Types of proportional reasoning of seventh grade junior high school students in Jombang

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Types of proportional reasoning of seventh grade junior high school students in Jombang

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Abstract. This research is a descriptive qualitative research that aims to describe the type of proportional reasoning of students. The research subjects were seventh grade students of SMP in Jombang Regency. The subject selection procedure is by purposive sampling. Data collection is done by means of tests, think aloud methods and semi-structured interviews. Data validity uses time triangulation. Data analysis techniques are carried out by: (1) grouping data in 4 categories, then reducing data not included in the 4 categories, (2) presenting data in narrative texts, and (3) concluding the type of proportional reasoning students then comparing subjects that are on the same type of proportional reasoning. Based on research conducted on 150 subjects of class VII SMP in Jombang regency, there were 62 students using cross multiplication, 30 students used additive reasoning, 45 students used multiplicative reasoning and 13 students used a mix of additive and multiplicative reasoning. Additive reasoning, the way the subject does it is to add one by one to many caterpillars associated with many leaves. In determining the missing value, the subject uses multiplicative reasoning by determining the scalar number first. Subjects with a mix of additive and multiplicative reasoning use numerical calculations and use images to reason problems. Cross multiplication, Subjects use the concept of comparable value by specifying unknown elements with a variable. Although not all subjects use formal reasoning (cross multiplication) in completing, but the reasoning of class VII students shows that it includes relative reasoning. They don't just pair numbers with numbers. Although, there are subjects who do not fully understand invariant and covariant relationships

1. Introduction

Students in learning mathematics, must have the ability to think because of the nature and characteristics of mathematical sciences related to real life problems. Thinking activities need a problem solver at each step in solving problems. Students must think in interpreting the problem, must think in selecting a problem solving strategy and apply it, so that an appropriate solution is obtained [1].

Problem solver also requires the support of mathematical arguments in solving problems [2] and [1]. Through arguments, the problem solver provides a description of the reasons for strengthening or rejecting opinions, or ideas. Problem solvers can also leave doubts and doubts so that they can determine, produce and support rational solutions. Therefore, the problem solver must use valid mathematical arguments.

The ability to use valid mathematical arguments is also needed when communicating. Communication skills are needed in conveying abstract mathematical objects to the audience [3]. Communication in mathematics and mathematics learning becomes necessary because mathematics is

a language and language as the best language in the community, so it is easy to understand that communication is essential in teaching, learning, and accessing mathematics.

The ability of the problem solver to argue is influenced by its mathematical abilities [4]. There are 3 types of basic mathematical thinking that are most useful that are relevant to the everyday world, namely: 1) proportional thinking; 2) estimation; and 3) mathematical modeling activities that are in line with the development of concepts in proportional thinking [5]. The essence of proportional reasoning is students' understanding of numbers in relative forms rather than absolute forms. Students use proportional reasoning in early mathematics learning, for example when they think of 6 as two times three or rather than thinking 6 as one less than 7. Next they use proportional reasoning when thinking about how the speed of 50 km / h is the same as the speed of 25 km /30 minutes. This is in line with [6] that proportional reasoning is found in materials such as congruence, opportunity or social arithmetic. In addition proportional reasoning is not only used in mathematical topics but also used in the fields of geography, speed, chemical composition and formula of a recipe [7].

Proportional reasoning is a person's understanding of the multiplication relationship between two quantities or more [8]. Proportional reasoning involves the ability to understand multiplicative relationships. The multiplicative relationship in this comparison is a relationship that involves multiplication. In addition to involving the ability to understand multiplicative relationships, states that the ability to understand differences between situations using additive and multiplicative relationships is one indication of proportional reasoning [8].

