Students’ logical-mathematical intelligence through the problem-solving approach

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Abstract. Logical-mathematical intelligence is one of the most dominant components of multiple intelligences in mathematics learning because it can be built in all topics in mathematics. Logical-mathematical intelligence is the ability of students in terms of numbers and logic, which involves the skills to process words and numbers, to use logic and analyze problems logically, to find formulas and to do investigations scientifically. The purpose of this study is to describe the logical-mathematical abilities of high school students. A total of 25 seventh-grade students in a junior high school in Banda Aceh participated in this study, but only three of them, with high, medium, and low criteria of logical-mathematical intelligence based on the test results, were selected to observe and analyze their logical-mathematical abilities. Data were conducted from a test and interview. The instrument used in this study was a student test sheet. The results showed that only a small number of students (three out of 25) had logical-mathematical intelligence in the indicators of numeracy and problem-solving. Then, it can be concluded that the students’ logical-mathematical intelligence is still low and needs to be further investigated.

1. Introduction

Mathematics is taught at schools from elementary to high school levels. Mathematics learning is expected to develop students’ various mathematical skills. There are many student characteristics in one school; they vary based on their intelligence or emotional level. In accordance with an individual psychology study, dimension and differential psychology provide a specific domain related to individual differences theory, which states that every human has his own distinctive traits, even identical twins have their own characteristics, and it is impossible for a person to be an exact copy of another [1]. If the teacher could not understand the individual differences between students, the aim of the learning would not be able to be achieved.

A student’s unique traits can be seen through multiple intelligences aspects [2]. Gardner emphasizes that each individual has eight types of intelligence summarized in the multiple intelligences. These multiple intelligences are linguistic, logical-mathematical, spatial, musical, kinesthetic, interpersonal, intrapersonal, and naturalistic. The intelligence of a student could be improved and developed. Bukit and Istarani state that multiple intelligences are essential matters for students’ intelligence development [3]. National Council of Teachers of Mathematics (NCTM) adds...
that multiple intelligences should be developed in the mathematics curriculum as they could help students make their own strategy and solving the problems in the learning process.

The most dominant intelligence in mathematics learning is logical-mathematical intelligence because it could be developed in every topic of mathematics learning. The logical-mathematical intelligence is an ability in processing numbers and logic which involves the ability in processing words and numbers, using logical thinking and analysis, finding a suitable formula, and doing a scientific exploration [4]. Meanwhile, Chatib explains that the logical-mathematical intelligence is the ability to understand calculations, patterns, logic and scientific thinking [5]. The other defines the logical-mathematical intelligence as an ability to do calculation and measurement, to examine proposition and hypothesis, and to complete number operations [6]. In conclusion, logical-mathematical intelligence is associated with numeracy and analytical ability, as well as the ability to think logically and scientifically.

Logical-mathematical intelligence has several main components. Said and Budimanjaya reveal the primary component of the logical-mathematical intelligence is the ability to understand logic or numerical patterns and the ability to process complex thoughts. This logical-mathematical intelligence is located in the specific brain area, left frontal lobe and right parietal or simply above the eyebrows [6]. The brief description of the logical-mathematical intelligence can be seen in Table 1.

Table 1. Description of the logical-mathematical intelligence

| Intelligence | Definition | Main competency | Competency | Brain area |
|--------------|------------|----------------|------------|------------|
| Logical-    | The ability to calculate,    | the ability to understand the logic or numerical | Numeracy, reasoning, logical thinking, and problem-solving | Left frontal lobe and right parietal |
| mathematical| measure, examine proposition and hypothesis, and complete number operations | patterns and the ability to process complex thoughts | | |

*aadopted from Said and Budimanjaya [6].

Logical-mathematical intelligence always plays an essential role in human life. This is in accordance with Soefandi and Pramudya, stating that the logical-mathematical intelligence is critical and necessary because numeracy ability is a crucial ability to change lives for the better [4]. Thus, it is safe to say that the logical-mathematical intelligence needs to be developed in various ways.

