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ABILITY OF MATHEMATICAL REPRESENTATION JUNIOR HIGH SCHOOL STUDENTS IN COMPLETING OPEN-ENDED PROBLEMS ARE REVIEWED FROM THE STYLE OF THINKING

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ABSTRACT

Mathematical representation is how a person communicates the mathematical ideas in question to others. This ability has an important role in learning mathematics, especially as a foundation to align problem solving. This study aims to describe the mathematical representational ability of junior high school students in solving open-ended problems. The study subjects were students of grade XI junior high school. This research is qualitative descriptive research. Taking subjects using purposive sampling, which is based on their thinking style. Data collection uses tests, questionnaires, and interviews. The results showed that the ability of mathematical representations of: (1) groups of students of concrete sequential thinking styles able to create and communicate mathematical ideas in the form of images, have not been able to make mathematical models perfectly and are sufficiently able to use written words or text; (2) groups of students of abstract sequential thinking styles are less able to create and communicate mathematical ideas in the form of drawings but able to create mathematical models of ideas or ideas and are sufficiently able to use written words or text; (3) groups of students of abstract random thinking styles are less able to create and communicate mathematical ideas in the form of drawings and create mathematical models of ideas or ideas, but are sufficiently able to use written words or text; (4) Groups of students of concrete random thinking styles are quite capable of creating and communicating mathematical ideas in the form of drawings, unable to create mathematical models of ideas or ideas, less able to use written words or text.
Keywords: *Mathematical Representation, Open-Ended, Thinking Style*

INTRODUCTION

Mathematical representations such as diagrams, graphs, written text (verbal) and symbols, have long been an important part of math learning in schools. The ability of mathematical representation has an important role in the learning of mathematics, because the ability of mathematical representation is closely related to other mathematical abilities, especially mathematical communication (Verscharffel et al, 2010: 1). When students are challenged to think and reason about mathematics, they use some mathematical symbols or expressions to communicate the results of their thinking to others.

Jones &Knuth (in Mustangin, 2015) states that a mathematical representation is a model or substitute form of a problem situation or aspect of a problem situation used to find a solution. Nctm (2000:67), states that mathematical representation is how a person communicates the answer or idea of mathematics in question to others. Standard mathematical representation abilities emphasize using symbols, charts, graphs and tables in connecting and expressing mathematical ideas.

The standard of mathematical representation ability set by NCTM (2000:67) is that it should allow students to: (1) create and use representations to organize, record, and communicate mathematical ideas, (2) Select, apply, and translate between mathematical representations to solve problems, (3) Use representations to model and interpret physical, social, and mathematical phenomena.

The ability of mathematical representation in this study is the ability of students to use and connect between representations in the form of symbols, images, mathematical expressions, and written text as achievements of their minds to find solutions. Students are expected to be able to make representations in the form of mathematical drawings to communicate their mathematical ideas in solving problems in revival and harmony materials. Students are expected to create mathematical models by using mathematical symbols or expressions to solve problems on revival and harmony materials. The indicators are: (1) Create and communicate mathematical ideas in images on revival and harmony material. The accuracy of this indicator can be seen from the accuracy of students in making images. (2) Create a mathematical model of an idea or idea by applying mathematical symbols and expressions in solving building and sharing problems. The accuracy of this indicator can be seen from the accuracy of students in making mathematical models by using mathematical symbols or expressions and applying them to problem solving. (3) Use written words or texts in resolving revival and partnership problems. Students are expected to use written words or text to solve problems on revival and harmony material. The accuracy of this indicator can be seen from the accuracy and flexibility of students in using written words or text.

The mathematical representation ability can be known by providing problems that can encourage students to bring up diverse representations (Sumarmo, 2011), one of which is open or *open-ended. Open-ended* problems are those that have more than one method or solution. *Open-ended issues* provide students with the opportunity to acquire knowledge, discover experience, and recognize them in several ways. Types of open problems are two, namely, problems with one correct answer but have many ways of solving or called *open-ended* techniques, both problems in many ways and many answers or *open-ended* answers. The use of *open-ended* problems can make students play an active role and increase the ability to think (Shimada, 1977: 3). Although the ability of teachers in building conceptions of mathematical repression, it is very influential on the construction of student representation abilities (Brijlall, 2012)

A person's thinking ability depends on how a person processes and receives information, or his thinking style. Gregore (in Yao Tung, 2015: 191) states that style of thinking is receiving and speaking information. Gregore suggests that how receiving information is divided into two ways: concrete and abstract. In receiving concretely people use all five senses, while abstractly accepting people tend to use intuition and imagination. Then, how to organize information and the thought process can be divided into two ways: sequential and random (random). In sequential thinkers people tend to organize thought processes regularly (step by step), whereas random thinkers tend to be random or in no particular order.

