Student's Mathematics Creative Thinking Skills in Terms of Logical Mathematical Intelligence

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Abstract:
The objective of this study is to describe the skills of creative thinking in terms of logical mathematical intelligence, by qualitative approach. Instruments used were questionnaires, tests, documentation, and interviews. 54 students of class XI, MA Al-Misri were given a type of multiple intelligences questionnaire. 14 students who have logical mathematical intelligence predominant chosen as the subject of research. The first test was given to determine the logical mathematical intelligence, then analyzed. The analysis showed consecutively 12; 8; 5; 3; and 1 subject(s) who has the characteristics classify, compare, perform basic numerical operations, deductive and inductive reasoning, and hypothesis formation and testing. Next, each subject was chosen for each those characteristics. Open ended question was given for the second test to describe student's creative thinking skills. Based on data analysis, it was found that the subjects with the characteristics classify, compare, perform basic numerical operations, deductive and inductive reasoning generally fulfill the components of creative thinking: problems sensitivity, fluency, flexibility and elaboration; and subject with characteristics of hypothesis formation and testing fulfill the four components later and novelty.

Keywords: creative thinking skills, logical mathematical intelligence, mathematics problem solving**.**

1. Introduction

Based on revised Bloom Taxonomy, highest cognitive domain is made the students be able to create. Therefore, it requires creative thinking skills to achieve it. Student's creativity and problem solving skills is also one of the goals in the national education system. On the other hand, student's creative thinking skills in solving mathematical problems influenced by the intelligence. This study was focused on number sense, and logical mathematical intelligence is one of multiple intelligences type that has major contribution to it. Torrance (1974) (in Leikin, 2011) states the four components in the creative thinking process: (1) Fluency refers to the continuity of ideas, flow of associations, and use of basic and universal knowledge, (2) Flexibility is associated with changing ideas, approaching a problem in various ways, and producing a variety of solutions, (3) Novelty is characterized by a unique way of

thinking and unique products of a mental or artistic activity, and (4) Elaboration refers to the ability to describe, illuminate, and generalize ideas. Guilford (1986) (in Stenberg, 1988) adds four components with problem sensitivity; the ability to detect, recognize, and understand and respond to a statement, situation or problem.

In Indonesia, school mathematics objectives are students are able to solve problems that include the ability to understand the problem, devised a mathematical model, solve the model and interpret the obtained solution.

Krulik and Rudnick (1989) stated that the problem is a situation, quantitative or otherwise, that confronts an individual or group of individuals, that requires resolution, and for which the individual sees no apparent path to the solution. The challenge must also be accepted by the individual. If he refuses to accept the challenge to solve it, then the situation can't be cited as a problem. They explain the definition of problem-solving as a process by which

an individual uses previously acquired knowledge, skills, and understanding to satisfy the demands of an unfamiliar situation. The process begins with the initial confrontation and concludes when an answer has been obtained and considered with regard to the initial conditions.The student must synthesize what he or she has learned and apply it to the new and different situation.

Creative thinking skills is an important point in the process of mathematical problem-solving. By student's creative thinking skills, the problem-solving process will become easier and focused. This process requires the ability to use a variety of strategies. Someone who is able to use a variety of ways to solve the problem and get a variety of answers can be regarded as a creative person.

Gardner (1983) argues that the logical mathematical intelligence is the ability to calculate, quantify, consider propositions and hypotheses and perform complex mathematical operations. This intelligence allows students to understand the relationships and linkages as well as abstract and symbolic ideas used; reasoning skills; and inductive and deductive thinking patterns. Armstrong (2009) explained that the logical mathematical intelligence is the ability to use numbers effectively and reason well. This intelligence includes sensitivity to patterns and logical relationships, statements and propositions (if-then, cause-effect), functions, and other relations abstraction. The process used in logical mathematical intelligence includes categorize, classify, deduce, generalize, calculate and test the hypothesis.

Willis and Johnson (2001) revealed that mathematical logical intelligence includes five core areas: (1) classify, (2) comparing, (3) basic numerical operations, (4) inductive and deductive reasoning, and (5) hypothesis forming and testing. Classify means students are able to understand the problems and sort out the information known and ask questions; comparing means linking what is

being asked with the knowledge that he had or devised a plan; perform basic numerical operations means implementing the devised plan by using the appropriate basic numeral operations; deductive reasoning means drawing conclusions from general to specific terms; inductive reasoning to draw conclusions from the particular to the general; and hypothesis formation means predict solution of a problem, and test the hypothesis is rechecking the problem solving that has been done.