In reality, at schools, students’ logical-mathematical intelligence is still poor; this can be seen from the low student achievement in mathematics learning. One of the main reasons is that the learning process still mostly focused on the teacher, and the students do not actively participate in the learning process and problem-solving. This will lead to the absence of logical-mathematical activities, and the students cannot find the learning concept. This condition is also happening in an eighth-grade classroom in Junior High School 1 Banguntapan. The problems in such situation are that the students have difficulties in understanding the concepts and tasks given, and the low participation by the students in the learning process. This condition then leads to the unenthusiastic response from the students while learning, and this will affect the students’ future achievement [7].

A good learning process is a learning process carried out by using a suitable strategy to achieve the learning objectives. An appropriate learning strategy is a strategy that can create a good learning condition for the students and gives the students a good learning experience [8]. Therefore, it is essential to apply and develop a constructive theory in the learning process so that the students could develop a good mindset and find knowledge by using their own experiences [9]. This fits the aim of the curriculum 2013 which demands that in the learning process, the students must actively participate
in the learning by doing activities such as exploration and the teacher is expected to play a role as a facilitator. The teacher also has to design the whole learning process so that the students can solve the problems given. The objective will be achieved if the learning approaches are developed according to the students’ needs. A good learning approach is the learning approach that could inspire the students to actively get involved in the learning process by exploring and solving the problems, and the teacher acts as a facilitator. This learning approach is named problem-solving approach. Learning strategy that could help develop the logical-mathematical intelligence is the strategy that applies the problem-solving approach [6].

Problem-solving can be defined as a method to produce a solution to a problem. Problem-solving is basically a process taken by someone to solve a problem that they face until the problem is no longer problematic for them [10]. It means that the problem-solving approach is a teaching guide which is theoretical or conceptual to train the students in solving mathematical problems using any available method or strategy. Problem-solving is one of the essential parts in the mathematics curriculum because, through learning and solving process, the students will obtain an experience of using their own knowledge and skills applied in a non-routine problem-solving.

There are three interpretations of problem-solving based on its outline: problem-solving as an objective, a process, and a basic skill. Problem-solving, as an objective, does not depend on a specific problem, procedure or method, and mathematics content; instead, the most important one is how to solve problems in mathematics learning. “Problem-solving can be carried out through four steps: (1) understanding the problem; (2) planning the problem-solving, (3) solving the problem according to the plan, (4) checking the solution obtained” [11]. The success of a learning process can be seen from the students’ achievement and their understanding of the subject.

Research conducted by Perez, Esther, Duque, Guzmán, García, and Fernández about logical-mathematical intelligence entitled “Game-Based Learning: Increasing the Logical-Mathematical, Naturalistic, and Linguistic Learning Levels of Primary School Students “, showed that a significant difference between children's learning levels in logical-mathematical, naturalistic and linguistic abilities before and after the application of game-based learning resulted in broad improvements in each indicator [12]. In this current study, the researchers intend to see the logical-mathematical intelligence of junior high school students through the problem-solving approach. Thus, the formulation of the problem in this research is “how is students' logical-mathematical intelligence through the problem-solving approach?”.

2. Method
This research is qualitative research that produces descriptive data in the form of words or oral statements from people and observed behaviour [13]. This study aims to describe the students' logical-mathematical intelligence. This study involved 25 seventh-grade students in Junior High School 6 Banda Aceh, who have learned linear equations in one variable. To observe and analyze the logical-mathematical intelligence of the students, three students with high, medium, and low logical-mathematical intelligence on the test results were chosen. The instrument used was a test item. The logical-mathematical intelligence test question was taken from the development of learning tools made by Adilla with valid and practice criteria [14]. Indicators of the logical-mathematical intelligence measured in this study are that the students can perform mathematical operations and problem-solving including, understanding the problem, devising a plan, carrying out the plan and looking back. The test item for the logical-mathematical intelligence is “A pilot flies a plane from Sultan Iskandar Muda International Airport to Soekarno-Hatta International Airport, initially at an altitude of 2,500 feet above sea level. Because of the cloud, the pilot turns the plane up to 10,000 feet. Please write a mathematical equation from the problem. Find out the increase in the plane’s altitude.” The time given to work on the test was ten minutes. The data were collected from the analysis results of the students’ answers on the test and interview.
3. Results and discussion
The results found that three out of 25 students correctly answered the logical-mathematical intelligence problem with indicators of numeracy and problem-solving. 18 out of 25 students obtained the answers but did not write down the complete steps of the solution; in other words, they did not meet the problem-solving indicator. Meanwhile, the rest of the students, four out of 25, did not answer the question at all.