Concrete sequential thinkers hold on to reality and process information orderly, linear, and sequential. The reality of concrete sequential thinkers awakens through the five senses. They show and remember reality easily and easily remember facts, information, formulas, and special rules. Concrete sequential thinkers have the characteristic of thinking that is "one after the other and real". Abstract sequential thinkers like to think in concepts and analyze information. The reality for abstract sequential thinkers is the world of metaphysical theory and abstract thinking. They appreciate people and organized and neat events. Their thought processes are logical, rational, and intellectual. Abstract sequential thinkers have the characteristic of thinking " one by one and imaginatively". Concrete random thinkers have experimental attitudes accompanied by less structured behavior. They tend to think based on reality, but take *a trial and error* approach. Hence they often make the intuitive leaps necessary for actual creative thinking. Concrete random thinkers have a strong drive to find alternatives

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and do things their way. Concrete random thinkers have the characteristic of thinking: "spontaneous and real". Abstract random thinkers absorb ideas, information, and impressions and organize them with reflection. They need to look at the whole picture at once, not gradually. For this reason, it will be helpful to know how everything connects with the whole before going into detail. Abstract random thinkers have the characteristic of thinking that is "spontaneous and imaginative" (Yao Tung, 2015: 192)

People with sequential thinking styles use the left brain dominantly, while those with random thinking styles use the right brain. Everyone has and wears all four thinking styles, only to be dominant in one or two styles of thinking alone. Mathematical representation is more broadly taught in learning mathematics in junior high school (junior high), one of which is in connecting concepts in mathematical materials. The mathematical representation ability is needed in problem solving activities, which should have been accustomed to the learning curriculum in 2013. The challenge of learning in this era is problem solving. Practicing this problem-solving ability, done by providing *open-ended problems*. Open or *open-ended problems* can train thinking skills.

Related to this, it is necessary to study the mathematical representation of students working on *open-ended* problems given each thinking style, especially in middle school students. This needs to be done as an identification effort so that a profile is obtained about the ability of mathematical representation of students, so that if it has not reached the desired level it can be improved based on the data obtained in this study. This is especially based on the characteristics of the style of thinking that everyone owns. With the right handler for each student who has a different thinking style, it is expected that an effective way can be obtained so that students have good representative abilities.

METHODS

This type of research is qualitative description research that focuses on the mathematical representation ability of junior high school students in solving *open-ended* problems in terms of thinking style. The sampling technique of the research subject used is *cluster sampling* followed by *purposive sampling* technique. These research instruments are researchers, thinking styles, tests of the ability of *open-ended* mathematical representations, interview guidelines, and documentation. Data analysis used is data reduction, data presentation, and conclusion withdrawal, while for validity of data using triangulation techniques.

