The Profiles of Students’ Problem Solving Abilities Visual Static Models in Mathematics

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Abstract. This study aims to determine the profile of the Mathematical Visual Static Model Problem Solving Ability. This study applies a qualitative approach by involving 8th-grade students at SMPN 1 Ajangale, who are selected from five different prototype groups and are based on students' equations or mistakes in solving visual static model problems. Research subjects were selected during the data collection process from visual static model tests and interviews. The results showed that in completing the visual static model test, namely the first subject: overall good problem solving in knowledge skills, logical thinking, and mathematical logic, but did not have mathematical visualization and mathematical representation; for the second subject: mathematical representation, but lacks the ability of mathematical knowledge, logical thinking, mathematical understanding, visualization, and problem solving; for the third subject: mathematical knowledge skills, mathematical representation, mathematical understanding, problem solving, logical thinking, and mathematical visualization; for the fourth subject: logical thinking, but does not have mathematical understanding, mathematical knowledge skills, problem solving, mathematical representation, and mathematical visualization; and for the five subjects: logical thinking and mathematical representation, but lack of knowledge of mathematics, problem solving, mathematical understanding, and mathematical visualization.

Keywords: problem solving ability, visual static models, mathematics

1. Introduction
Theoretically mathematics is a science that aims to educate children to be able to think logically, critically, rationally, and confidently. Although in reality, many people view mathematics as a difficult field of study. Nevertheless, everyone must learn it because it is a means to solve the problems of daily life [1].

Mathematics is one of the most abstract sciences, where all things related to it are described or represented by symbols. So, to facilitate learning in the class of students must master mathematical concepts properly and correctly before working on mathematical problems. Therefore, students will be easier to solve mathematical problems.

One of the important things in school mathematics is problem solving. NTCM (Pape) states that, \textquotedblleft Mathematics educators have been called to teach mathematics through problem solving.	extquotedblright [2]. Also,
Hufferd-Ackles, et al., also states, "The curriculum provides support for students to use alternative methods of solving problems" [3]. That’s mean, "mathematical educators have been called to teach mathematics through problem solving". Meanwhile, the according to Acles means that "the curriculum provides support for students to use alternative methods of problem solving". This is because, "Learning mathematics is a process of transforming one’s ways and acting" [4]. According to Simon’s, "learning mathematics is a way of transforming someone to know (conception) and act".

The importance of problem solving ability was also expressed by Branca (Effendi), that problem solving ability is the heart of mathematics [5]. Students' problem solving abilities are related to the stages of solving mathematical problems. Polya, (Arifin & Asdar), the stage of solving mathematical problems are "Understanding the problem, devising a plan, carrying out the plan, and looking back" [6]. So, the steps to solve math problems according to Polya are understanding the problem, planning problem solving, implementing problem solving plans, and re-checking procedures and results of settlement".

According to Saad and Ghani, mathematical problems are defined as situations that have clear goals but are faced with obstacles due to a lack of algorithms that are known to describe them in order to obtain a solution [7]. Meanwhile, Polya, in 1973 (Rofiqoh) explained mathematical problems in two types, namely the problem of finding (problem to find) and the problem of proving (problem to prove) [8]. Search problems, namely problems that aim to find, determine, or get the value of a certain object that is unknown in the problem and give the appropriate conditions. While the problem proves that is the problem with a procedure to determine a statement true or false.

In solving mathematical problems, there are several factors that influence it according to Cornelis Jacob [8], namely: 1) mathematical background, 2) previous experience with similar problems, 3) reading ability, 4) perseverance, 5) tolerance for ambiguity and 6) spatial ability, age, and sex.

Erman Suherman (Windari, et al.) the ability to solve mathematical problems can be seen from: 1) understanding the problem, students can identify known elements, asked questions, and adequacy of elements needed, 2) planning problems, students can formulate mathematical problems or compile mathematical models. And also students can apply strategies to solve various problems; 3) solving problems, students are expected to be able to do the planning well; and 4) check again and draw conclusions [9].

