Scaffolding profile in solving geometry problems in terms of van Hiele level

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Abstract. Solving the geometry problem is not an easy matter for some students. In addition to relying on understanding concepts, problem type exercises, scaffolding is also considered important to assist students in solving geometry problems. This study looked at the scaffolding process for students in solving geometry problems in terms of the van Hiele level. There are three groups of research subjects with each group of subjects representing students who have the ability of geometry at the visual, analytical, and informal deduction levels at the van Hiele level. The research method used is descriptive qualitative. Qualitative methods are used to analyze the subject scaffolding at each level of van Hiele in solving geometry problems. The results of the study found that subjects with a visual level tend to solve problems by presenting them in the form of images without observing in-depth the concepts used. So it takes scaffolding in terms of image presentation, mathematical concepts, and problem-solving flow. Subjects with the level of analysis identify the nature of the wake in the problem to determine the mathematical concepts used. Scaffolding is needed in the form of image presentation and problem-solving flow. While subjects with an informal level of deduction can determine the mathematical concepts used by first looking at the properties of the image. However, subjects at this level still need scaffolding in the problem-solving flow.

1. Introduction
Facts show that many students encounter difficulties in solving problems in the field of geometry. Moreover, the types of questions from various exams ranging from semester exams to national exams already use questions with the Higher Order Thinking Skills (HOTS) standard. Besides the practice and habituation of students in working on problems is at risk in this situation, it is hoped that scaffolding from the teacher can also be used as a solution to overcome these problems.

Radford et al in his writing "Fostering learner independence through heuristic scaffolding: A valuable role for teaching assistants” says that Scaffolding originated from Vygotsky's sociocultural theory [1]. This theory proposes that, through social interaction with others at the intermental level, children develop higher mental functions such as thinking and reasoning. To be effective, such social exchange must be within the zone of proximal development (ZPD), which is the distance between what they can achieve themselves and what they can do with the help of others who are more capable [2].

Scaffolding is to provide individuals with assistance at the beginning of learning, then reduce the assistance and provide opportunities for students to take over their duties after being able to do it independently. Assistance provided by teachers can be in the form of instructions, warnings, encouragement, describing problems in other forms that allow students to be independent. Scaffolding means the teacher’s way to guide students to achieve success. Teacher encouragement is needed so
that students can achieve optimal achievement. Not only in the learning process, scaffolding can also be given in the process of solving problems to help children in solving problems or tasks.

Scaffolding has a contribution to the process of learning and teaching in class. This was revealed as a positive strategy even though the research said it was still not maximal in the implementation process [3]. Anghileri proposed three levels in scaffolding that specifically support mathematics learning, namely Level 1: Environmental provisions (classroom organization, artifacts such as blocks) that is the learning process that can take place without direct intervention from the teacher. Level 2: Explaining, reviewing and restructuring. There is a direct interaction between the teacher and students associated with the subject matter to be given in class. Level 3: Developing Conceptual thinking. Teaching and learning activities that emphasize the development of conceptual thinking skills. At this level, students get support to build, develop, and produce conceptual discourse [4].

Van Hiele level descriptors for five level. Visual level: children are able to recognize and name basic shapes. Analysis level: recognizable traits but as separate entities and not related to each other, informal deduction level: students begin to build relationships between the properties of forms, formal deduction level: the meaning of deduction is realized and students know what is needed to develop an evidence and definition is needed so that the evidence becomes clear, and rigor level: students understand the axiom system and can accept evidence that is contrary to intuition and what is real to students as long as the argument is valid [5].

2. Research methods

There are three groups of subjects in this research, with the details of one group of subjects representing the geometry ability of students at visual level of van Hiele levels, one group of subjects representing the geometry ability of students at analysis level of van Hiele levels, and one group of subjects representing the ability of geometry students at informal deduction level of van Hiele levels [6,7]. Then the three groups of subjects are given a geometry problem that requires high-level thinking skills in solving them.

During the problem-solving process, students waited for and conducted interviews and scaffolding by researchers. From the series of problem-solving processes, the result will be analyzed qualitatively about scaffolding process needed by the subject to solve the problem presented based on the ability of van Hiele level geometry. Then from the description of the scaffolding students will formulate a scaffolding profile in solving geometry problems in terms of the van Hiele level.

3. Research Finding

Students are given geometry problems as follows.

![Figure 1. Research question.](image)
Based on research conducted on subjects at the visual, analytical, and informal deduction levels of van Hiele, the following data were obtained.

