Rachmat and Sumiati (2016) who investigate treasure game method, and research by Putri and Suparno (2020) that utilizes technology computer to upgrade children's ability in understanding geometric shapes.

Nevertheless, the studies above still focus on increasing the understanding of geometric shapes in children. Research concerning early childhood education teachers' or prospective teachers' understanding about geometric shapes has not yet been explored well while the understanding of early childhood education teachers and prospective teachers is considered crucial. Teachers play a significant role in students' success at school, including how well teachers understand basic mathematics one of which the topic is geometric shapes. This is supported by the Zone of Proximal Development (ZPD) theory

proposed by Vygotsky. ZPD explains the distance between actual developmental level and potential level of development under the guidance of an adult or more capable friend. According to this theory, children can achieve developments that exceed their actual abilities if they are facilitated by more competent teachers, parents or friends. It means that in the context of a school, the Zone of Proximal Development will not occur if teachers in schools are not knowledgeable. Therefore, it is important to study how early childhood education teachers and prospective teachers understand geometric shapes.

B. Method

This study used descriptive qualitative approach to answer the research question of how early childhood education teachers and prospective teachers understand geometric shapes. The participants of this research were 3 early childhood education teachers (A, B, and C) and 3 prospective teachers (X, Y, and Z). The teachers are from different schools located in different cities. Teacher A has an early childhood education degree with 1 year working experience. Teacher B is graduated from a high school but has basic training certificate for early childhood education teacher and has been teaching for 8 years. Meanwhile, teacher C holds a bachelor's degree not from early childhood education major. She has 4 years of experience in teaching. Those three teachers' different educational backgrounds represent the real condition of early childhood education teachers in Indonesia, so the results of this study could give a better understanding despite the fact that it was small-scale research.

The three prospective teachers, X, Y, and Z, are students in an Islamic institute in Indonesia. They have passed Math and Science for Children Course. The course was taught in one semester and equals to 14 weeks of 2 academic hours in each meeting. Educational qualification and experience in teaching are included by the researcher to see if there are any differences in understanding geometric shapes by participants. In brief, the participants of this study can be seen in the following table.

Table 1. Participants of the Research

Participants	Educational Qualification	Teaching Experience
teacher A	Early Childhood Education (ECE) undergraduate degree	1 year
teacher B	high school and basic ECE training	8 years
teacher C	undergraduate degree not in ECE	4 years
Prospective teachers X, Y, and Z	ECE students in a Islamic Institute	Passing Math and Science for Children Course

Due to the time constraint to conduct the research, in-depth interview became the main data collection technique. Interviews were done voluntarily by phone or WhatsApp voice notes depending on the agreement between the researcher and participants. The interviews were conducted in January 8, 2022, approximately for 15-20 minutes in each interview. The participants determined the day and time of the interview. Before the interview, the researcher asked permission from participants whether allowed to make recording during the interview. After they agreed, the researcher ensured the confidentiality of the participants' identities as part of the research ethics. This was also done to make participants more comfortable when answering the questions during the interview. The researcher used a letter code to replace the participant's name. Participants also had the right to not answer the question if they felt the question given was not relevant, or they did not feel comfortable.

Semi-structured interview was chosen in which the researcher already prepared a set of questions but also had open possibility to ask other questions depended on participants' answers. Hancock and Algozzine (2011) state that in semi - structured interview, the researcher has some

questions that were used as a guide in doing the interview, but other questions could be added according to responses from the participants (Hancock & Algozzine, 2011). The data from the interview were transcribed for the next stage, data analysis.

The data were analysed using six phases of thematic analysis from Braun and Clarke (2006). The first phase was started by getting familiar with the data. This stage was done when the researcher wrote the interview transcript and read it repeatedly. Second phase was giving initial code for the data. It was done by marking the data using coloured pencils. The next phase was looking for a theme by selecting and sorting the code generated in the second phase. The selected themes would be the result, so they need to be supported by sufficient data. The fourth phase was done by reviewing the themes. Researchers looked back at the themes and checked again the data supporting each theme. The fifth phase was defining and naming the theme relevant for research results. The last phase was writing a report to answer the research question. The six phases were conducted continuously and could be repeated if required (Braun & Clarke, 2006). The three themes emerged in data analysis were ECE teachers' and prospective teachers' content knowledge of 2-dimensional geometry, the process in teaching and learning geometry, and assessment in geometry learning.