Students' ability to think proportionally affects their understanding of fractions and measurements in elementary school, and supports their understanding of function and algebra in secondary schools and beyond [9]. Proportional reasoning is more about number reasoning than formal procedural solutions of proportions. Students in solving the problem of proportions are often directed by the teacher to use cross multiplication procedures. This procedure has the advantage of being efficient and widely applicable in all contexts and domains. But [10] study shows that students do not easily learn cross-multiplication algorithms, or they refuse to use them. This is probably due to the difficulty of connecting cross-multiplication algorithms with their previous understanding of ratios [7]. This procedure is not compatible with mental surgery involved in developing strategies and is less meaningful in certain situations.

[11] rates proportional reasoning to 4, namely level 0, 1, 2, and 3. At level 0, students cannot use proportional reasoning, because they are still fixated by guessing or using visual assistance. At level 1, students use images, manipulations, or mathematical models that match the problem given. Students can also make qualitative comparisons which are multiplying each value that forms a ratio. At level 2, students can manipulate comparative situations using numbers. To solve the comparison problem, level 2 students are able to use a combination of each unit, find and use unit values per unit, identify or use scalar factors, use table help, use fractions worth, and build both sizes. At level 3, students can set a proportion by using variables and solving these variables by using cross multiplication rules. Students also fully understand covariant and invariant relationships. Invariant is a relationship between two quantities that have the same fixed value, while covariance is two sizes in each ratio varies together. In addition, Lamon stated that there are 4 characteristics a person has when doing proportional reasoning, namely, 1) Understanding covariations, 2) Identifying proportional and non-proportional situations, 3) Applying multiplicative strategies, and 4) Understanding the terms of use ratio [12].

Based on this background, the researcher conducted the research with the aim of describing the type of proportional reasoning of the seventh grade junior high school students in Jombang. This is because, in general, students in junior high school have an age range between 13 and 16 years. Piaget & Inhelder's research results show that children are not capable of proportional reasoning until around 11 years [13]. So that students' proportional reasoning abilities begin to develop above the age of 12 years.

2. Method

The research approach used in this study is qualitative research. The researcher used a qualitative research approach with a type of descriptive research because qualitative research with this type of research is relevant and possible to achieve the objectives of this study. The purpose of this study is to describe the type of proportional reasoning of grade VII junior high school students in Jombang.

The researcher revealed and obtained an overview of the types of proportional reasoning of junior high school students in Jombang through careful and careful examination and detail and depth. The researcher explores what is being thought, written, drawn, pronounced by the subject when facing the problem given. The researcher describes / presents the data obtained based on the actual situation.

The research subjects were seventh grade junior high school students in Jombang. The reason for choosing this subject is that students already have proportional reasoning skills when elementary school and these abilities begin to develop because the subject will learn the concepts of function and algebra. There are 2 supporting instruments in this study, namely: problem solving task sheets and interview guidelines. The main instrument is the researcher himself. This task sheet is used to describe the type of proportional reasoning of 7th grade students in Jombang. This problem is adapted from the problem of the comparison between leaves eaten by caterpillars from the National Center for Education Statistics, the National Assessment of Education Progress (NAEP) http://nces.ed.gov/nationalreportcard/itmrls/startsearch.asp . The following problems are given to the subject

> Slavin requires 5 leaves every day to feed 3 caterpillars. How many leaves does Slavin need every day for 18 caterpillars? Use pictures, words, or numbers to show how you get answers!

The second supporting instrument of research is interview guidelines. The researcher used semi-structured interviews to reveal more in the proportional reasoning process carried out by students during the process of solving the problem given. Broadly speaking, interviews are conducted to find out what the subject is thinking when concluding something and taking a step. Questions can be "How do you think about this?" Or "What do you think now?" Questions are also asked to find out the reason for the subject when using the steps of thinking.