Glass and Holyoak (Jacob) express four components basic in solving problems, namely: 1) Purpose, or description which is a solution against problems; 2) Description of relevant objects to reach a solution as a source that can be used and any combination or challenges that can be covered; 3) The set of operations, or actions taken to help reach a solution; and 4) A set of boundaries that do not have to be broken in solving problem. So that, from these four components clearly visible that in a solution to the problem includes the existence of information information clear to solve mathematical problems, goals you want achieved, and actions that can be taken to achieve the goal, so problem solving goes well according to that expected [10].

Visual Static Models are a certain type of mathematical visual representation that still includes pictorial images of mathematical concepts. Visual Static Models are also interpreted as still images that are either printed or drawn on the page to represent mathematical concepts. In this study, also adopted definition of Arcavi (in Anderson-Pence, et al.) for visualization mathematics: "The ability to create, use, interpret, and reflect on images in the mind or on paper" [11]. The definition of mathematical visualization according to Arcavi means that, "the ability to make, use, interpret, and reflect images in the mind or on paper". Using and creating Visual Static Models, students can develop their visualization skills. Visualization supporting meaningful connections with different types of representation and abstract mathematical concepts. Lesh, Post, and Behr (in Anderson-Pence, et al.) identified five types of mathematical representations: static images, model manipulation, symbol writing, real life situations, and oral language. Understanding mathematical concepts involves a) remembering concepts between different types of representations, b) manipulating concepts flexibly in a type of representation, and c) translating concepts from one type of representation to another [11].

Static images are an interesting part of this study, because static models are what students often develop when solving problems, and what students often see on tests, worksheets, and in textbooks during typical mathematics learning [12]. And also, according to Clark, Nguyen, and Sweller
(in Anderson-Pence, et al.) visual representation alleviates cognitive burdens during problem solving and according to Woleck (in Anderson-Pence et al.) allows students to mentally work on one part of the model without having to track the entire model in their minds [11]. For example, many students automatically draw a square divided into three parts, two of which are shaded, when they hear or see the symbol of \( \frac{2}{3} \) (two-thirds). This visual model allows students to retain the whole-part meaning of fractions.

Based on the study Regarding Visual Static Models, what is meant by Visual Static Models in this study is a visual model in mathematics that requires students' ability to create, use, interpret, and reflect the images they have in mind on paper, using objects (media/images) immovable or silent whose presentation can be printed or illustrated on paper, where the object reflects mathematical concepts to find solutions to mathematical problems.

Meanwhile, students' problem solving abilities related to the problem of Visual Static Models for the importance of this study were only reviewed from the six abilities of problem solving aspects, namely: 1) Mathematical Knowledge Ability; 2) Mathematical Understanding Ability; 3) The ability of mathematical representation; 4) The ability to think logically; 5) Problem Solving Capabilities; and 6) The ability of Mathematical Visualization.

2. Method

2.1 Design
The research is a qualitative research, which aims to determine the profile of students’ problem solving abilities visual static models in Mathematics on the material fractions.

2.2 Respondents
This research was conducted at SMPN 1 Ajangale. Research subject is students class VIII.C SMPN 1 Junior High School. The main criteria for the selection of subjects are students who have studied fraction material while in elementary school.

2.3 Procedure
The procedure in this study consisted of the following 3 stages: 1) All students of class VIII.C were given visual tests of static models; 2) Students who complete the visual static models test in the same way or the same error, are grouped into one group; and 3) Each group is represented by one subject, where this group is then referred to as a prototype. The number of subjects in this study is as many as existing prototypes.

2.4 Instrument
The instrument in this research is a researcher own as instrument main, visual static models problem test sheets, and interview guidelines.