Trustworthiness was done by member checking. Member checking is a technique that can be used for ensuring reliability. It is also called validation from participant. Member checking is done by providing data or results of the study to participant for ensuring data accuracy (Birt et al., 2016). In this study, member checking was done by giving a copy of the interview transcript and short summary of findings to participants.

C. Result and Discussion

Geometry is originated from the Greek; geo means earth and Metron means measurement. Because of that, in Kamus Besar Bahasa Indonesia, there are 2 meanings of geometry. First, geometry is interpreted as measuring knowledge. Another definition of geometry is "a branch of mathematics

that explain the properties of lines, angles, planes, and spaces” (Kemendikbud, 2022). Meanwhile, Hasbi and Rachmawati (2020) give definition to geometry as “a mathematical concept concerned with the question of forms and spatial relations” (p. 3). Spatial relationship means an understanding of the location, space or position, such as up, down, right, and left. Based on this definition, introducing and teaching geometric shapes to children are possible as geometric shapes are around them. However, in the context of schools, this cannot be done without the help of knowledgeable teachers.

To know teachers and perspective teachers’ content knowledge of shapes, in the beginning of the interview, participants were asked whether they recognized 2-dimensional shapes shown in the picture below and asked to mention their names.

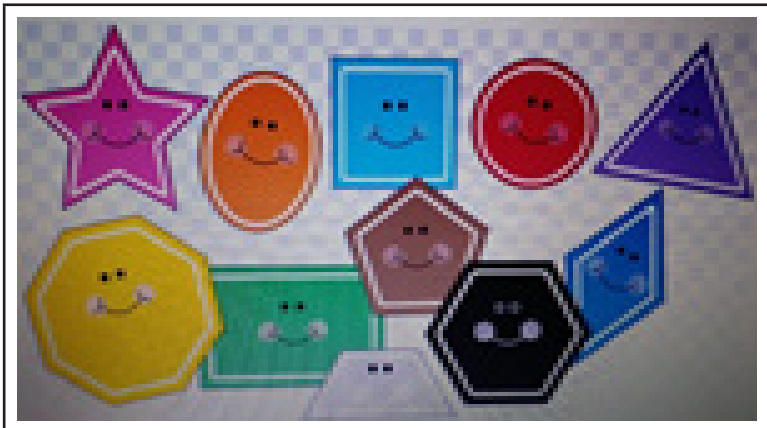


Figure 1. 2-dimensional shapes

Source: <https://www.pngdownload.id/png-xr4vow/>

Table 1. Participants' Answers

Participants	Mentioning the name of shapes	Accuracy
Teacher A	Star, oval, square, circle, triangle, octagon, rectangle, trapezium, pentagon, hexagon, parallelogram	All correct except parallelogram (should be rhombus)
Teacher B	Star, oval, square, circle, triangle, octagon, rectangle, trapezium, pentagon, hexagon, rhombus	All correct
Teacher C	Star, oval, square, circle, triangle, octagon, rectangle, trapezium, pentagon, don't know, don't know	All correct except hexagon, rhombus
Prospective teacher X	Pentagram, oval, square, circle, triangle, octagon, rectangle, trapezium, pentagon, hexagon, rhombus	All correct except the pentagram (should be star)
Prospective teacher Y	Star, oval, square, circle, triangle, octagon, rectangle, trapezium, pentagon, hexagon, kite	All correct except kite (should be rhombus)
Prospective teacher Z	Star, oval, square, circle, triangle, octagon, rectangle, trapezium, pentagon, hexagon, rhombus	All correct

Clements and Sarama (2011) argue that teachers' understanding of geometric shapes in general, including early childhood education (ECE) teachers, is still low although they also acknowledge that there are some exceptions. They explain further that most teachers lack of preparation in teaching geometric shapes to students (Clements & Sarama, 2011). A study conducted by Markovits & Patkin (2020) to assess Israeli preschool teachers about their content knowledge of shapes also showed that they lack of it. This also happened to the participants in this study. Based on the interview,

from 6 participants, only 2 people can mention all types of 2-dimensional shapes correctly. Participants explained that they taught geometric shapes to children based on what they learnt when they studied at school, as stated by the excerpts of the interview below.