2. Methods

This study is descriptive research by qualitative approach. The data was conducted by tests, observations, questionnaires, and interviews. The data were analyzed qualitatively. The study begins by giving questionnaires to 54 students of class XI MA Al-Misri in the academic year 2016/2017 to know their type of multiple intelligences. Subjects were 14 students with the type of logical mathematical intelligence predominant. The first test was given to the subjects was to determine the characteristics of logical mathematical intelligence. The second test was given to five subjects that represent each logical mathematical intelligence characteristics to know their creative thinking skills.

3. Results

Based on data analysis, from 14 test subjects with logical mathematical intelligence: (1) characteristics 'classify': 11 subjects were able to classify information and write down it; (2) characteristics 'compare': 8 subjects were able to fulfill it; (3) characteristics of basic numerical operation, the subject was able to fulfill it was 5 subjects; (4) characteristics of inductive and deductive reasoning, the subject was able to fulfill it was 3 subjects; and (5) hypothesis formation and testing characteristics are met 1 subject. The result was shown in Figure 1.
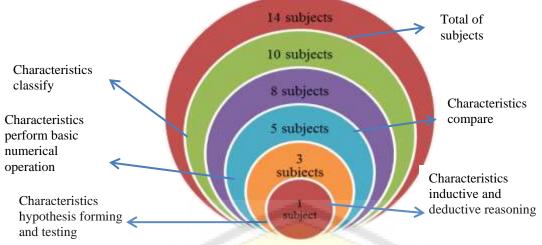
Figure 1. Diagram of Subjects Who Has Logical Mathematical Intelligence

Creative thinking skills of each five characteristics of logical mathematical intelligence, as follows: (1) S11 with characteristic classifying, able to show problem sensitivity, fluency, flexibility, and elaboration; (2) S12 with characteristics of comparing, shows problem sensitivity, fluency, flexibility, and elaboration; (3) S05 with basic numerical operation capable of fulfilling fluency, flexibility, and elaboration; (4) S04 with characteristics of inductive and deductive reasoning, meet problems sensitivity, fluency, flexibility, and elaboration; (5) S09 with hypothesis formation and testing fulfill all components of creative thinking.

4. Discussion

From the analysis of the characteristics of logical mathematical intelligence, it is known that not all the characteristics of a logical mathematical intelligence are fulfilled by each of research subjects. For characteristics 'classify', 10 subjects have been able to do it. While 4 others are still having difficulties. There are various difficulties experienced by subjects. Subjects who have not been able to distinguish the concept of numbers and numeral. This has implications for their failure to classify what is being asked. Their mistake to understand the concept of numbers and numeral is also being a cause of his failure in classifying the information. The other difficulty is when the subject can't understand the phrase of 'perfect square'. This reason makes some subjects are not capable of classifying.

For characteristics 'compare', only 8 subjects were able to write about the relationship of the information and the question. Three subjects who have not been able to understand the questions well, will not be able to associate the information and their knowledge. Therefore, students who can't classify would have trouble to fulfill these characteristics. As Krulik and Rudnick (1989) argue that in problem-solving individuals use the knowledge, skills, and understanding to meet the demands of the new situation (Krulik and Rudnick, 1989). It can be said that the five questions are given to research subjects is a problem, since the question about number sense is not a subject for class XI.

Furthermore, for the characteristic 'perform basic numerical operation', there are 6 subjects were able to fulfill it. 5 other people can't operate number well. Students who have not been able to associate information and knowledge and meet the characteristics of 'comparison', will have difficulty to solve a given problem. On the other hand, there is a subject that still makes mistakes in number operations, due to his misunderstanding about numerical operation procedure as well.

For the characteristic 'deductive and inductive reasoning', only three subjects were able to fulfill it. This characteristic is only shown by those who are able to 'classify' and 'compare'. In fact, it is only a few subjects are able to reason, either inductive or deductive. The process of reasoning, both deductive and inductive, need the application of requires prior knowledge. As the opinion of Fisher (2008), that reasoning is one important part of critical thinking process and reasoning is not an easy process that can be done by everyone. The lack of knowledge and concepts that are embedded in the study also become the reason for the small number that meets these characteristics. Both inductive and deductive reasoning, obviously require information as a premise to be used in obtaining a logical conclusion. While not all of the mathematical concepts that have been taught in the previous school they understood well.

Hypothesis formation and testing characteristics are met by one person for all questions given. Most of the subjects have difficulties in forming hypotheses

because they do not really understand how to put forward the hypothesis of a problem.

