Studies of level visual thinking in geometry

Anwar and D Juandi

Department of Mathematics Education, Postgraduate School Universitas Pendidikan Indonesia, 229 Dr. Setia Budhi Street, Bandung 40154, Indonesia

E-mail: anwar@upi.edu

Abstract. Learning mathematics is how students get information that is built capable of solving a problem. One way of thinking someone is by visual thinking. Visual thinking has an important role in the success of mathematics learning, especially in solving mathematical problems that require high-level reasoning, one of them in solving the problems of abstract geometry. Although to help students develop their ability to think visually or visualize, first the teacher must pay attention to the level of visual thinking of students. This paper aims to determine the level of visual thinking in geometry. Based on the results of the literature review the authors built three levels of visual thinking in geometry, level 0: Non-visual (NV), level 1: local visual (LV) and level 2: Global Visual (GV).

1. Introduction

Learning mathematics is how participants get information that is built to resolve a debate. To receive information, it cannot be separated from the thought process. Thinking is a mental activity, thinking is a process for producing representations through information transformation, then gathering information related to visuals and containing other information related to abstract forms [1]. Understanding of visual information in thinking is called visualization or visual thinking (Visual Thinking).

Visual Thinking is an intuitive intellectual process and the idea of visual imagination, both in mental imaging or through images [2]. [3] defines visual thinking as the ability, process, and results of creation, interpretation, use, and ideas about images, images, and diagrams in mind, on paper or using technological tools. [4] defines visual thinking is also an ability to change all types of information into images, graphics or other forms that can help to communicate information. So that visualization and visual thinking is a thinking ability that converts verbal statements into images, images, and graphics.

The research literature on mathematics education has long discussed the benefits of visualization or visual thinking and analysis in mathematical thinking. Even according to Huang, visual thinking has become an interesting field for a number of researchers concerned with mathematics education so many researchers emphasize the importance of visual thinking and visual reasoning for learning mathematics, and visual thinking is a fundamental aspect of understanding, constructing mathematical concepts [5]. In addition, visual thinking is also interested in discussing considering many previous researchers found that due to the use of incorrect visual representations so students experience limitations and difficulties. Student difficulties found in solving problems, diagrams, reading graphs correctly, understanding formal mathematical concepts and solving mathematical problems. One branch of mathematics that requires the ability to think visually in understanding concepts and solving mathematical problems, namely geometry.

Geometry is a branch of mathematics that is taught at every school level, from elementary school to college. In studying geometry can foster the ability to think logically, develop problem-solving and giving reasons and can support many other topics in mathematics. According to[6] said five basic
geometry skills need to be discussed and considered in-depth at the secondary school level, namely visual, verbal, drawing, logic and applied skills.

Although geometry has been taught since elementary school, in reality, geometry is still considered a material that is difficult for students to understand. For example: students are given a case which is; *A swimming pool with a length of 80 meters, a width of 20 meters and a depth of the left side of the pool 1 meter and ramps to a depth of the right side of the pool 3 meters, then draw a model of the pool and calculate the volume of the pool if the water is filled?*. 

Look at the following three student answers;

![Student 1](image1)
![Student 2](image2)
![Student 3](image3)

**Figure 1. Student answers in drawing / illustrating**

Based on Figure one above, it appears that from the three students answer in describing the swimming pool model according to the information in that problem is not true. For example: student 1’s answer in describing the shape is unclear and the assignment of grades that are still wrong and does not show a geometric shape, as well as student’s 2 which has a flat figure shape, incorrectly placed grades and does not illustrate the shape of a swimming pool, as well as student 3 which actually has seen a building space, but the placement of values is wrong so the illustration is wrong. This shows that there are differences in students visual thinking processes in solving that problem, it also states that there are differences in the level of visual thinking in solving problems.

2. **Methods**

The research used a qualitative approach with a grounded theory method. Grounded theory is a qualitative research design in which the inquirer generates a general explanation (a theory) of a process, an action, or an interaction shaped by the views of a large number of participants [7]. But in this paper, the author is still reviewing articles and journals related to visual thinking and the level of visual thinking. The results of the study of various articles or journals will be used to determine levels of visual thinking in geometry.

