Exploring Geometric Cognition of Young Children

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Abstract

The purpose of this study was to explore young children's geometric cognition by means of figures. The participants selected from a kindergarten in Pingtung County, Taiwan, included 10 children from the first year class, 11 from the second year class, and 5 from the third year class. Researchers observed and recorded the children's performance through activities and interviews. Seven activities applied in the study included three phases of manipulating objects, identifying figures, and constructing figures.

The study showed most of the young children described figures by their experiential perception, where only a small number of them could partly identify a figure's attributes. For further future study, it is suggested that researchers examine children in their implicit and naive conceptions of geometry.

Key words: figure test, geometric figures, spatial concept

Ⅰ.INTRODUCTION

What is geometry? Why do young children need to gain geometric knowledge? Freudenthal (1973, cited from Bruni & Seidenstein, 1990) pointed out that geometry is the research of spatial relationships and that teachers should provide children the best opportunity for integrating math with real world concepts. Through their sensory experience stimulated from space, young children develop sound understanding by applying the senses of sight and touch, plus linguistic expression.

In order to grasp young children's development of geometric knowledge, researchers exposed them to a series of geometric activities on figures. The researchers analyzed the data collected from the observations, recordings, and interviews.

The Curriculum Standards for Kindergartens, published by the Taiwanese Ministry of Education (2003) indicate that the goal in elementary education is to develop children's correct learning conceptions, attitudes, and methods of natural science. It is also said from its learning content that spatial concept is a very important and common core conception.

Ⅱ.THEORETICAL BACKGROUND

Piaget and other theorists (Piaget, Inhelder, & Szeminska, 1960; Piaget & Inhelder, 1967) have suggested three levels of children's geometric development: A: topological, the whole of geometric shapes, for example, connectedness, enclosure, not taking size into account, B: projective, observing an object from different angles, C: Euclidean, taking the distance, direction, angle, and length of an object into account. Children ages 3 to 4 are at the topological level, in which they represent figures as enclosure or openness regardless of Euclidean geometry, such as side lengths, angles, and sizes. Children ages 4 to 6 are in the transition stage; it's not until ages 6 to 8 that they perceive the concept of Euclidean geometry.

Kao (2002) researched children's strategies for geometry recognition and linguistic expression of figures. He found children's misconception of space mainly resulted from a figure's closure, position, and size. Kindergarteners are subject to misidentify a square when it was placed on an incline. They tended to describe a circle and a rectangle with their sense of sight, for example, most children described a triangle as "three angles." Zhung (2005) found that young children needed to receive clues about their surroundings to identify their position and direction. She analyzed children's spatial cognition abilities via spatial cognitive maps made by the children to gain insight into their cognitive abilities and into the spatial cognitive variances with different ages. Chou (2005) proposed young children could develop excellent spatial concepts through hands- on activities. Teachers could revise the activities in accordance with children's ages and characteristics, and classroom setting to meet their needs.

Ⅲ.METHODOLOGIES

1: Participants

The sample of the study, selected from a kindergarten in Pingtung County, Taiwan, included 10 children from the first year class, 11 from the second year class, and 5 from the third year class (thirteen boys and thirteen girls).

2: Instrument Design

Researches regarding teaching and learning geometry plus young children's geometric strategies of different ages from field observation were collected and analyzed. Seven hands-on geometric activities were then developed following the analysis. The activities applied for the research were conducted with observation and interview shown as following:

(1)Manipulating real objects: to perceive geometric models through the senses of sight and touch and to describe the name of a figure and its attributes.

(2)Recognizing figures: to judge the position, size, spatial relation of a plane figure.

(3)Recognizing open and closed figures: to trace a figure from one side to the other with their fingers.

(4)Recognizing the open direction of a figure: young children consider an angle as a closed place while an open direction as an open place.

(5)Recognizing geometric figures: to explore if children discover the attributes figures by informal reasoning.

(6)Duplicating lines- lines are basic elements of shapes. Children are asked to draw identical lines as shown on the paper.

(7)Constructing figures- to observe children's abilities of drawing and hand-eye coordination by children's hand drawings and their movements..

The teachers of the kindergarten were asked to comment on the testing instrument of the seven activities before a trial test was givent to three children chosen from the first year class, the second year, and the third year class. After discussion and revision according to the results of the drafts, a final version of the testing instrument was created.

3. Activity Designs and Assessment

Figure tests for this study included seven questions. Each child had 25 minutes to finish the tests. The children's performances were observed and recorded.

4. Data collection

Qualitative data collection for the study involved individual interviews, test records, and video recordings of the entire process of activities, from which a thorough analysis of young children's geometric cognition were expected. Quantitative data collected statistical and analytical information through science activities so that the levels of young children's geometric cognition could be understood.