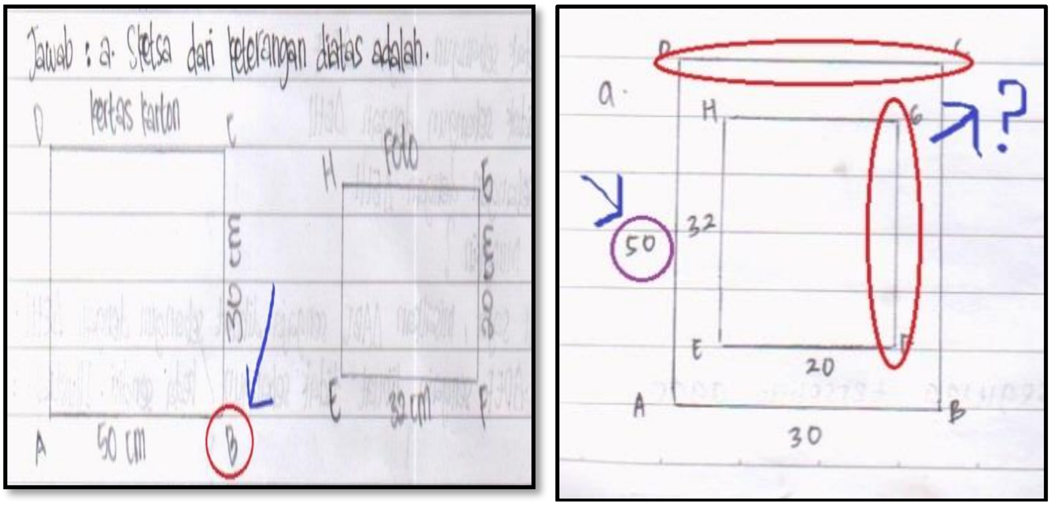
RESULTS AND DISCUSSION

The subjects in this study were 10 students, each of 3 students' thinking styles except concrete random thinking styles, because there was only 1 student with a concrete random thinking style. Here is an example of the results of student representations on indicators of making and communicating mathematical ideas in images on revival and harmony material.

Questions to measure indicators:

4. Doni akan membuat sebuah bingkai dari kertas karton. Kertas karton tersebut berukuran 50 cm x 30 cm. Doni memiliki sebuah foto berukuran 32 cm x 20 cm. Foto tersebut akan diletakan pada bingkai yang dibuat oleh Doni. Tentukan:
   a. Sketsa dari keadaan di atas!

Examples of student work:



(a) (b)

Figure 1. Work results: (a) Subjects of concrete sequential thinking styles
(b) Abstract sequential thinking style subjects

Based on the results of tests and interviews, subjects can create and communicate mathematical ideas in the form of images on revival and harmony material. Based on figure 1(a), subjects can describe cardboard paper sketches and photographs. The shape of the image is rational and neat with a complete description that is the name and size of the image. The subject also adds the name caption of each corner point to the image. The interview results can be concluded that the subject can explain the symbols and images made along with the caption clearly and briefly. Figure 1(b), shows the subject has been able to sketch neatly but the shape is irrational, because the length of the photo depicted is shorter than the width of the cardboard, should be longer. The subject adds a caption in the form of an image size according to the circumstances, but not accompanied by a unit of length and a name caption on the image. The subject creates an angular point symbol on each image with capital letters. The picture above concluded that the subjects were less able to sketch cardboard paper and photographs. The subjects explained the images and captions made during the interview. The subjects explained that the ABCD rectangle is a cardboard paper sketch and the EFGH rectangle is a photo sketch, but is inconsistent in mentioning the size of the cardboard and photo paper. Based on test results, subject interviews, and standard mathematical representations of the NCTM (2000:67), subjects are less able to create and communicate mathematical ideas in images on revival and harmony material.

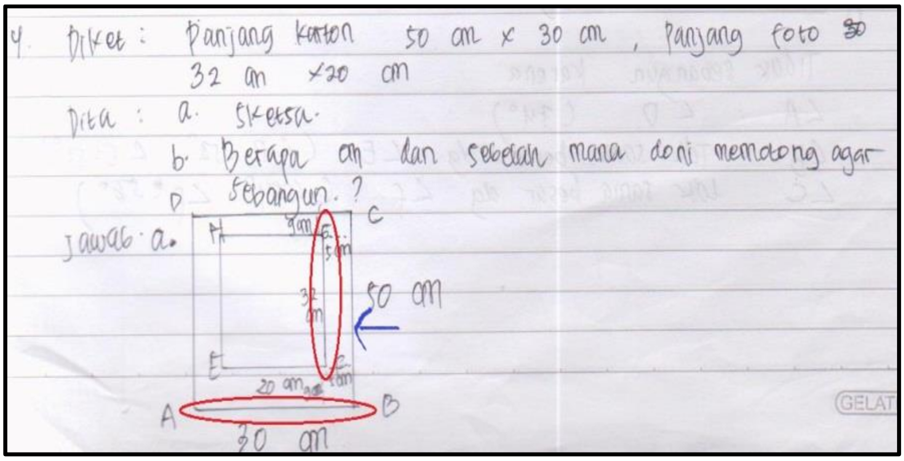


Figure 2 (a). Results of work Subjects abstract Random thinking style

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Based on test results, interviews and by standard mathematical representation of the NCTM (2000:67), subjects were less able to create and communicate mathematical ideas in the form of images on revival and harmony material. Figure 2(a) shows subjects less able to describe cardboard paper sketches and photographs. The picture is neat but the shape is irrational and complete. The length of the photo is shorter than the width of the cardboard, it should be longer. The subject adds a caption in the form of the size of the image according to the circumstances, creating an angular point symbol using capital letters, possibly the width of the left right side of the image, but there is no caption of the image name. During the interview the subjects explained the images and captions clearly and in detail, explaining how to determine the width of the edge between the cardboard paper and the photo.

