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Misconceptions of Comparison and Scale in Students in Conventional Didactic Designs

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***Abstract*:**
This qualitative study aimed to describe the misconceptions of student in Ratio and Scale. The subjects of this study were students of class VII-E MTs Negeri 2 Bandar Lampung in the 2019/2020 school year. The qualitative data was about student misconceptions obtained through observation, documentation, learning outcomes tests and interviews. Furthermore, data analysis was carried out through three stages, namely data reduction, data presentation, and drawing conclusions. Based on the research results, it was concluded that: Class VII-E students made many misconceptions with indicators b, c, and d. Students' misconceptions were influenced by several factors, that was: students did not understand the learning material and did not focus on reading questions, the initial concept they received was wrong, and they was weak in Fractions concept of. In addition, the conventional didactic design used had created many significant misconceptions in students because this design contained a lot of fraction concepts that were less mastered by students.
***Keywords*:** Misconceptions, Ratio and Scale, Conventional Didactical Design.

1. INTRODUCTION

Many people think that students go to school because they don't know their brains. Whereas according to Resnick (1983), students do not come to class with "empty heads." Instead, they came up with a theory built from their everyday experiences. Brown, J. S. and Burton, R. R. (1978), Osborne &Wittrock (1983), and Mestre (1987) added that students have actively developed their own theories that students use to understand the world even though they are incomplete and not completely correct. If the theories built by these students contradict the theories given in school, there will be a deviation of concepts or misconceptions. At that time, there were procedural changes applied by students in solving basic arithmetic problems.
Based on the opinions above, it can be said that misconceptions are significant deviations from concepts caused by procedural changes applied by students. This procedural change is motivated by the experiences students to have in applying previous concepts or theories.
According to Mestre (1989), misconceptions are a big problem for two reasons. First, because it interferes with learning when students use it to interpret new experiences. Second, because students are emotionally and intellectually attached to the misconceptions, they have actively built up. Therefore, students find it difficult to let go of their misconceptions, which can hurt learning.

These findings show teachers that their students almost always come to class with complicated ideas about the subject at hand. Furthermore, researchers say that repeating lessons or making them clearer will not help students who already have strong misconceptions (Champagne, Klopfer&Gunstone, 1982; Resnick, 1983; McDermott, 1984).

Mathematics is a vital subject in school. Students' ability to understand and master mathematics greatly determines their success in other fields of study and in solving advanced mathematics problems (Tiwari& Fatima, 2019). Therefore, every student is expected to master mathematical concepts well.

The fact that is happening now is that many students do not master mathematical concepts well, which results in misconceptions and mistakes in these students (Tiwari& Fatima (2019), Jamaludin&Maat (2020)). This error involves semantically significant deviations from the correct procedure.

Mathematical misconceptions that occur in junior high and high school will greatly affect their academic success in the first years of college (Naseer (2015); Andriani, et al., (2017). The opinion of Naseer, Andriani et al. Reinforces the statement of Thariq (2008), whose research was conducted at a British university. Most (> 40%) of university applicants experienced problems, one of which was the concept of fractions, indicating that there is something that needs to be addressed in mathematics learning in secondary schools.

The concept of comparison and scale has an important role in various fields of science. In junior high school, this concept is given to grade VII students. In conventional didactic design, this concept uses the concept of fractions a lot. Students also deal with many integer operations, especially multiplication and division. Generally, students can memorize the multiplication and division of integers. However, when calculations are presented in algebraic expressions, several problems can occur (Jupri & Drijvers, 2016). It is not uncommon for students not to do it like they did when they were solving arithmetic expressions. Also, their thinking about counting causes many misunderstandings in students' minds (Baroudi, 2006).

In the 2013 curriculum, the concept of Comparison and Scale is advanced after students learn the operations of integers and fractions. The ability to complete these integer and fraction operations is the main requirement in understanding the concept of Comparison and Scale and other advanced concepts.