Ⅳ.RESULTS AND DISCUSSION

Activity 1: Manipulating Objects

A. Question: What shape do you think it is?

□Apple_____ □Sandwich_____ □Handkerchief____ □Tissue___

□Book_____ □CD _____□Eraser_____ □Roof____

B. Observation and Record

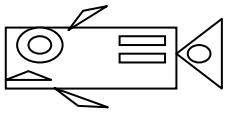
All of the 26 young children could identify the basic shapes.

C. Analysis and Discussion

All of the children (n=26) were able to say the names of the shapes, but only 3 of them could identify the shape diamond when a handkerchief were formed into a diamond. Most of the children falsely called it a square or a rectangle.

Activity 2: Recognizing Figures

A: Question: How many circles, triangles, squares, and rectangles are there in this figure?



B: Observation and record

Children were asked to determine the position, size, and spatial relation of a plane figure. Ninety-two percent (n=24) was at variance in identifying three-dimensional figures with different ages. The third year class achieved a 100% passing rate. The second year class achieved 73-percent passing rate. (n=8). The first year class only achieved 40% (n=4) passing rate.

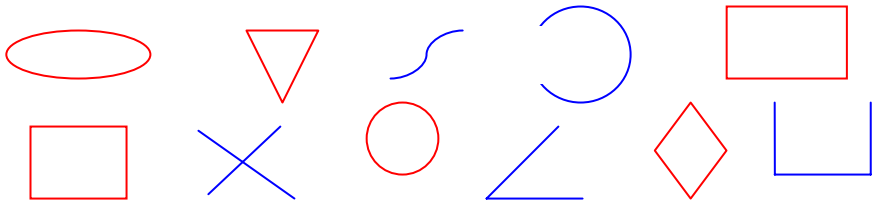
C. Analysis and Discussion

During the activities, the third year class could each correctly identify circles, triangles, and squares. Four children of the second year class were confused with squares and rectangles, in which they did not have sound conception of side length of a quadrangle. One of the children had a hard time distinguishing an inner circle from an outer circle; some of

the children also had difficulty in distinguishing a square and a rectangle. However, there were 4 children in the first year class having very good recognition of a circle and 3 of a triangle, while 2 children considered the rectangle and the square to be the same thing. They did not pay attention to the four equal sides of a square.

Activity 3: Identifying Figures

A. Question: Given a piece of paper, the children were asked to point out which figures were open, and which were closed.



B. Observation and Record

(1)The first year class: Five children could answer the questions correctly. The children even gave examples from daily life. For instance: A fan had 4 blades.

(2)The second year class: All of the 10 children had strong identification with open and closed figures. They regarded an open figure as a hole and vice versa so that most of them could pass the test.

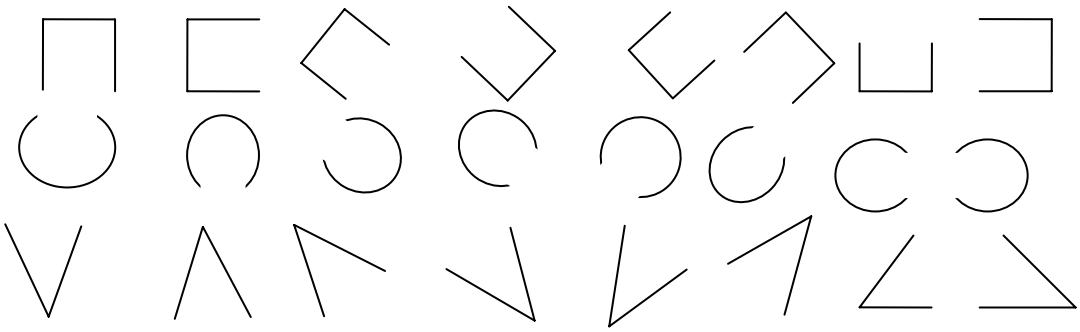
(3)The first year class: The children were weak identifying open and closed figures, where only one of them passed the test. Later by teaching the children an open figure was when a big bad wolf could get in and eat people and, if it was closed, the wolf was kept out, more of them passed the second test. However, there were still 7 of them could not identify curved lines.

C. Analysis and Discussion

hildren in the second and third year classes could each identify open and closed figures, while most of the children in the first year class had weak identification with the figures. The first year class passed the second test after being given a hint.

Activity 4: Identifying Figures

A. Question: Given a piece of paper, the children were asked to identify the open orientation of a figure.



B. Observation and Record

(1) The second and third class students were able to point out the open orientation of up,

down, left, and right with their hands as if they were having their vision checked.