2.5 Data Analysis
Data analysis techniques used in this study is descriptive. The steps in profiling provide a description of students' problem-solving abilities regarding problems related to visual static models are consisted of the following 7 stages: 1) Choose one (1) class of students among four classes of students VIII with certain considerations. 2) Give a test that contains visual static models problems to the selected class. 3) After giving the test, followed by collecting student answers. 4) Student answers are collected, then grouped based on the characteristics (similarities or errors) of student answers. 5) From the fourth point (4th) students answer groups will be obtained which will be referred to as prototype I for group one (1st profile of problem solving), prototype II for group two (2nd profile problem solving), and so on until prototype n for group n (profile of problem solving). From the fifth (fifth) point, one (1) subject is chosen from each prototype based on certain considerations. Then these selected subjects will be interviewed later. 7) After taking the step in the sixth point (6), the profiling of the students’
ability to solve the problems related to visual static models, has reached the step of profiling the final problem solving abilities.

3. Result

Based on the analysis of the results of student answers and verification of data through interviews, obtained grouping of the characteristics of the answers (prototypes) and profiles of the problem solving abilities of the subject in solving visual static models problems in fractional material. The grouping of answers and a general description of the problem solving skills are as follows:

3.1. Subjects from the first prototype

The subject has characteristics are write down incorrect reasons for solving problems, giving rise to inappropriate relevance between answers and reasons, and solving fraction value problems and give a sign $<$, $=$, $>$ to compare two fractions. And, the problem solving ability of the subject is good mathematical knowledge skills, a good mathematical understanding ability, and the ability to think logically well, in solving visual problems with static models and fraction material. But, do not have yet: the ability of good mathematical representation, the ability to solve a good problem as a whole, mathematical visualization skills, in solving visual problems with static models and fraction material.

3.2. Subjects from the second prototype

The subject has characteristics are understanding in completing the sum of different denominations of incorrect denominators, cannot provide reasons for solving questions about everyday problems, and does not understand the concept of fractions of value, and do not write the way to get the $<$, $=$, $>$ sign to compare the two fractions. And, have a good mathematical representation ability, in solving problems in solving visual problems with static models and fraction material. But, do not have yet: mathematical knowledge skills, mathematical understanding skills, the ability to think logically well, the ability to solve a good problem, and mathematical visualization skills in solving visual problems with static models and fraction material.

3.3. Subjects from the third prototype

The subject has characteristics are the accuracy of the relevance between answers and reasons for solving questions about everyday problems, and the method used in solving fraction worth problems is different from the way the majority is to answer about fractional value problems, that is by multiplying fractions by a number or dividing the fraction by multiples. And, having good mathematical knowledge skills, mathematical understanding skills, mathematical representation ability, the ability to think logically well, the ability to solve good problems, and mathematical visualization skills in solving visual problems with static models and fraction material.

3.4. Subjects from the fourth prototype

The subject has characteristics was identified that in this group do not really understand how to add fractions, and the irrelevance of answers and reasons in answering problems regarding daily problems. And, have a good the ability to think logically well, in solving problems in solving visual problems with static models and fraction material. But, do not have yet: mathematical knowledge skills, mathematical understanding skills, the ability of good mathematical representation, the ability to solve a good problem, and mathematical visualization skills in solving visual problems with static models and fraction material.

3.5. Subjects from the fifth prototype

The subject has characteristics was identified that in this group do not really understand how to add fractions, the method used in solving fraction worth problems is different from the way the majority is to answer about a fraction worth issue, that is by dividing the fraction by multiples thereof, and identified that students in this group did not understand about comparing two fractions. And, have a good mathematical representation ability and the ability to think logically well, in solving visual problems with static models and fraction material. But, do not have yet: mathematical knowledge
skills, mathematical understanding skills, the ability to solve a good problem, mathematical visualization skills, in solving visual problems with static models and fraction material.

The following are some of the subject's answers in solving the problem of visual static models, which can be seen in the following figure:

![Figure 1. The subject solves the problem of Visual Static Models](image)

Figure 1 shows that the subject has understood the comparison of the value of the fraction by applying of Visual Static Models. The subject can understand the problem of the story well, and can convert it appropriately into a static visual model, and also can interpret static visual images well. So, these problems can be resolved properly.

![Figure 2. The subject of the addition by interpreting the image of Visual Static Models](image)

Figure 2 shows that the subject can turn the static visual model into a fraction symbol. Although not able to get the final result right. However, after the interview to investigate answers to the subject, it was found that the subject does not remember well the ways or steps in performing the addition operation fractions.