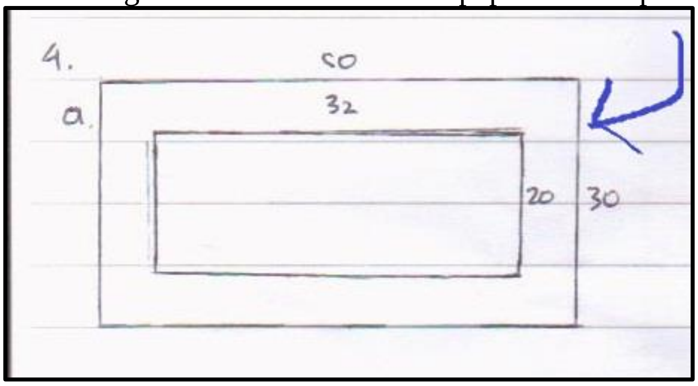

Figure 2 (b). Results of work Subjects abstract Random thinking style

Figure 2(b) explains that the subject can depict cardboard paper sketches and photographs. The image forms rationally and neatly but the caption is incomplete. The subject adds a caption in the form of an image size with no length units and is not accompanied by an image name. Subjects were able to explain images and captions at the time of the interview, but mentioning sizes were not accompanied by units of length. Based on test results, interviews and by standard mathematical representation of the NCTM (2000:67), subjects are sufficiently able to create and communicate mathematical ideas in the form of images on revival and harmony material.

Based on the results of the overall analysis of the results of the test the ability of mathematical representation of students in working on *open-ended* problems and interviews with concrete sequential, sequentially absrak, abstract random, and concrete randomized thinking methods were obtained as follows:

1. Student Group of Concrete Sequential Thinking Styles

This group can create and communicate mathematical ideas in images in revival and harmony material. When the interview can explain the images and captions made. The picture is rational and correct, this is by the characteristics of concrete sequential thinking style that is very careful. So that in making the image is not original, but pay attention to the accuracy of the shape.

Concrete sequential thinkers cannot create mathematical models of ideas or ideas by applying mathematical symbols and expressions in solving revival and partnership problems. Most can explain the steps of completion at the interview, but do not mention the mathematical model first, but rather directly on the calculation operation. So that in solving the problem tends to be what it is and directly, without the beginning of the mathematical model. This is in accordance with the opinion of Gregore (Yao Tung, 2015) that one of the characteristics of concrete sequential thinking style directly on the problem is not to be convoluted in solving things but directly to the problem.

On the other hand, this type of thinker can use written words or texts to solve the problem of revival and partnership. When interviews are mostly able to explain the answers and the reasons for the evidence appropriately and tend to be brief. This is by the characteristics of a practical concrete sequential style of thinking: likes to use a short way to solve problems (Yao Tung, 2015). Therefore, they tend to write proof of answer without being accompanied by a detailed reason.

2. Abstract Sequential Thinking Style Student Group

Abstract sequential thinkers are less able to create and communicate mathematical ideas in images in revival and harmony material. When interviewed most do not explain the picture precisely and completely. Most of the images created are inaccurate and rational because comparing length and width is not appropriate.

This group can create mathematical models of ideas or ideas by applying mathematical symbols and expressions in solving revival and partnership problems. However, some solutions do not have a mathematical model. The interview can explain the steps of completion with a clear and clear. This result reinforces the opinion of Gregore (Yao Tung, 2015), that the characteristics of a systematic abstract sequential thinking style, namely like to solve problems following the sequential and orderly steps of completion from stage one to the next.