(2) The children had strong spatial concepts of and rapid reactions to up & down, left & right, the upper right, the lower right, the upper left, and the lower left.

C. Analysis and discussion

The second and third year classes had quick responses to an open orientation due to the experience of vision checking while the minority of the first year class could not understand the purpose of the openness.

Activity 5: Identifying figures

A. Question: Given a piece of paper with 30 numbered figures, the children were asked to identify which is square, which is not square, which is triangle, and which is not triangle?

B. Observation and Record

(1) Figures with base line were easily recognized by the children. For examples: figures 10 and 26 are squares; figures 27, 17, 2, 8, and 22 are not triangles.

(2) Levels of geometric thinking have nothing to do with the children's ages. The children's performances of this recognition are associated with if the teachers' instructional methods can meet the children's development.

(3) Some of the children considered that a regular triangle and a square have to parallel a tabletop.

C. Analysis and Discussion

The third year class could each complete the identification very well, and 2 of children in the second class were able to distinguish the discrepancy in a square and a quadrangle. However, the first year class thought a quadrangle was a square and a triangle was as same as a regular one.

These children were realizing how to pay attention to the properties of the figures and describe them. For example, a square has four equal sides and 90 degrees; the opposite sides of a rectangle are the same length. Despite this, most of the children did not draw four angles at the corners. Generally, the older the child is, the more right angles he or she will distinguish.

Activity 6: Duplicating Lines

A. Question: The children were asked to draw lines as shown below on a piece of paper.

Vertical lines Oblique lines Curved lines Horizontal lines Oblique lines

B. Observation and Record

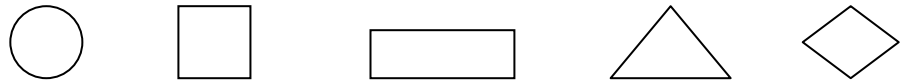
In the process of duplicating lines, the young children completed the tast quickly on horizontal and vertical lines, yet were confused with the directions of curved lines. The third year class was the only class able to draw the lines without any errors.

C. Analysis and Discussion

Most of the children excelled at duplicating lines. Overall, the whole year class did well in the duplicating lines. 9 out of the second year class passed the duplication test, while only 3 out of the first year class succeeded in it.

Activity 7: Constructing Figures

A. Question: Children were asked to construct figures on a piece of paper as shown:



Circle Square Rectangle Triangle Diamond

B. Observation and Record

The researchers drew five basic figures: regular triangle, circle, square, diamond, and rectangle on the top of a piece of paper and invited the children to construct each figure below the example without any assistant tools. The third year class passed in all of the figures, except one child failing the shape diamond. Ten children of the second year class passed the circle, 9 the square, and 8 the rectangle & triangle. As for the diamond, there was only one child who failed. Nine children of the first year class passed the circle except for one. Only one child in the first year class passed the shape square.

C. Analysis and Discussion

(1) The young children displayed a thorough understanding of duplicating the shapes, and were all working very hard on it. A circle was the fastest finished figure, whereas a diamond with multiple angles was the most difficult shape to complete. The shape of square and rectangle were drawn almost the same.

(2) The children who completed the circle might not be able to identify the diamond.

(3) Duplicating figures was even more difficult than identifying figures particularly in the first year class children.

Ⅴ.CONCLUSIONS AND SUGGESTIONS

As young children grow, their conceptions keep developing by continuously receiving new information. According to Piaget's theory of cognitive psychology, young children learn to fit the realities by assimilation and accommodation. The process of forming a concept can be regarded as assimilation, while the development of a concept can be seen as accommodation. Learning is unceasing constructive progress of assimilation, accommodation, and knowledge restructuring. It is essential for early childhood educators to understand young children's conception of ego development in order to smoothly lead children into future scientific concepts.

This study shows most of the young children perceive a figure as a whole when describing its Attributes and just a few of them can tell about the properties of its parts. Children at the early childhood level can merely conceive and not recognize geometric shapes. Because of lacking mature visual perceptions, they are unable to recognize the differences of the same kind shapes. For example, they can distinguish a square from a circle, but they cannot distinguish a square from a

rectangle.

Actually children's mental representation of the real world is no longer more than a memory, but an actively reconstructive symbolic representation of an object. The process of the reconstruction is not simply perceptual. How do children identify an object before seeing it? Instruction in geometry should provide a visual and analytic learning setting so that the children's visual perception limitation can be conquered. This study suggests that in the future, the findings in children's geometric concepts can be applied to pedagogy and to experimental teaching projects to assess young children's geometric cognition and development.

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