Several studies have discussed misconceptions in the concept of comparison and scale. Fadillah (2016) uses the Certainty Of Response Index (CRI) to describe grade 7 students' math misconceptions in Pontianak, Indonesia. CRI is a scale of student confidence in answering questions. The value of this scale starts from 0 (guess), 1 (somewhat guessed), 2 (not sure correct), 3 (correct), 4 (almost certainly correct), 5 (definitely correct). The level of student confidence is low if students fill in the CRI scale 0, 1, or 2. The student confidence level is said to be high if the student fills the CRI scale 3, 4, or 5. Fadillah's research results show that students' misconceptions occur in unit conversion, division operations, a fraction of value, the concept of worth comparison, and reversing value.

Meanwhile, the results of Celen's (2018) research on 7th-grade students in Turkey show that student misconceptions arise due to the weak concept of fractions. The document analysis method used by Celin includes analysis of written answers, which contains information about the answers to the 7 open-ended questions given. Students' answers are divided into two categories, namely formal and informal answers. There are three types of assessments in each category: True, False, and Doubtful. Also, there is an assessment for those who do not answer.

In conventional didactic designs, teachers generally use the concept of fractions a lot. Suppose A:B = 2:3. If you know that A is 10, what is the value of B? Generally, the solutions taught are as follows:

$$A : B = 2 : 3$$

$$A = 20$$

$$B = \frac{3}{2} \text{ x } 20 = 30$$

The didactic design above has been used by teachers for years in (conventional) teaching, while the results are not satisfactory. So far, not many researchers pay attention to the relationship between students' mathematical misconceptions and the didactic design presented. This is very important because the results of the analysis of the relationship that occurs will bring up new ideas in compiling a didactic design of Comparisons and Scale, which are arranged based on student learning barriers. Therefore, this article will analyze the relationship between students' mathematical misconceptions and conventional didactic designs used by teachers.

2. METHOD

This study uses qualitative methods. The subjects in this study were class VII-E students at MTs Negeri 2 Bandar Lampung for the 2019/2020 academic year, totaling 27 students. Students in this class were chosen because they have heterogeneous thinking skills and are not a superior class.
Reduction (selection) of study subjects is carried out to obtain more in-depth and detailed information about student misconceptions that appear in the results and learning process of comparison and scale material with the scientific approach. This is by the opinion of O'Donoghue& Punch (2003), which states that qualitative subjects are chosen to obtain maximum information, not to be generalized. All students who were research subjects in class VII-E were given a test, and their test results were checked. After that, an analysis of the misconceptions that emerged was carried out.
In this study, the data collected is data on student learning outcomes taught by conventional didactic designs. This data is collected using observation techniques or observations with open observation because the data tends to be known by the study subjects. Also, documentation of student learning activities is carried out during the learning process. In-depth interviews were conducted with students who made misconceptions based on the indicators of misconceptions in this study to validate student work.
The instrument used in this study consisted of field note sheets used to record learning activities related to student misconceptions and unstructured interview guidelines adapted to the student's conditions. This guide is based on the information needed and adjusted to the indicators of concept errors, recording devices, and test questions designed to determine students' misconceptions. The student's test instrument was first tested and declared valid and met the specified criteria for reliability, difficulty level, and differentiation.

In the next stage, an analysis of misconceptions is carried out on the corrected test results for each item in question. Then compiled the percentage value of the concept error. After that, an analysis of conventional didactic designs was carried out based on the misconceptions that occurred.
In this article, errors in mathematical concepts will be analyzed through a case study with two categories from Egodawatte (2011).
The first category, students' lack of understanding or misuse of concepts which tends to trigger several mistakes and misunderstandings with the following indicators:

a. Not able to restate the concept
b. Making mistakes in using various symbols/formulas/theorems
c. Not able to change a representation form into another representation.
d. Not able to interpret or apply the concept

The second category, some other common flaws, can occur in any problem-solving situation while committing some mistake. For example, students rush to solve a problem without reading or to understand it correctly, using the wrong shortcut method, lacking or not using metacognitive skills such as not monitoring the solution process, not verifying answers, and so on
The test is given in the form of a description and consists of 3 items. The test was conducted on 27-28 January 2020. This test was conducted to determine students' understanding of the Comparison and Scale learning material. After that, to check the test data's validity on students who had misconceptions and their causes, an interview was conducted. The interview lasted for two days, namely on 3 and 4 February 2020.