3. **Result and Discussion**

Thinking is a complex combination of words, images, scenarios, colors and even sounds or music [8]. According to Gilmer thinking is a problem solving and the process of using substitute ideas or symbols that appear physically [9]. So that this thinking is a form of mental activity or processing information in the mind.

[10] explains that there are three ways of thinking a person namely: auditory thinking, visual thinking, and kinesthetic thinking, related to how our brain processes information based on hearing, sight and gestures and feelings like the picture below.
Visualization is the ability, process, and product of the creation, interpretation, use, and reflection of images, diagrams that are in our minds, then written / illustrated on paper or by using technological tools, with the aim of describing and communicating information, thinking and developing idea which was previously unknown and provides understanding [3]. Visualizing a situation or object involves mental manipulations of various alternatives to solve problems related to a situation or object without using concrete objects [10]. Whereas [11] states that visualization is a transformation between mental construction and external objects, media or events. The individual identifies with the object or process in him or in his mind. Visualization is an individual's ability to see and understand problem situations.

Visual Thinking is an intuitive intellectual process and the idea of visual imagination, both in mental imaging or through images [2]. [3] defines visual thinking as the ability, process, and results of creation, interpretation, use, and ideas about images, images, and diagrams in mind, on paper or using technological tools. [4] defines visual thinking is also an ability to change all types of information into images, graphics or other forms that can help to communicate information. Visual thinking is the process of forming and relating ideas and discovering new emergent patterns [12].

Based on the opinions of experts about visual thinking, the author defines visual thinking is the process of analytical thinking in interpreting and understanding information or concepts that exist in the mind in the form of images, images, graphics, diagrams or other forms that can help to communicate information.

Visual thinking plays an important role in the success of learning because students who learn without using the ability of Visual thinking are prone to experience misconceptions, the ability of Visual thinking plays a role in solving problems of problems that require high-level reasoning. In addition, it can also make it easier to understand complex problems, simplify problems, see connections to related problems, instead of calculations, can be a bridge from abstract-verbal to clearer forms, helping to clarify what is seen from the problem in line with what is thought.

**Level of visual thinking**

In visual thinking, a person has levels or levels of thinking. This is in line with the results of Huang study of 15 participants then grouped into three levels of visual thinking in understanding the concept of unlimited integrals. These three levels are non-visual, local visual and global visual. This non-visual group cannot recognize the relationship between area and integral, solving problems using symbolic representation, relying on analytic thinking and not visual thinking; this visual local group is able to see and confirm the relationship between various visual images, but cannot yet distinguish the relationship between the two; whereas global visual groups can use relationship relationships to build consistent structures based on the relationship between various visual images. So the authors build the characteristics of the level of visual thinking on geometry as in the table below.
Table 1. Characteristics of the level of visual thinking in geometry

| Level of visual thinking | Characteristics |
|--------------------------|-----------------|
| Non-visual               | - Students do not involve visual thinking in solving geometry problems;   
|                          | - Students tend to solve geometry problems using symbolic representations; 
|                          | - Students in solving geometry problems are still in the invalid category; |
| Local visual             | - Students already involve visual thinking; 
|                          | - Students have not been able to distinguish the relationship between several images in geometry; 
|                          | - Students use symbolic representation correctly; 
|                          | - Students are able to solve geometry problems |
| Global visual            | - Students already involve visual thinking; 
|                          | - Students are able to distinguish relationships between images, begin to recognize the traits they observe, have been able to mention the regularities found in the images they make or observe; 
|                          | - Students have used symbolic representation correctly; 
|                          | - Students solve geometry problems correctly |

Based on the table above, the level of visual thinking in geometry can be described as shown below.