3.1. Level 0 subject (van Hiele Visual Level)
The subject answer

![Figure 2. Visual level subject answer.](image)

**Table 1. Visual level subject interview.**

| P1 1001 | From the picture, how is your idea to solve it? |
|---------|-----------------------------------------------|
| S1 1001 | (Long silence with no response)               |
| P1 1002 | What kind of two-dimensional figure it is?    |
| S1 1002 | Rectangle, but (silence) there is also a triangle |
| P1 1003 | It means that $\alpha$ is what kind of triangle part? |
| S1 1003 | Triangle side                                 |
| P1 1004 | How to define the length?                     |
| S1 1004 | (Long silence, look at the researcher and smile) |
| P1 1005 | Remember the Pythagorean theorem? Can it be used for all triangles? |
| S1 1005 | For right-angled triangle (doubtful)           |
| P1 1006 | Is there any right-angled triangle on this picture? |
| S1 1006 | There is no sign of it                         |
| P1 1007 | Can you provide a line to form a definite triangle? |
| S1 1007 | Add a line here (point to a perpendicular line that intersects at point $\theta$) |

Van Hiele level descriptors for the visual level namely students can identify and operate structures such as squares, rectangles, triangles, and other geometric configurations such as lines, angles, and characteristics according to their visual form. Subjects at this level cannot directly guess how the problem can be solved. The observation and analysis process of the subject is only focused on visualizing images that appear, just like focusing on the rectangular and triangular. The subject also know that $\alpha$ that is asked is part of the triangle side.

Then the teacher gives further scaffolding in the form of a stimulus to come up with an idea about what triangles can be used. The teacher gives instructions by first raising the issue of what is the Pythagoras theorem. The Pythagoras theorem is presented as scaffolding for the subject to recall the right-angled triangle. So that the subject gets a clue that he needs the role of a right-angled triangle in solving the problem. The next scaffolding provided is to make right triangles by first adding helplines to the problem. The series of scaffolding process provided by the teacher as a form of service to subjects at the visual level that has the characteristics of identifying lines, angles, square, triangles, and other geometric configurations.
P1 1008  What do you get from drawing a line through point O?
S1 1008  There are 4 rectangles, these lines (referring to the four lines that are asked and known) rectangles diagonal
P1 1009  Did it form the right-angled triangles as expected?
S1 1009  Yes, Half of this triangle (referring to one of the triangles)
P1 1010  Using the Pythagorean theorem, can you present it in the form of an equation?
S1 1010  Yes, I can
P1 1011  Using all these 4 equations, what can you do to define the value $a$?
S1 1011  (Long silence with no response)
P1 1012  There are four equations, whereas you will determine the value of one of these equations. what do you have to do?
S1 1012  Add up or subtract between several equations
P1 1013  Which equation will be added or subtracted? (Long silence)
                  Pay attention to the sides of the equation of the same size. What you are looking for is the length of $a$. So, which equation can be used to define $a$?
S1 1013  Equation 1 is summed with Equation 3
Why is it?

Because GC has the same size as DE, then \(DE^2 + EO^2 = 3^2\). The Value of \(a\) is 16.

The interview above continuous with subject indicators at van Hiele visual level according to Fuys. The subject identified the properties in the rectangle formed by the addition of two perpendicular lines. Researchers provide scaffolding by asking whether the right triangle formed as a stimulus. Scaffolding in the form of instructions for using the Pythagoras theorem to be some equation is also needed by the subject. Based on the data above we know that many types of scaffolding in the form of instructions or directions, questions, and so on in helping the subject at the visual level of van Hiele in solving a problem.

The data above shows that subjects who are at the visual level cannot immediately decide on a theory, proposition, or flow in the process of solving a problem. Subjects tend to observe and identify the visible characteristics. So it is necessary to observe the properties of the shape visually first, then try to arrange and connect some of the properties of the shape as a basis for determining the theorem or the flow of problem-solving. The type of scaffolding students needed in the process of presenting and processing a flat figure, flow in the process of problem-solving, and some concepts in mathematics.