Data collection to reveal proportional reasoning, in the first stage is given a problem solving task sheet to the subject. Subjects were asked to express verbally as much as possible what was thought during the problem solving process. This kind of data collection is called the think out loud method. According to [14] the think out loud method has two important steps, namely: (1) students write down or express their thinking awareness when solving problems (deeper than just explaining the behavior that is shown). (2) students must report what they really think right now (not just what they remembered a moment ago). Whereas [15], [16], [17] use the term think aloud. According to Van Someren et al., The method of thinking aloud is done by asking the subject to speak loudly when solving a problem and what is voiced can be repeated if needed during the problem solving process. That way the subject can tell about what is being thought. In this study this method is termed think aloud. The subject activity is loudly speaking while solving problems, recorded with a recording device.

Furthermore, task-based interviews are carried out related to problem solving. Data credibility is done through triangulation. Triangulation in this research is done by comparing or checking data aloud, written results and interview results. The process of data analysis in this study was carried out during and after the data collection process. This is done so that the data obtained can be arranged systematically and easier to interpret.

1. The process of analyzing the data in this study is carried out with the following steps: The subject-j (j = 1,2,3, ...) is given a question about the first proportional problem. Subjects were asked to work on the problem by expressing their thoughts orally so that oral and written data were obtained. After obtaining research data, then the identification of data is then carried out, namely written and organized data so that conclusions can be drawn. Data collection is categorized into four, namely problem solving using cross multiplication strategies, looking for

unit values, and using scalar factors, and using combinations of each value. The next step is to present well-prepared, coherent data so that it is easily seen, read, and understood about an event or event in the form of narrative text. Next is to draw conclusions from the data collected and verify these conclusions. The subject-j (j = 1,2,3, ...) is then given a question about the second proportional problem. Data from the second problem solving test were analyzed like the first problem-solving test data.

2. The results of the analysis of the first and second test data are crystallized by distinguishing the results of the first meeting test with the second meeting to obtain valid data. Valid data is used to determine the type of proportional reasoning of students.
3. The final step is to compare the description of proportional reasoning from a subject that satisfies the same type of proportional reasoning. The same description is the main finding of the study, and if there are different descriptions, it becomes another finding in the study.

3. Research Results and Discussion

The researcher involved 150 seventh grade junior high school students in Jombang. There were 30 students using additive reasoning, 45 students used multiplicative reasoning, 13 students used a mix of additive and multiplicative reasoning, and 62 students used cross multiplication in solving problems.

3.1. Additive Reasoning

Determination of missing values, the way in which the subject is done is to add one by one to many caterpillars associated with many leaves. The following are aloud snapshots and written answers to the subject in describing additive reasoning.

> "This is a comparison of the value of yes, 3 caterpillars need 5 leaves, so 3 caterpillars plus 3 caterpillars so 6 caterpillars need these 5 leaves plus 5 so that these 6 caterpillars need 10 leaves. Then added 3 more caterpillars to become 9 caterpillars, this added 5 more leaves to 15 leaves, so 9 caterpillars need 15 leaves. Then add 3, plus 3 and continue until the number of caterpillars is 18. And this leaf is also added to 5, so it will meet dech 18 caterpillar with leaves of 30 ".

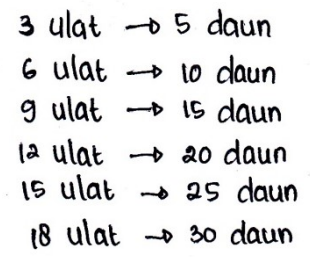

Figure 1. Written Answer of Subject AJ

In solving problems, subjects tend to use addition operations to get the values asked. Furthermore, the subject stated that knowing the existence of a strategy other than addition is a cross times strategy to solve the problem. But not using it because the subject believes that the addition strategy is more accurate in determining the missing value and there is a fear of making mistakes. This is in line with Walle's (2007) opinion that students in class VII rarely use cross-multiplication methods to solve the problem of proportions, even though the cross-multiplication method has been taught. The following is an interview interviewer with the subject.

Researcher : You said about this comparison of values, huh?
Subject AJ : Yes
Researcher : Why?