Figure 1 below shows the answer of Student 1 that answered the question correctly and met the indicators of numeracy and problem-solving.

![Figure 1: Student 1’s answers](image)

The test results revealed that the student understood the question thoroughly and was able to make a mathematical equation from the information given in the problem. This was evident, in his answer sheet, that the student correctly wrote all steps of problem-solving: understanding the problem, devising a plan, carrying out the plan and looking back. As such, the student could find the answer to this problem correctly. This result was confirmed through the interview as in the following excerpt.

**P:** What do you understand from the problem?
**S:** The problem is...there is a plane that flies at the initial height of 2,500 feet, then flies at higher altitude until it reaches 10,000 feet. The question is...how many feet does the plane’s altitude increase?
**Q:** Why did you make that mathematical equation as you wrote in the stage of devising a plan. Can you justify that?
**S:** Because to find out how many feet the altitude increases, we need the initial height plus the increased height equals to the final height.

Then, Figure 2 below shows the answer of Student 2 who answered the problem but did not write the complete steps and the answer is slightly precise.
In the stage of understanding the problem, the student wrote down what is known from the problem, but it is still not quite right in the phrase “raise the height to = 10,000 feet”. The student should have written “the final height = 10,000 feet”. The student also did not state what is asked in the problem. In the stage of devising a plan, the student wrote "the initial height = the final height" which is incorrect, and it is not in accordance with the mathematical equation written "2,500 + x = 10,000". The equation should be "the initial height + x = the final height". While at the stage of carrying out the plan and looking back, the student’s answer is correct. This answer shows that the student did not understand the problem-solving steps and could not explain what had been written. This is confirmed by the interview excerpt as follows.

Q: What do you understand from the problem?
S: The altitude is initially 2,500 feet, then it increases up to 10,000 feet.
Q: What is asked in this problem?
S: x value
Q: What does it mean by x value?
S: (The student is silent and does not answer anything)
Q: Is the initial height the same as the final height?
S: Not the same
Q: Why did you write the equation of 2,500 + x = 10,000?
S: (The student is silent, not answering)

On the other hand, Student 3 did not solve the problem given by the researchers, but rather only wrote his name and class. The interview with the student is provided in the excerpt below.

P: Why don't you solve the problem?
S: I don’t know how to do it
P: What do you understand from the problem?
S: (The student is reading the question)
P: Please tell me the situation of the problem as you understand it
S: (The student keeps silent, does not say anything)
Based on the description of the students' answers above, it can be concluded that the students' logical-mathematical intelligence is still low because only three out of 25 students met the indicators of the logical-mathematical intelligence measured by the researchers. The low logical-mathematical intelligence may be caused by the instrument that has shortcomings and needs to be revised; for this reason, the students' logical-mathematical intelligence needs to be investigated further. Learning styles of the students with logical-mathematical intelligence tendencies are learning with numbers, learning by using computers, learning by making hypotheses or thoughts first, learning through cases and trying to find a way out [15]. The students with high logical-mathematical intelligence tend to have the characteristics, such as easy to analyze and study the cause and effect of what is happening. Such students have a tendency to like counting activities and to have high speed in solving mathematical problems. If they do not understand, they will generally ask questions and look for answers to things they don't understand. Thus students who have high logical-mathematical intelligence will excel in mathematics [16].

4. Conclusion
The study results showed that only a small number of students (three out of 25) had logical-mathematical intelligence in the indicators of numeracy and problem-solving. Then, it can be concluded that the students' logical-mathematical intelligence is still low and needs to be further investigated.

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