3.2. Level 1 subject (van Hiele Analysis Level)

The subject answer

![Figure 5. Analysis level subject answer.](image)

Table 3. Analysis level subject interview.

| Question | Response |
|----------|----------|
| P2 1001  | From the picture, how is your idea to solve it? |
| S2 1001  | (Long Silence) This is Rectangle, but it seems like \(a\) is not part of the diagonal. Is not straight |
| P2 1002  | How about the triangle at that figure, can you use it to define the value of \(a\)? |
| S2 1002  | Maybe yes (doubtful and confused) |
| P2 1003  | It means that \(a\) is one of the triangle sides Do you still remember the theorem that can be used for triangle? |
| S2 1003  | Pythagorean theorem, but only on right-angled triangles. |
| P2 1004  | good Is there any right-angled triangle on this picture? |
| S2 1004  | Nothing |
| P2 1005  | How can you make a right-angled triangle so that the value of \(a\) can be determined? The four lines intersect at O |
| S2 1005  | It means that we have to make a new line that intersects on O, so that it will become the right-angled triangle. |
Van Hiele level descriptors for the level of analysis students can analyze shapes based on their components and relationships between components, determine the properties of group of shapes empirically, and use traits to solve problems. Subjects in this level consider the properties that exist in the rectangle in the form of diagonals to determine the value of $a$. Because rectangular diagonal properties cannot be used in this problem, the subject gets scaffolding from the teacher to use the properties in the triangle to solve it.

Then the teacher gives further scaffolding in the form of a stimulus to come up with an idea about what triangles can be used. The teacher gives instructions by first raising the issue of what is the right-angled triangle. A right-angled triangle is raised as a scaffolding for the subject to recall the special properties inherent in the right triangle. So that subjects can predict and can guess that the Pythagorean theorem can be used in solving the problem. The series and process of scaffolding provided by the teacher as a form of service to the subject at the level of analysis have the characteristics of using built-in recognizable attributes but as separate entities and not related to each other.

**Figure 6.** Analysis level subject answer.

**Figure 7.** Analysis level subject answer.

**Table 4.** Analysis level subject interview.

|   |   |
|---|---|
| P2 1006 | What do you get from drawing a line through point O? |
| S2 1006 | These four lines (pointing to four intersecting lines at point O) the hypotenuse of a right-angled triangle. |
| P2 1007 | Using the Pythagorean theorem, can you present it in the form of an equation? |
| S2 1007 | Yes, You can |
| P2 1008 | Using all these 4 equations, what can you do to define the value $a$? |
| S2 1008 | (Long Silence) |
| P2 1009 | There are four equations, whereas you will determine the value of one of these equations. what do you have to do? |
| S2 1009 | Eliminating an equation that already has a value (Elimination) |
The interview above continue with the subject indicators at van Hiele visual level according to Fuys. The subject can recognize the properties of right-angled triangles formed by perpendicular lines through point O. It is also able to integrate well between geometry material which is the subject of problems with material elimination and substitution, with various types and types scaffolding in the form of instructions, directions, questions as a stimulus, and visual scaffolding provided by the teacher.

The data above shows that subjects who are at the visual level cannot immediately decide on a theory, proposition, or flow in the process of solving a problem. So it is necessary to observe the properties of the shape visually, then try to arrange and connect some of the properties of the shape as a basis for determining the theorem or the flow of problem-solving. Besides that, the type of scaffolding that students need at the level of analysis is an initial explanation from the researcher to clarify the problem or correct students' perceptions. scaffolding in the form of assistance to connect between the properties of the shape known by the subject as a basis for determining the theorem and the flow of problem-solving. At this level, students still need visual scaffolding.

3.3. Level 2 subject (van Hiele Informal Deduction Level)

The subject answer

![Image](Figure 8. Informal deduction level subject answer.)

**Table 5. Informal deduction level subject interview**

| P3 1001 | From the picture, how is your idea to solve it? |
|--------|------------------------------------------------|
| S3 1001 | a Is triangle side of right-angled triangle EBC It means that it used the Pythagorean theorem. |
| P3 1002 | are you sure that the EBC triangle is right-angled? |
| S3 1002 | Eh… (Silent thinking) There is no right-angled sign, meaning it’s not like (expression of confusion) |
| P3 1003 | How can you make a right-angled triangle so that the value of a can be determined? The four lines intersect at one point |
| S3 1003 | Oh ... That means add perpendicular lines that also intersect at one point B. |
The van Hiele level descriptor for the level of informal deduction is students can formulate and use definitions, provide informal arguments and arrange the sequence of traits given previously. Subjects at this level have begun to estimate the use of theorems and definitions that can be used in the process of solving problems by first observing the various properties of the wake. The subjects estimated that the EBC formed a right-angled triangle at B.