Figure 3. Level of visual thinking

3.1. Illustration

Mr. Andi wants to install the ceramics in the middle room with an area of 12 x 8 m, 2 bedrooms 4 x 3 m, 1 master room which is 6 x 4 m, a kitchen that is 8 x 3 m, and a bathroom that is 3 x 2 m. If Mr. Andi wants to install ceramics in each room with a size of 50 x 50 cm and a size of 20 x 20 cm for the bathroom.

a. Draw a sketch of Mr. Andi's house!

b. How many ceramic boxes are needed by Mr. Andi to be installed in the living room, bedroom, master room, and kitchen, if each box is 1 meter wide!

c. How many ceramic boxes are needed by Mr. Andi to be paired in the bathroom, if each box is 1 meter wide!

d. If the price of 1 ceramic box that is 50 x 50 cm is Rp. 86,000.00 and 1 ceramic box measuring 20 x 20 cm is Rp. 75,000.00, so how much money must be spent by Mr. Andi to buy the ceramics!
From the above problems, based on the answers and problem-solving processes we can determine students in the level of visual thinking as shown below:

- **Student non-visual:** Students do not sketch Andi's house, the process and results of the settlement are invalid, solving problems directly using symbols, do not take pictures or sketch the problem validly, do not involve visual thinking in solving the above problems;
- **Student local visual:** Resolving problems by creating images, has not been able to connect the interrelationships of answers b, c and has not been able to distinguish the relationship between several images;
- **Student global visual:** Solve problems by making pictures, able to connect every problem in a, b, c and d, solve it with the right procedure, able to explain the relationship of each picture he made.

### 4. Conclusion

Visual thinking is the process of analytical thinking in interpreting and understanding information or concepts that exist in the mind in the form of images, images, graphics, diagrams or other forms that can help to communicate information. Visual thinking plays an important role in the success of learning because students who learn without using visual thinking skills are prone to misconceptions, the ability to think visually is to solve problems from questions that require high-level reasoning. In addition, it can also make it easier to understand complex problems, simplify problems, see connections to related problems, instead of calculations, can be a bridge from abstract-verbal to clearer forms, help clarify what is seen from the problem in line with what is thought. Based on the results of the study of visual thinking, the authors build the level of visual thinking in geometry into four levels, level 0 and level 1, non-visual (NV); level 1, local visual (LV); and level 2, global visual (GV).

### Acknowledgments

The authors would like to thank the Lembaga Pengelola Dana Pendidikan (LPDP) as the sponsor of this research in a contract number: 201710210811817. The opinions expressed in this paper are those of the authors and do not necessarily represent the views of LPDP.

### References

[1] Solso R L, Maclin O H, Maclin M K 2007 *Psikologi Kognitif* (Jakarta: Erlangga)

[2] Brouseau G 1991 *Theory of Didactical Situation in Mathematics* (Dordrecht: Kluwer Academic Publishers)

[3] Bolton S 2011 *The Coding Visual Thinking* Never Workshop, Visualising creative strategies

[4] Arcavi A 2003 The role of visual representations in the learning of mathematics *Educational Studies in Mathematics* **52** 215-41

[5] Stoke 2001 *Visual Literacy in Teaching and Learning: A Literature Perspective* (US: Troy State University)

[6] Huang HC 2013 Engineering student's visual thinking of the concept of definite integral *Global Journal of Engineering Education* (New Taipei City, Taiwan: Ming-Chi University of Technology)

[7] Hoffer A 1981 Geometry is more than proof *The Mathematics Teacher* **74** 11-8

[8] Creswell 2013 *Qualitative Inquiry Research Design Choosing Among Five Approaches* (London: SAGE Publications)

[9] Nicholl R 2006 *Accelerated Learning for the 21st Century* (Bandung: Nuansa)

[10] Gilmer 1970 *Psychology* (New York: Harper)

[11] MOE 2001 *Curriculum Planning and Development Division: Mathematics Syllabus* (Singapore: Author)

[12] Zaskiss R D 1996 Coordinating visual and analytic strategies: A study of student understanding *Journal for Research in Mathematics Education* **27** 435-57