There are 14 subjects students with logical mathematical intelligence. But in reality, not all subjects had a good characteristic of it. It is known from previous analysis that many subjects are difficult to meet the five characteristics of logical mathematical intelligence.

Difficulty in understanding the sentence is one of the causes of the subject's inability to classify and solve the problem. While research by Arani and Mubarakeh (2012) shows that mathematical logical intelligence is related to students' cognitive strategies in the process of understanding sentences. Students with good mathematical logical intelligence will have a better understanding of sentences. In the process of solving mathematical problems, students with this type of intelligence will be easier in understanding the sentence.

Mistakes in understanding mathematical concepts by several subjects were one cause of the lack of logical mathematical intelligence characteristics are met. Santrock (2011: 3) states that the concept is a category classifying objects, events, and characteristics based on the same forms. Someone who does not have a good concept on a case, he would have found that the most trivial problems become difficult to formulate and even impossible to solve. As happened in the subject of this study, those who fail to understand the concept of numbers and numeral with either unable to understand the question, so he was not able to classify.

The process of comparing the information known on the matter with the devised plan will also be hard if the mathematical concept owned by the subject is lack. The same thing applies to the characteristics of deductive and inductive reasoning, and hypothesis forming and testing. Santrock (2013) argues that an important aspect of inductive reasoning is the observation that repeated, so that information about similar experiences accumulated to the point where repetitive patterns can be detected and more accurate conclusions can be drawn. The lack of math knowledge and concepts would have trouble doing repeated observations on the information needed to solve problems so that the reasoning process also be hard.

From creative thinking skills analysis with five subjects, it is known that most subjects only meet four of the five components: sensitivity problems, fluency, flexibility, and elaboration. Only S09 is able to show the novelty on her solution.

S11 who meet better characteristics of classifying, able to show components problems sensitivity, fluency, flexibility, and elaboration. S12 who has better characteristics of compare, shown creative thinking skills are almost the same as the S11. S05 who has better characteristics of performing basic numerical operation fulfill the components of fluency, flexibility, and elaboration. S04 who has better characteristics of inductive and deductive reasoning, shown creative thinking skills better than previous subjects. He was able to present some new and different solutions. S09 who has better characteristics of hypothesis forming and testing able to present new solutions, so that she meets all components of creative thinking.

Based on the analysis of the creative thinking processes of research subjects, it is known that the S09 who has better characteristics of hypothesis forming and testing shown creative thinking skills better than the four other subjects. The process hypothesis forming and testing obviously have to go through the process of classifying, comparing, perform basic operations numbers and both inductive and deductive reasoning. Thus, it can be said that this subject has a logical mathematical intelligence better than other subjects.

Palaniappan (2007) describes the results of his research that creativity has a correlation with intelligence and academic achievement. Creativity can complement the lack of intelligence so that students with high creativity can achieve better performance despite their low intelligence. Conversely, intelligence also has a role in supporting student creativity. Previous research by Dalal and Rani (2013) have shown a positive correlation between intelligence (IQ) with student's creativity, instead this study focused only on the logical mathematical intelligence. The IQ measurements using a set of questions that include language skills and mathematics. Logical mathematical and linguistic intelligence can guarantee success in a variety of IQ tests because they are targeted intelligence tests. A person with a high IQ has good mathematical and language ability. Based on the Gardner's idea of multiple intelligences (1983), the indicator of mathematics ability used in IQ tests analog to the type of logical intelligence characteristics, i.e a person's ability to think according to the rules of logic, understand and analyze the patterns of numbers, and solve problems use the thinking ability.

5. Conclusion and Recommendations

The analysis showed 12; 8; 5; 3; and 1 subject(s) who fulfill the characteristics classify, compare,

perform a basic numerical operation, deductive and inductive reasoning, and hypothesis forming and testing. For the second test given to five subjects that represent each logical mathematical intelligence characteristics, it was found that the subjects with the characteristics classify, compare, perform basic numerical operations, deductive and inductive reasoning fulfill component of creative thinking: problem sensitivity, fluency, flexibility and elaboration; and hypothesis forming and testing characteristics fulfill all components.

Based on the result of this study, teachers are expected to familiarize students with math problem solving; as well as familiarize students to think creatively by presenting the open ended questions.

6. Disclosure Statement

This research earns open problems. For example, if research is focused on geometry, then the corresponding type of intelligence is a spatial visual. A person with spatial visual intelligence has a visual sensitivity about lines, shapes, and spaces. Related to the findings of researchers that there are some subjects who can't distinguish the concept of numbers and numeral, then research can be developed to analyze errors in the understanding of concepts that still often appear in students in learning mathematics.

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