Teacher C: “ I learnt geometric shapes from mathematics when I was student in junior or high school”

Teacher A: “ I teach shapes based on what I learnt in the university and by watching You Tube”

Lack of understanding about geometric shapes was also shown when participants were asked to explain the attributes or characteristics of a geometric shape. All participants only explained the attributes based on the physical appearance of the shapes instead of using the accurate mathematical language. Markovits & Patkin (2020, page 8) call this kind of definition as “intuitive definition” or children’s definition.

Prospective teacher Z:

“Triangle has 3 sides and has 180-degree angle, but I may not tell children about the angle. It is too difficult for children, so I will just explain that triangle has 3 sides”

Teacher A: “ Circle is round. Triangle has 3 lines. One line is slanted in the right. Another is slanted in the left then straight down. There are 3 sharp edges”

Van Hiele (1987), a researcher and educator from the Netherlands, suggests 5 stages of learning geometry (Abdullah & Zakaria, 2013).

1. Visualization stage (Level 0)

At visualization stage, students already know types of geometric shapes based on appearances. It can be seen from their ability to point or mention the name of the shape when they are asked. However, at this stage, they cannot mention attributes or characteristics of the shape. At this stage, it is not suggested to introduce attributes of geometric shapes to students, otherwise children will only study through memorization not an understanding.

2. Analytical stage (Level 1)

If in the previous stage children cannot mention the attributes of shapes, at analytical stage, children are able to mention characteristics or attributes of shapes by observing, experimenting, modeling, etc. For example, they can mention that triangle has 3 sides, and square has four 4 sides. However, in this stage, children cannot compare and see connection between shapes. For example, when they ask why a square is not a triangle. Children will find difficulties to comprehend that question.

3. Informal deduction stage (Level 2)

At informal deduction stage, students can find the connection between shapes and provide definition of shape fairly. They can even justify their reasoning, for example, why an object is called square.

4. Formal deduction stage (Level 3)

In this stage, children not only can accept a proof but also can create even more than 1 proof about shapes. Students can mention the name of the shape based on their observations. For example, they can conclude that an object is a square based on attributes or characteristics mentioned by the teacher.

5. Rigor stage (Level 4)

This is the highest stage, so it needs a complex thinking. Students understand geometric shapes thoroughly and accurately along with their attributes. They do formal reasoning and are able to analyze consequence from manipulation axioms and definitions.

Referring to 4 levels of geometric learning proposed by Van Hiele (1987), the participants of this study reach analytical stage (level 1) where they can mention characteristics or attributes of shapes. However, the analysis was not deep, just based on what they saw from the physical appearance of the shape or "intuitive definition". Even, participants did not use the correct term to describe the characteristics, or there were some characteristics left out. For example, they did not mention that a triangle is a close shaped with three sides and has 3 corners. Only 1 participant who mentioned that a

triangle had corners. However, she said that it was too difficult to be taught to children so it can be assumed that she would not mention about this attribute when she taught.

It is interesting to find out that this finding is similar with the research done by Clements and Sarama (2011). The prospective teachers in their research could draw a square, but most of them could not provide proper definition of square. They did not mention having 4 corners as an attribute of a square. Based on the interview in this study above, the researcher also found that all participants did not mention corner as characteristic of triangle.

Another case to show that participants' understanding of geometric shapes needs to be improved was seen when participants were asked to draw a triangle. There are 6 different types of triangles. Based on the sides, triangles are divided into 3; equilateral triangle, scalene triangle, and isosceles triangle. Based on the angles, it falls into 3 categories; acute triangle, obtuse triangle, and right triangle. The finding shows that 4 out of 6 participants drew equilateral triangle, only 2 participants drew another type of triangle (right triangle) as can be seen below.