Subject AJ : Yes, this looks like a comparison of values
Researcher : Are there other ways to answer this question?
Subject AJ : Emmm can use cross multiplication
Researcher : Why use it?
Subject AJ : This way the answer is more precise and usually I am wrong if I use cross multiplication
Researcher : You can use cross multiplication
Subject AJ : You can, but are afraid of being wrong
Researcher : Try using cross multiplication
Subject AJ : What about Emmm if it's wrong?
Researcher : It's okay, just try it
Subject AJ : Three per 5 equals 18 per x. three x equals 5 times 18. Five times 18 equals 90

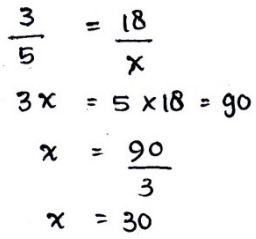

Figure 2. Written Answer of Subject AJ

Another interesting thing is when students already know about the form of comparison, but do not use this form of comparison in solving problems and are more likely to use informal strategies to solve comparison problems. Vincent (2009) reveals that, students do some assumptions in reasoning, and do not have to use known algorithms. According to Langrall and Swafford (2000) this subject is at level 1, where the subject uses images, manipulations, or mathematical models that match the problem given. Subjects can also make qualitative comparisons which are multiplying each value that forms a ratio.

3.2. Multiplicative Reasoning

Subjects using multiplicative reasoning first determine scalar numbers. The following are aloud snippets and written answers to the subject in describing multiplicative reasoning.

"What is known is that 3 caterpillars eat 5 leaves. What is asked is that many leaves are eaten by 18 caterpillars. Now 3 to 18 is multiplied by 6, the leaf must also be multiplied by 6, 5 times 6 and 30 of these. So 18 caterpillars need 30 leaves to eat ".

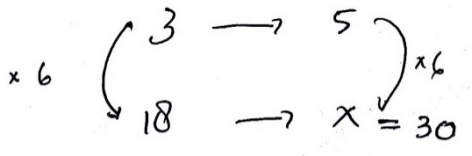

Figure 3. Written Answer of Subject HY

In determining the missing value, the subject states that the quantities in different size spaces change together. In addition, subjects also identified indirect proportions using the change in quantity. The subject represents the quantities into ratios that form proportions, then the subject uses

multiplication operations by determining the scalar factor first to get the value in question. According to Langrall and Swafford (2000) these students are on level 2, where students can manipulate comparative situations using numbers. To solve the comparison problem, level 2 students were able to use scalar factors.

3.3. Mix Additive And Multiplicative Reasoning

Besides using numerical calculations, use images to reason with these problems. The subject in determining the number of caterpillars by means of addition, while in determining the number of leaves that corresponds to the caterpillar multiply. The following is a snapshot of the thoughts and written answers to the subject in describing additive and multiplicative reasoning.