Scaffolding from the teacher in this condition is important to give. The teacher has the authority to provide scaffolding in the form of giving questions as a stimulus so that students check the answers. Students can know and be sure that the answer is not right. Then the teacher gives further scaffolding in the form of a stimulus to come up with an idea about how the Pythagorean theorem can be used. In other words, the subject at the level of informal deduction can formulate several definitions and traits in determining the theorem to be used in the problem-solving process. With some types of scaffolding provided by the teacher.

![Figure 9. Informal deduction level subject answer.](image)

![Figure 10. Informal deduction level subject answer.](image)

**Table 6.** Informal deduction level subject interview.

| Subject | Question                                                                 | Answer |
|---------|---------------------------------------------------------------------------|--------|
| P3 1004 | What do you get from adding these two perpendicular lines?                |        |
| S3 1004 | These four lines (pointing to four intersecting lines at point B) the hypotenuse of a right-angled triangle. |        |
| P3 1005 | Using the Pythagorean theorem, can you present it in the form of an equation? |        |
| S3 1005 | Yes, I can                                                               |        |
| P3 1006 | Using all these 4 equations, what can you do to define the value \(a\)?   |        |
| S3 1006 | Maybe the substitution elimination material is ...                        |        |
|         | (Linear Equation System Of Two Variablematerial using elimination and substitution) |        |
| P3 1007 | Which equation will be eliminated?                                       |        |
Pay attention to the sides of the equation of the same size. What you are looking for is the length of $a$, So, which equation can be used to define $a$?

Eeeh... (doubtful)

Equation 1 is summed with Equation 3

Why is it?

Because CH has the same size as DG, then $CH^2 + CG^2 = 3^2$. And the $a$ is 16

The continuation of the interview above is also consistent with subject indicators at van hiele visual level according to Fuys. The subject can connect the properties and several definitions in the problem-solving process. It is also able to integrate between geometry material which is the subject of problems with material elimination and substitution, with various types and scaffolding in the form of instructions, directions, questions as a stimulus, and visual scaffolding provided by the teacher.

The data above shows that subjects who are at the visual level cannot immediately decide on a theory, proposition, or flow in the process of solving a problem. Besides that, the type of scaffolding that students need at the level of analysis is an initial explanation from the researcher to clarify the problem or correct students' perceptions. There are some questions as a stimulus to bring up idea and material.

4. Discussion

Based on data above, it is found that subjects with a visual level tend to solve problems by presenting it in the form of images without depth observation into the concept. So it takes scaffolding in terms of the presentation and processing of flat shapes, mathematical concepts, and problem solving flow. This finding is in accordance with the theory of van Hiele according to Fuys who said that subjects at the visual level were able to identify and operate structures such as squares, rectangles, triangles, and other geometric configurations. Subjects with the level of analysis identify the nature of the problem to determine the mathematical concepts used. So it takes scaffolding in the form of image presentation and problem solving flow. This finding is also in accordance with van Hiele's theory according to Fuys who said that subjects at the level of analysis are able to analyze shapes based on their components and relationships between components, determine the properties of group of shapes empirically, and use traits to solve problems. Whereas subjects with informal deduction level can determine the mathematical concepts used by first looking at the properties of the shapes. However, subjects at this level still need scaffolding in the problem solving flow. This finding is also in accordance with van Hiele's theory according to Fuys who said that subjects at the level of analysis are able to formulate and use definitions, provide informal arguments and arrange the sequence of properties given previously. This can be seen from the ability of the subject in establishing the Pythagoras theorem as a tool to solve the research problems.

5. Conclusion

The results showed that subjects with a visual level tend to solve the problem by presenting it in the form of images without depth observation into the concept. So it takes scaffolding in terms of the presentation and processing of flat shapes, mathematical concepts, and problem solving flow. Subjects with the level of analysis identify the nature of the problem to determine the mathematical concepts used. Scaffolding is needed in the form of image presentation and problem solving flow. Whereas subjects with informal deduction level can determine the mathematical concepts used by first looking at the properties of the shapes. However, subjects at this level still need scaffolding in the problem solving flow.

The recommendation for further research is to discuss the benefits of this research, after the subject gets the right scaffolding in solving geometry problems, will later improve the creativity of the subject
in solve the other problems. This research can apply in higher level of education with geometry capabilities according to higher level of van Hiele level geometry.

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