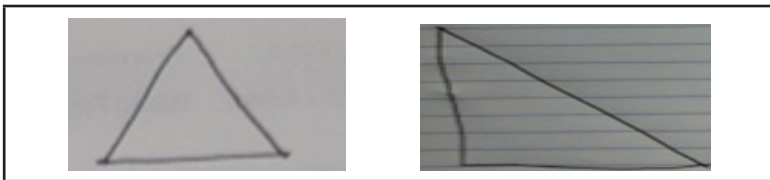


Figure 2. equilateral triangle (left) and right triangle (right)

When participants were asked about their reason why they chose to draw equilateral triangle, they answered this type of triangle was the most common model so children could understand easily. Meanwhile, for those who answered right triangle, participants felt that the triangle was not quite popular so children would learn something new.

Prospective teacher Y:

“Equilateral triangle is the most common, so it is easy for children” (prospective teacher Y)

Teacher B: “Right triangle is not often seen by children, so I choose it”

It is understandable when most participants drew equilateral triangle because it is a prototype or the most common model of triangle (Lipovec, 2009). However, other models or variants of triangle also need to be taught to children. Lipovec (2009) states that if learning is too tied to one image (prototype), it will cause difficulties in children's reasoning thinking. For example, connecting the idea of triangle into equilateral triangle will put limitation in children's thinking. Children will experience difficulty in recognizing other variants of triangles because they only familiar with equilateral triangle.

Lipovec (2009) explains further that using prototype as a model not only affects children's ability to recognize shape but also affects how they will draw the image. It means that if teachers tend to draw equilateral triangle, children will draw the same model as it is what they learn from their teacher. "Such rigid visual prototypes can rule children's thinking throughout their lives" (Clements et al., 2018, p. 10).

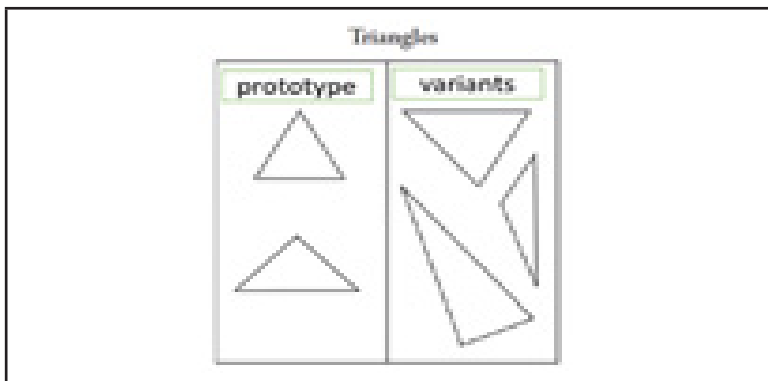


Figure 3. Prototype and variants triangles
Source: adapted from Clements et al., (2018)

There are several factors influencing students' success in study. Those factors are heredity, environment, interest and talent, freedom, and level of thinking maturity (Sa'ida, 2021). From those factors, environment is the most influential factor (Sa'ida, 2021). The environment here can be in the form of the educators. Educators need to provide the appropriate stimulus to help children to improve their ability including in geometry. In order to do that, teachers should have adequate knowledge.

Lack of understanding in geometric shapes will influence teacher's preparation in teaching and further impact children's understanding about geometric shapes. Even in the early childhood education curriculum, 3-4-year-old children only learn to group 2-dimensional shapes (triangle, square, and circle), 4-5-year-old children learn to differentiate geometric and other shapes, and 5-6-year-old children learn to sort things based on 5 series or more shapes, sizes, or colors (Ministry of Education and Culture, 2014). It does not mean that teachers only have to learn that. Teachers need to have competence beyond that level or above what is necessary to be taught to children.

Teaching geometry stimulates children's competence in mathematics and their cognitive skill. According to Clements and Sarama (2011), children's ability in geometry can be a foundation to teach mathematics more deeply because learning geometry is closely related to mathematics reasoning and a number of other mathematical concepts and skills such as proportional reasoning, knowledge in summarizing, concepts and properties, and data management and processing. However, all of them do not occur in vacuum. It is almost impossible how teachers can assist children to understand the basic knowledge of geometric shapes if teachers themselves do not have adequate knowledge about that. Teachers play a key role.