4. Discussion

Based on the research and interviews that have been conducted, as well as making transcripts of interview results, it was found that the five research subjects had a tendency to be able to solve visual static model problems. This can be seen from several ability indicators that can be fulfilled by the subject based on each ability. However, only one of the five subjects found could fulfill the overall indicators of each ability.

As for the implicit grouping of prototypes, it was found that students in the same group (this is based on the way students one and other students in resolving static models) tend to have the same learning style. The prototype group I tends to have kinesthetic learning styles. The prototype group II tends to have a kinesthetic learning style. The prototype III group has a visual and kinesthetic learning style. The prototype IV group has a visual and kinesthetic learning style. As well, the prototype group
V has a kinesthetic learning style. This gives an implicit indication, that the way students think in solving a problem can be the same when viewed from their learning style.

In general, a visual subject in understanding problems by reading questions aloud. And, the visual subject in planning the settlement, the subject revealed the answer smoothly at the interview. Meanwhile, kinesthetic subjects in understanding the problem by reading the questions in a low voice. And, the kinesthetic subject in planning the solution, the subject slowly reveals at the interview, while paying attention to the answers he has written.

The way the subject resolves visual static models is influenced by cognitive abilities, and the way the subject processes symbols and uses information to solve certain problems. This is in accordance with the opinion of Wolfe and Johnson (Oh and Lim) which states that: “individuals are different in their ways of seeking and processing information, and cognitive styles serve as relatively stable indicators of how learners perceive and interpret information, and respond to learning environments” [13].

Where, the opinion of Wolfe and Johnson means that, a person has a different way of finding and processing information, and a relatively stable cognitive style functions as an indicator of how students perceive and interpret information, and respond to the learning environment. Meanwhile, the limitations of the use of visual static models in learning are in improving students' understanding skills in operating the symbols of addition (+), subtraction (-), multiplication (×), and division (÷) in fractions. Because this requires skills to illustrate the fraction in the image, if the two images that describe the fraction form have been operated. Visual static models can be used in the learning process in fraction material, but a good understanding is needed by the teacher in terms of illustrating changes in shading and shaded parts in the picture that show fractions, if fraction operation is carried out.

5. Conclusion

Based on the results of the research obtained after conducting research and analysis of the data that has been carried out, the following conclusions are obtained:

1. Profile of students' ability to solve visual static models problems originating from prototype I is: having good mathematical knowledge, having good mathematical understanding skills, having good logical thinking skills. However, it does not yet have good mathematical representation ability, it does not have the ability to solve problems as a whole as a whole, and does not yet have good mathematical visualization skills in resolving visual problems with static models and fractions.

2. Profile of students' ability to solve visual static models problem that comes from prototype II is: do not have good mathematical knowledge ability, do not have good mathematical understanding skills, do not have good logical thinking skills, do not have the ability to solve good problems, and do not have good mathematical visualization skills. However, it has a good mathematical representation ability, in solving problems in solving visual problems with static models and fractions.

3. Profile of students' ability to solve visual static models problem from prototype III is: having good mathematical knowledge ability, having good mathematical understanding ability, having good mathematical representation ability, having good logical thinking skills, having problem solving skills good, and has good mathematical visualization skills in solving problems in solving visual problems with static models and fraction material.

4. Profile of students' ability to solve visual static models problem that comes from prototype IV are: do not have good mathematical knowledge ability, do not have good mathematical understanding skills, do not have good mathematical representation skills, do not have the ability to solve good problems, and do not have good mathematical visualization skills. However, having good logical thinking skills is good, in solving problems in solving visual problems with static models of fraction material.

5. Profile of students' ability to solve visual static models problem that comes from prototype V is: do not have good mathematical knowledge skills, do not have good mathematical understanding skills, do not have good problem solving skills, do not have good mathematical visualization skills.
However, it has a good mathematical representation ability, and has good logical thinking skills, in solving problems in solving visual problems with static models and fractions.

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