3. RESULT AND DISCUSSION

Concept errors were analyzed based on student test results. The following are the results of the analysis of the concept errors of class VII-E students:

Problem No. 1 (Not discussed because it was not intended for this study)

Problem No. 2: The shoe shop "HARMONIC" sells three shoe brands, namely shoes A, shoes B, and shoes C. The total price for the three shoes is Rp. 2,600,000,-. The price comparison for the three shoes is 1:5:7. One day Anita wanted to buy a shoe that was sold at the shop. However, Anita only has Rp. 500,000,-. Determine the price of shoes A, shoes B, and shoes C, and how much money must be added or change if Anita wants to buy shoe brand B?

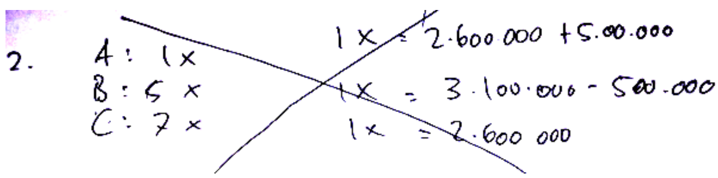

Figure 1. Answer No. 2 AR

Based on Figure 1, it appears that students have made a misconception on indicator c, which is unable to change a form of representation into another form of representation, and indicator b, which is making mistakes in using various formulas. In indicator c, students are specifically unable to interpret the story problem's intent into a mathematical model.

Mistakes in interpreting the meaning of the problem are the opening doors to misconceptions. According to Bernardo (1999), students' problems in solving word problems often stem from difficulties in understanding the problem structure embedded in the problem text. Or in other words, according to Phonapichat, Wongwanich,&Sujiva (2014), students have difficulty understanding the keywords that appear in the questions, so they cannot interpret them in mathematical sentences. This is confirmed by the results of the interviews conducted. Based on the interview results, AR students experienced misconceptions because they did not understand the questions.

Elementary and middle school students do not only experience problems in indicator care (Novriani& Surya, 2017; Khodeir et al., 2017). Even in tertiary institutions, errors in interpreting questions and representing them in other forms are also encountered (Jana, 2018).

In addition to indicator c, AR also misconceptions for indicator b. In this case, AR admitted that he could not determine which formula to use. This is understandable, considering that AR does not understand the questions given.

Accumulatively, question number 2 was not answered by 3 students with a percentage of 11.11%. 24 students answered with details: 5 out of 27 students made a concept error, the percentage was 18.52%. 8 students made mistakes in principle or procedural, with a percentage of 29.63%. Meanwhile, 11 students answered correctly, with a percentage of 40.74%.

Problem Number 3: One-day, Adit estimates that the food supply for 60 chickens will run out in 12 days. If that day he buys another 20 chickens, will the food supply run out in time?

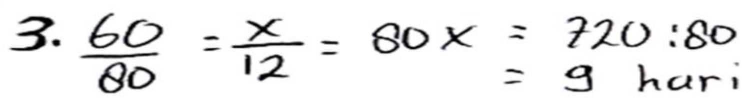

Figure 2. Answer No. 3 AZS students

Based on Figure 2, students have made a concept error. The indicator of misconception is point d. that is, being unable to interpret or apply the concept. Students who make misconceptions like this are 12 out of 27 students with a percentage of 44.45%.

Based on interviews with AZS students, he stated that he is accustomed to solving a problem regardless of the process. For AZS students, what matters is the result. Based on this interview, it appears that AZS students can interpret the questions and intuitively know the answers. It's just that he does not know that he has made a conceptual and procedural error. He thinks that 80 x = 720. Then to find the value of x, he no longer writes x = 720: 80. He just writes 80x = 720: 80. He immediately writes the result, which is = 9 days, which should be x = 9 days. That is, he doesn't understand the concept of algebra properly. Nor does he understand why the results are like that and do not know this is a reverse value comparison concept.

Raharjanti, Nusantara, & Mulyati (2016), and Fadillah (2016) also found this conceptual error, which said that students had difficulty applying the concept of comparisons to reverse this value. Likewise, Sarımanoğlu(2019) who found an error using the equal sign (=) in the problem-solving process.