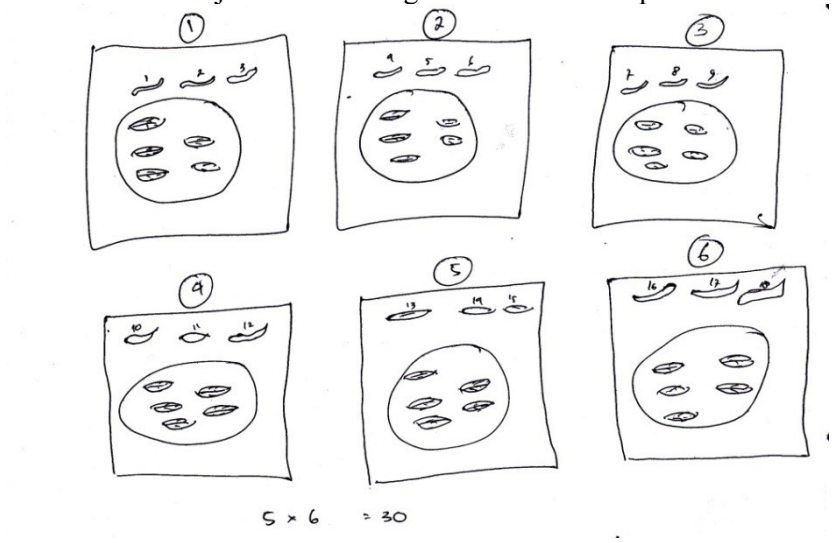

Figure 4. Written Answers of MK Subjects

> "This question is a comparison of values. These are 3 caterpillars, 5 leaves, this is also 3 caterpillars, 5 leaves, this is also 3 caterpillars, 5 leaves, this is also 3 caterpillars, 5 leaves, this is also 3 caterpillars, 5 leaves. Now, the caterpillars are 18, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18. Then the leaves ... there are 1 , 2, 3, 4, 5, 6, there are 6 boxes of leaf caterpillars. So there are 6 times the increase in the leaves 5 times 6 will be 30 ".

The subject uses images, manipulations, or mathematical models that match the problem given. Subjects can also make qualitative comparisons which are to multiply each value that forms a ratio. Next Subjects uses scalar factors in determining missing value. According to Langrall and Swafford (2000) these Subjects are at level 2.

Another interesting thing is when the subject already knows about the form of comparison, but does not use this form of comparison in solving problems and is more likely to use informal strategies to solve comparison problems. Vincent (2009) reveals that, students do some assumptions in reasoning, and do not have to use known algorithms.

At the time of solving the problem, the subject uses media images, this is because the numbers in the question are actually representations of the media image. This is in line with Walle's (2007) statement that students are expected to use media images aimed at instilling the initial concept of comparison before being introduced to algorithmic procedures. So that in recognizing a comparison, students do not directly produce algorithmic skills or procedures.

3.4. Cross multiplication

In solving the problem, the subject uses the concept of comparative value, where the subject specifies unknown elements with a variable. In finding the value of the variable, the subject uses cross multiplication. In general, subjects use cross multiplication because their teacher teaches it in school. According to Langrall and Swafford (2000) students who can establish a proportion by using variables and solving these variables by using cross multiplication rules are at level 3. The following are aloud snippets and written answers to the subject in describing their reasoning.

> "Yes, this is a comparison of the value, the number of caterpillars compared to many leaves is $\frac{3}{5} = \frac{18}{a}$, a number of leaves that will be eaten by caterpillars. This uses cross multiplication which is 3 times a number with 18 times 5 equals 90 to be a same as this 30. Now there are 30 leaves that are eaten by many caterpillars. "

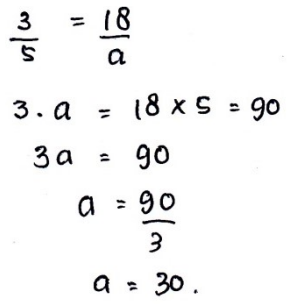

Figure 5. Written Answer of Subject MD

The activity carried out by the subject is to compare three of the known quantities to find one value in question. The subject stated that the quantities that exist, namely many leaves with many leaves as a result of multiplicative relationships. This shows that the subject recognizes the problem situation given is a proportional situation. So that the subject fulfills one component in carrying out proportional reasoning, namely recognizing differences in changes in quantities caused by additive or multiplicative relationships of given problem situations [11].

4. Conclusion

Based on the research conducted on 150 seventh grade students in Jombang, there are four types of proportional reasoning students, namely: additives, multiplicatives, mix of additive and multiplicative, and cross multiplication. Additive reasoning, the way the subject does it is to add one by one to many caterpillars associated with many leaves. In determining the missing value, the subject uses multiplicative reasoning by determining the scalar number first. Subjects with a mix of additive and multiplicative reasoning use numerical calculations and use images to reason problems. Cross multiplication, Subjects use the concept of comparable value by specifying unknown elements with a variable. Although not all subjects use formal reasoning (cross multiplication) in completing, but the reasoning of class VII students shows that it includes relative reasoning. They don't just pair numbers with numbers.

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