1. The Process in Teaching and Learning Geometry

All participants did similar activities in teaching geometric shapes to children. First, the teachers would bring or draw a geometric shape. After that, the teachers introduced the name of the shape. Finally, the teachers asked children to look for or match the shape with objects, as shown in the interview excerpts below.

prospective teacher X :

" I draw a triangle, then mention the name of the shape to children. After that, I ask children to look for example of shapes that I drew earlier"

Teacher C: “ Introduce the name of the shape, ask children to draw, give worksheet to match the shape with real objects”

In introducing geometry in early childhood education context, educators can connect geometric shapes with concrete objects around children (Rachmat & Sumiati, 2016) as all participants did in this study. For example, square is like books, windows, floors, etc but teachers should not limit the objects based on what children see in the class. In addition, educators need to provide opportunities for children to explore shapes further. For instance, by giving children the opportunity to explore through grouping objects based on the same geometric shape, manipulating shapes, combining various shapes into a creation or even breaking shapes.

Teachers should provide varied, child-centered, and fun activities, not just introducing the names of geometric shapes and asking children to repeat what the teacher said and answering teachers’ question to name the shape (Rachmat & Sumiati, 2016) . Giving similar activities will cause children less interested in the subject they learn. They will get bored with the less challenging and monotonous lesson. This also will impact children’s understanding in geometry such as having low level of geometric shape ability and hindering children’s potential in their cognitive development.

2. Assessment in Geometry Learning

Participants were asked how they ensured that children knew the shape they just learned. All participants answered that they would ask children to mention what shape they just learnt or ask them to take a certain shape among other different shapes. Learning was considered successful when children could correctly answer or take the shape requested by the teacher.

Teacher B: “ We repeat. We ask children to mention the name of the shape”

Prospective Teacher Y:

“We give many kinds of shapes, for example

in doing tassel. Then, we ask children to take a certain shape. When they take the wrong shape, it means they have not succeeded yet”

Clements and Sarama (2011) explain that the interaction between teacher and children in learning geometry is underdeveloped. Usually, children are only requested to repeat what they already know about shape without being given new or additional information (Clements & Sarama, 2011). Teachers only ask close-ended question, such as “what shape is it?”. If children answer correctly, teachers only respond “correct” without giving elaboration or asking follow-up question to assist children to develop their ability justifying their answer. This happens in this study. Teachers just asked the name of the shapes to children to assess children’s understanding of shapes. This kind of question can be considered as a low level order of thinking instead of asking children to justify their answer to stimulate their higher order of thinking. Markovits and Patkin (2020) argue that ECE teachers do not provide sufficient stimulation about geometric shapes to children. The impact of such monotonous learning will make children to be bored and not interested in learning, be less attentive to teachers, and be passive learners (Rachmat & Sumiati, 2016).

D. Conclusion

In Indonesia, mathematics in early childhood education context still emphasizes on numbers. Other basic mathematics subjects, such as geometry possibly gets less attention. The findings of this study can be used an example. Despite their educational backgrounds or teaching experiences, early childhood education teachers and prospective teachers showed lack of understanding about geometric shapes in three areas, their content knowledge of shapes, how to teach and assess children’s learning in geometry.

Preschool teachers’ quality of knowledge impacts the children’s knowledge. This is also applicable in geometric shapes. Despite the limitation of the study in which the data solely gathered through interview, the condition found in this

research can impact children's understanding in geometry such as having low level of geometric shape ability, getting bored with the less challenging and monotonous lesson, hindering children's potential in their cognitive development, etc.

Considering the fact that in Indonesia, the education background of early childhood education teachers is varied and the limitation of time given by universities to teach early mathematics to prospective teachers, schools and universities can provide professional development or additional training in other areas of early mathematics, such as geometry. Early childhood education teachers as well as prospective teachers should be encouraged to sharpen their knowledge instead of just being content with what they already learnt at school or universities. All children deserve good quality of education. It can be achieved only when teachers become long life learners not only their students.

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