Accumulatively, question number 3 was answered by all students who made misconceptions totaling 12 out of 27 students with a percentage of 44.45%. Meanwhile, 15 students answered correctly, with a percentage of 55.55%.

Problem Number 4a: Kasep will hold a party located at Jalan Anggrek No.1, Kemiling, Bandar Lampung. Kasep wants to make a plan for the location of the party. Help Kasep determined:

a. The plan's scale, if 5 cm on the plan represents 0.2 km, in fact.

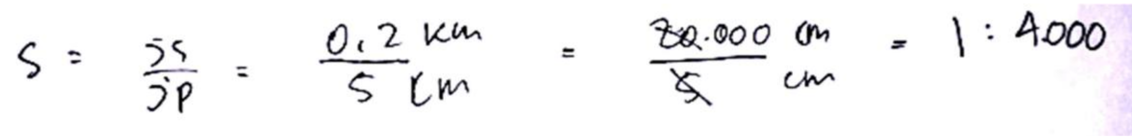

Figure 3 Answer No. 4a AR Student

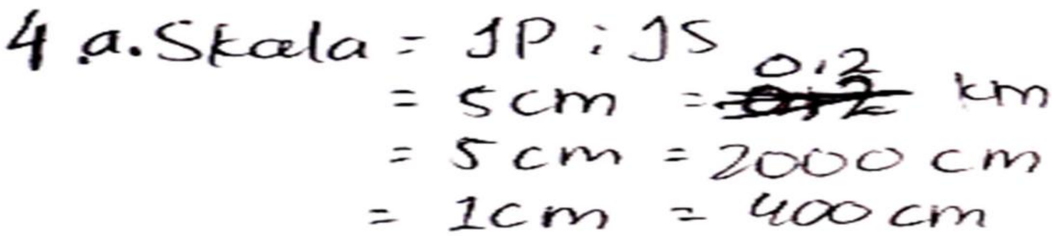

Figure 4 Answer No. 4a TRA Students

Based on figures 3 and 4, students made misconceptions. The indicators of misconceptions are point b and point d, respectively. Based on the interview, the AR student stated that the formula he used was correct, according to him. AR students do not realize that the formula he has applied to find a scale so far is a misconception.

AR students use their own understanding, not based on the reasoning and concepts given. He stated that when the scale value "= 4000" was obtained, the scale was 1: 4000. He considered 4000 to be the same as 1: 4000 in finding the scale.

Meanwhile, there were indications that TRA students were unable to apply concepts in problem-solving. TRA students were correct in determining the formula used to find the scale. However, he wrote that "scale = jp = js". This is a misconception. It assumes the same 1: 400 as 1 = 400. He admitted that he understood the material on this scale and was not aware of the misconceptions he had made. So far, he has never been reprimanded or corrected by the teacher when writing a wrong answer because he thinks the colon (:) is the same as the equal sign (=).

Based on the AR and TRA answers during the interview, it appears that both of them have wrong and persistent belief systems. Whereas according to Mazana, Montero, & Casmir (2019), this belief is closely related to students' confidence in their ability to study a subject. This means that if this belief is already wrong and persists, it will have a bad effect on understanding the concept of advanced material. Students will continue to make misconceptions.

Meanwhile, Neidorf et al. (2020) said that, in general, this false belief is a misunderstanding that is not by the scientific explanation given during the learning process. This means there is a process of acceptance of students' wrong concepts.

Many factors influence this cumulatively; all students answered question number 4a with 18 students out of 27 students who made misconceptions with a percentage of 66.67%. 8 students made mistakes in principle or procedural, with a percentage of 29.63%. Simultaneously, students who answered correctly amounted to 1 person with a percentage of 3.70%.