Their ability to use written words or text in solving revival and partnership problems, belongs to sufficient criteria. Most complete the answer with evidence along with the reason. When interviews are mostly able to explain the reasons of the evidence made clearly. This is by the characteristics of abstract sequential thinking styles that like to think about things in depth. So that in answering the question does not stop at an argument but is accompanied by detailed evidence.

3. Abstract Random Thinking Style Student Group

This group's ability to create and communicate mathematical ideas in the form of images in the material of revival and partnership with precise, rational, and complete, is still relatively lacking. When interviews most look confused in explaining the picture, and some are still incomplete in explaining the caption on the picture.

Abstract random thinkers cannot create mathematical models of ideas or ideas by applying mathematical symbols and expressions in solving revival and partnership problems. Most at the time of the interview did not mention the mathematical model when describing the settlement steps. One of the characteristics of spontaneous abstract random thinking style is to like to do something spontaneously / suddenly, without thinking or without being planned (Yao Tung, 2015). So that in solving the problem is not preceded by making a mathematical model, but directly on the calculation operation.

Groups of abstract random thinking styles are quite capable of using words or written text to solve revival and partnership problems. When interviews are largely unable to explain the reasons for the evidence made. This is by the characteristics of abstract random thinking style of communicating, namely likes to communicate / exchange information with other friends about something. So that in answering the problem can use words, even though the answer has not been accompanied by proper evidence.

4. Group of Students Concrete Random Thinking Style

This group can create and communicate mathematical ideas in the form of images in revival and harmony material, but not yet rational and complete. When the interview can explain the picture made.

These thinkers cannot create mathematical models of ideas or ideas by applying mathematical symbols and expressions in solving revival and partnership problems. When interviewing most of the difficulties in explaining the settlement steps and not mention the mathematical model on the settlement steps made.

As Yao Tung said in 2015, concrete random thinkers find alternatives and work on things their way. They are less able to use written words or texts in resolving revival and support problems, and are accompanied by precise evidence, but evidence is not accompanied by reason. When the interview can explain the answer to the question briefly.

Based on the above explanation, it can be concluded that the group of students of concrete sequential thinking style is superior to the first indicator, namely making and communicating mathematical ideas in the form of images on revival and sharing materials. While the group of students abstract sequential thinking style excels at the second indicator, which is to make a mathematical model of ideas or ideas by applying mathematical symbols and expressions in solving revival and partnership problems. In addition, groups of students of abstract random thinking styles can use words or written text to solve revival and partnership problems. While the group of students of concrete random thinking style can create and communicate mathematical ideas in the form of images on revival and harmony material.

Sequential types are equally capable of two indicators of mathematical representation ability, but excel at different indicators. Groups of students of concrete sequential thinking style excel in making images, this is because it is more careful when making images so that they are precise and rational (Yao Tung, 2015). While the group of students abstract sequential thinking style excels in making mathematical models, because in solving problems by the stages of completion or systematically.

Concrete and random thinkers have different characteristics on the ability of mathematical representations. Groups of students of concrete sequential thinking styles and concrete randoms are both able to create images, it is just that images created by concrete randoms are not as precise as concrete sequences. While the group of students abstract sequential thinking style and abstract random can create mathematical models, random abstracts are still incomplete and precise.

CONCLUSIONS

Based on the results of the study above, the following conclusions were reached:

1. Groups of students of concrete sequential thinking styles can create and communicate mathematical ideas in the form of images in revival and harmony materials and can use written words or text to solve revival and harmony problems. However, it is less able to create a mathematical model of an idea or idea by applying mathematical symbols and expressions in solving revival and harmony problems.
2. Groups of students of abstract sequential thinking styles are less able to create and communicate mathematical ideas in images on revival material. However, it can create a mathematical model of an idea or idea by applying mathematical symbols and expressions, and is quite capable of using written words or text in solving revival and sharing problems.
3. Groups of students of abstract random thinking styles are less able to create and communicate mathematical ideas in the form of symbols or images and mathematical models of ideas or ideas by applying mathematical symbols and expressions in solving revival and harmony problems. However, it can use written words or text in solving revival and partnership problems.
4. Groups of students of concrete random thinking styles can create and communicate mathematical ideas in the form of drawings on revival material. However, it cannot create a mathematical model of an idea or ideas by applying mathematical symbols and expressions to solve revival and harmony problems. Moreover, still less able to use words or written text to solve the revival and harmony problem.

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