The quantitative reasoning ability of high school students

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Abstract. Quantitative reasoning is a mental activity that emphasizes drawing conclusions based on quantitative data or information. Students are often wrong in solving quantitative reasoning problems. Students do not understand very well the relationship between the information provided with the questions in the problem. The solution to this problem is to investigate students’ quantitative reasoning ability. This study aims to find out the activities of students’ quantitative reasoning abilities. This research uses a qualitative approach. Twenty-three high school students were involved in this study. Data is collected by giving tests in the form of quantitative reasoning ability questions. After the test, a brief interview was conducted with some students. The results of this study indicate that students still have difficulties in answering questions in the form of quantitative reasoning abilities. Therefore serious attention is needed to improve students’ quantitative reasoning abilities.

1. Introduction

Mathematics is one of the subjects that students begin to learn since elementary school, high school and even up to college. Mathematics is intended to equip students with logical, analytical, systematic, critical and creative thinking and the ability to work together [1]. Students need to master mathematical concepts as early as possible to be able to master and create technology in the future [2]. The purpose of learning mathematics according to the National Council of Teachers of Mathematics (NCTM) is to develop mathematical abilities which include problem-solving ability, reasoning ability, communication ability, ability to make connections, and representation ability [3].

Reasoning is a thinking process that is needed to draw conclusions or make a new statement that is true based on several true statements that have been proven true [4]. Reasoning has an important role because it is one of the goals of learning in mathematics. According to O’Daffer and Thornquist [5], reasoning is the most important ability that is continuously used to understand mathematics or to solve problems in mathematics. Therefore, mathematical reasoning ability is very important to be owned by students to be able to understand mathematical concepts.

The ability of reasoning is important for everyone and also to be applied in the curriculum of learning in schools [6]. The importance of reasoning ability for students in schools is written in the Minister of National Education Regulation number 64 of 2013. It is stated that the standard of mathematics content is so that students can use reasoning on patterns and attributes, perform mathematical manipulation in making generalizations, compile evidence, and explain ideas and mathematical statements.

Reasoning is the process of drawing conclusions in thinking activities [7]. There are three types of reasoning in mathematics, namely, sequential or deductive, inductive, and quantitative reasoning [8]. In this study, the researchers focus on quantitative reasoning. Quantitative reasoning already exists in children aged five years to adult level. Therefore, the ability of quantitative reasoning is the ability that
exists in mathematics learning which is used to analyze quantitative information. Quantitative reasoning requires the use of mathematical content for assessment purposes and to solve general problems [9].

Quantitative reasoning is a type of reasoning that uses patterns and attributes, performs mathematical manipulation in generalizing, compiling evidence, or explaining mathematical ideas and statements. Quantitative reasoning is a type of reasoning that must be acquired in mathematics learning. Several studies have proven the importance of quantitative reasoning [10]. The American Mathematical Association’s report on mathematical objectives discusses quantitative reasoning as an ability that must be possessed and developed in all high school and college students [11]. Therefore, the ability of quantitative reasoning should be introduced to students as the basis for improving the quality of Indonesian mathematics education.

But the reality that occurs in the field, quantitative reasoning has not been fully involved in the stages of the mathematics learning process especially in Algebra. This condition causes students to only memorize formulas without knowing the true meaning of the Algebra material. Quantitative reasoning abilities should be used as a material reflection to improve the process of further learning. However, in improving the process of learning mathematics, adjustments is needed to suit the needs of students. Furthermore, a teacher is also expected to understand the quantitative reasoning abilities possessed by their students.

Several studies on quantitative reasoning have been carried out [12]. In this study, we focus on students' quantitative reasoning on trigonometry material. The purpose of this study is to describe the quantitative reasoning capabilities of high school students. Most studies use the final outcome data. In this study, we analyzed the students' quantitative reasoning abilities with indicators.

2. Method
This study aims to describe students’ quantitative reasoning skills at an Islamic private high school in Aceh Besar, Indonesia. The study utilized a descriptive qualitative approach. The participants were 23 students in grade 4 science 1. Quantitative reasoning ability data was collected through a test consisting of four questions in the form of description [13]. The data is reinforced by interview guidelines. The problem refers to six indicators: 1) reading and understanding information provided in various forms; 2) interpreting quantitative information and drawing conclusions, 3) solving problems using arithmetic, algebra, geometry, or statistical methods; 4) estimating answers and checking the eligibility; 5) communicating quantitative information; and 6) making a limitation of the mathematical or statistical methods [10,14].