Problem Number 4b: Kasep will hold a party located at Jalan Anggrek No.1, Kemiling, Bandar Lampung. Kasep wants to make a plan for the location of the party. Help Kasep determine:

b. Distance on the map, if Kasep wants to make a scale of 1: 200,000 with an actual distance of 3 km

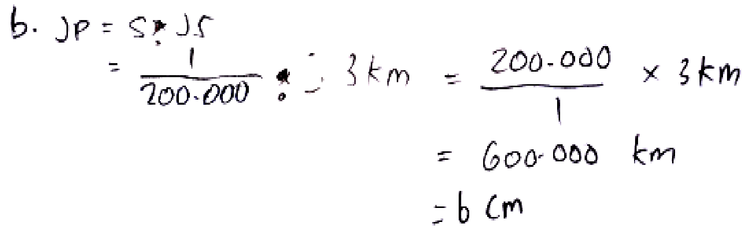

Figure 5. Answer No. ARN 4b

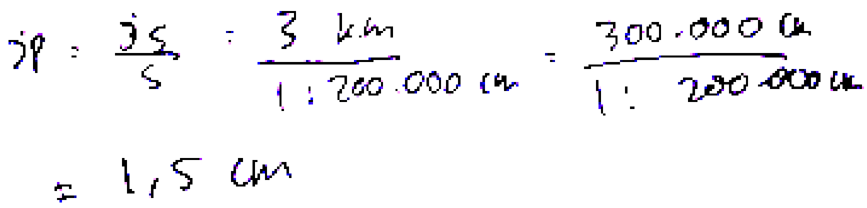

Figure 6. Answer No. 4b AR

Based on figures 5 and 6, students made concept errors. Indicators of misconceptions are points b and d. Based on interviews conducted with ARN students, he forgot to use the scale formula. Therefore he was unable to determine the correct formula. He felt that what he had done was correct, even though he was also wrong in the problem-solving algorithm that contained the fractions in it. He thinks that jp = s: js. Since s is a fraction, division by that fraction is the same as multiplying by the fraction but reversed between the numerator and denominator. Hence, it reversed the scale. Whereas what should be reversed is the fraction that is the divider.

The results of interviews with AR students, he stated that he had obtained the formula during elementary school, from learning at school and in tutoring. He didn't know it was a misconception. He applies it because he feels using the formula will get the result quickly. He was wrong in the problem-solving algorithm; he assumed that 300,000 divided by 1: 200,000 is the same as 300,000 divided by 200,000. Even though the result is correct, there are still misconceptions that he is not aware of.

Cumulatively, 2 students did not answer question number 4b, with a percentage of 7.41%. While 25 students answered with details: students who made misconceptions were 22 students out of 27 students with a percentage of 81.48%. 2 students made a principle or procedural error with a percentage of 7.41%. Simultaneously, students who answered correctly amounted to 1 person with a percentage of 3.70%.

Based on the overall results of interviews with class VII-E students who experienced misconceptions, it is known that the causes include:

a. Students do not understand the learning material, are not accustomed to working on questions that are different from the example, and do not focus on reading questions.
b. The initial concept that the students received was wrong.
c. Students' beliefs are false.
d. Students are confused when receiving concepts from the teacher during the learning process.
e. Teaching materials do not support student understanding.

Some students admit that they do not understand the learning with the didactic design presented by the teacher. The flow of the concept which contains fractions is difficult for students to understand. Some of them also think that the ratio a: b is the same as the fraction a/b though both are different quantities.
For most of the students, the concept of worth comparison between 2 objects can be easily understood. However, if the problems given are not the same as what has been done before, they will experience difficulties in the resolution process.
Basically, conventional didactic designs can easily be accepted by students if they master the concepts of multiplication, division, and fraction. However, in many studies, students have many problems with the concept of fractions (Ikhwanudin, 2019); Kor et al., 2019; Ikhwanudin2018). Therefore, a didactic design of Comparisons and Scales must be prepared that uses the concept of fractions a little.

4. CONCLUSION

Based on the results of the analysis of student misconceptions on the Comparison and Scale material, it was concluded that there had been misconceptions among students, indicators of misconceptions that were mostly carried out were indicators b, c, and d, and student misconceptions were influenced by several factors including because the students themselves who do not understand the learning material, do not focus on reading questions, the initial concept they receive is wrong, and is weak in the concept of fractions. In this article, the didactic design used is the conventional didactic design. This design found many misconceptions in students significantly. To minimize these misconceptions, it is necessary to develop a new didactic design that can make it easier for students to understand concepts and solve related problems independently and correctly.

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