After the test, several students were selected for interviews. The purpose of the interview was to find out students' understanding of the test and to find out things that did not appear when the students were answering the test questions. The instruments used in this research are validated instruments.

3. Results and discussions
3.1. Reading and understanding information
The results of quantitative reasoning ability test with the indicator reading and understanding information provided in various forms showed that only 8 out of 23 students completed the questions correctly, 10 students answered the questions but they were not right and the rest of the students did not answer the question. In order to solve a question, the students should be able to identify which sentence gives information and which sentence gives the task [15].

3.2 Interpreting quantitative information and drawing conclusions
The results of quantitative reasoning ability with the indicator of interpreting quantitative information and drawing conclusions showed that only 3 out of 23 students could answer correctly, 6 students gave wrong answer and the other did not answer the question. Figure 1 shows a student’s correct answer in interpreting quantitative information and drawing conclusions.
3.3. Solving problems using arithmetic, algebra, geometry, or statistical methods

The results of quantitative reasoning ability with the indicator of solving a problem using arithmetic, algebra, geometry or statistical methods showed that only 5 out of 23 students answered correctly, 2 students gave wrong answers and the others did not solve the problem. Figure 2 shows a student’s incorrect answer in solving a problem. The question states that machine A finishes a job by itself in 10 minutes, while machine B in 15 minutes, so what is the time for the two machines to finish the job together.

![Figure 2. A student’s answers to question no 4.](image)

The results show that the students could not apply the correct procedure to solve the question. This was confirmed by the students’ response during the interview.

P: How to determine the time required for machines A and B?
S: Add up the time needed for each machine.

3. 4. Estimating answers and checking the eligibility

The results of quantitative reasoning ability with the indicator of estimating answers and checking eligibility show that only 5 out of 23 students solved the questions correctly, 3 students answered incorrectly and the others did not answer at all. From the students’ answer, it was found that the students can predict the answers, but their answer was not quite right.

3. 5. Communicating quantitative information

The results of quantitative reasoning ability with the indicator of communicating quantitative information show that only 3 out of 23 students solved the problem correctly, while the other students could not answer correctly. Figure 3 shows a student’s incorrect answer to a question about the ratio of the circumference of a rectangle and a square.
The length of rectangle R is 30 and its width is 10. The length of square S is 5. What is the circumference of S compared to that of R?

Student’s answer:
L (rectangle R) = p x l
= 30 x 10
= 300

From the results, it was found that the students knew the quantitative information but they could not derive correct overall information from the question. This is as shown during the interview, as stated below.

P: How do you determine the circumferences of rectangle R and S?
S: Because the length and width are known so all I need to do is multiply the length and the width.

The result shows that the students still need help in understanding a question, especially a word problem. To help the students, a teacher should encourage the students to explain their thinking and reasons behind their decision in solving a problem. The more often the teacher asks the students to communicate quantitative information and explain their response, the more involved the students are in their own thinking and learning and the higher their achievement in mathematics [16]. Therefore a teacher should have good questioning skills.

3. 6. Making a limitation of the mathematical or statistical methods
The results of the quantitative reasoning ability with the indicator of making a limitation of the mathematical or statistical methods show that only 2 out of 23 students answered correctly and others did not answer at all. This shows that the students’ quantitative reasoning ability is low.

From the results of the interview, the students who were not able to answer the question at all stated that the reason they did not answer the question was because they did not understand the information from the questions. This implies that it is highly important to communicate with students and let them express their learning difficulties. In solving mathematics problems, the students need more exercises so they can get used to understanding word problems. They need to be trained to open their mind and try to understand the information given in a word problem. More studies are needed to help students communicate their strategy and explain their responses because the more the students are involved in the class, the higher their mathematics achievement can be [17]. To prepare students better in solving mathematical problems, a teacher must often provide questions about quantitative reasoning in order to develop students’ understanding based on the given problem [18].

4. Conclusion
Based on data analysis, it can be concluded that the students’ quantitative reasoning ability is classified as a low category. It shows from the quantitative reasoning ability test. For the first indicator, the students gained 72.1%, for the second indicator 60.9%, for the third indicator 55.6%, for the fourth indicator 40.1%, for the fifth indicator 15.1%, and for the sixth indicator 10.1%. This study implies that students need help in improving their quantitative reasoning abilities.

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