IDENTIFICATION ERRORS OF FIXED MINDSET STUDENT ON SOLVING MATHEMATICAL DEDUCTIVE REASONING PROBLEM

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Abstract

Mathematical mindset is very important for students. A negative student's perception of reasoning has the potential to make students do not understand mathematics meaningfully and make an error. The purpose of this study was to identify students fixed mindset error on solving the deductive reasoning test about number operations. There are two types of mindset: growth mindset and fixed mindset. This study focused only on fixed mindset. Fixed mindset can be divided into strong fixed mindset and fixed mindset with some growth ideas. The types of errors to be investigated were factual, conceptual, and procedural. In addition, the reasoning indicator used only is making conjecture, proofs, and conclusions. The research was conducted in the 7th grade of junior high school. This study used a mindset questionnaire, deductive reasoning test, and interview guidelines. The participant selection was begun by classifying 32 students based on the type of mindset and filtered for fixed mindset group. The questionnaire results found 3 students with fixed mindset. However, there was no student with strong fixed mindset. All three subjects had fixed mindset with some growth ideas. Next, three selected subjects were interviewed. Based on the student answer sheet and their respond during interview, most student errors occurred in making conjecture and proofs. In both of the indicators, all errors tended to procedural error. However, factual and conceptual errors still existed. In general, factual errors occurred due to a lack of understanding of mathematical statements. In general, conceptual error occurs because of the lack of students understanding in concept of multiplication, power of number, and multiplicative number. The procedural error occurs while the student was wrong in manipulating mathematics such as errors in positive or negative numbers and measurement conversion.

Keywords: errors, fixed mindset, deductive, mathematical reasoning, number operation

1. INTRODUCTION

Mathematical reasoning is the foundation to construct mathematical knowledge. The ability of mathematical reasoning is divided into two: inductive reasoning and deductive reasoning. The difference between the two lies in the way of reasoning in which conclusions in the inductive reasoning of conclusions based on observations of limited data whereas deductive reasoning is based on agreed rules (Hendriana & Sumarmo, 2014). The indicators of deductive reasoning used were making conjecture and logical conclusions. Deductive reasoning being the ability to apply agreed formulas and rules still needs improvement and should be included in the learning curriculum (Flegas & Charalampos, 2013). This requires students to understand

what they have gained and what the conclusions of applying the formula. The process of remembering and applying the formula does require a process of reasoning so the questions will give good reason and be resolved. Kurikulum 2013 as Indonesian curriculum learning today tries to accommodate the application of students' reasoning abilities.

Researches such as TIMSS from Mullis, Martin, Foy, & Hooper (2015) and PISA 2015 issued by OECD (2016) are study to measure students' mathematics skills. One of them is students' reasoning abilities. Data from TIMSS 2015 showed that Indonesian students' mathematics score is 397 with position 45 of 50 countries. This is supported also by data from PISA 2015 showed Indonesia is ranked 63 from 69 countries. The low level of reasoning, in general, makes students having a lack of mathematics understanding. Students having difficulty in understanding mathematical problems have the potential to make errors. Error analysis is also required in the process of maturing a suitable learning plan in order to minimize students in answering the questions given difficulties. In addition to being useful as a teacher evaluation tool, analysis is also required by students. Students, who already understand what and why he was wrong, will form a new pattern in his brain so that his understanding increases (Boaler, 2013).

There are three types of errors according to Brown & Skow (2016) namely factual error, procedural error, and conceptual error. Factual error is an error that occurs when the student doesn't understand the information in the question such as terms and symbols. Procedural error is an error that occurs in the completion of stages in the mathematical process such as misconfigured measurements and misplaced decimal places. The last, the conceptual error is an error that occurs in understanding the concept such as congruence relationship, the nature of waking flat, general rule of the powers.

There are many factors in influencing student's mathematics understanding: internal and external factors. One of the internal factors is students' perception of mathematics whih well defined as mindset in term of perceptual psychology. Mindset according to Dweck (2006) is a belief about a power that can change one's psychological aspect such as thoughts, awareness, feelings, attitudes, and others. In addition, Dweck also explained that there is an influence between mathematics learning and student mindset.The student will be be lazy to learn mathematics while they consider mathematics is difficult.

There are two types of mindsets in each individual. Both types of mindset are the growth mindset and fixed mindset. In reality a person is not completely dominated by one type of mindset. The majority of them have a combination of them. Dweck (2006) created a measuring device called Mindset Quiz. Through these measurements Dweck divides the mindset into four categories: strong growth mindset, growth mindset with some fixed ideas, fixed mindset with some growth, and strong fixed mindset. Students who are fixed-mindset (strong and fixed with some growth ideas) in mathematics will assume that mathematical ability is influenced by talent. So when they assume that they are not gifted in mathematics then they will easily give up if having trouble in math. Consequently, they will make the perception that mathematics is difficult and useless learning mathematics because their mathematical ability still can't be increased.

Beside students' reasoning abilities, teachers also need an analysis of the student's mindset. Teachers are still having trouble detecting children's cognitive abilities (Thiede et al., 2015). There is still very limited research in Indonesia that raise the mindset of students especially in math. When viewed from the needs, mindset research can be used by teachers in making teaching both for the class and personal approach to the students. The combination of these two analyses is considered important in supporting the process of student improvement both cognitively and affectively students in mathematics. By having a growth mindset, students' expectations are more motivated in their learning, so it can increase their learning outcomes (Boaler, 2013). So the purpose of this study was to identify students fixed mindset error in solving the deductive reasoning test especially in number operations.

2. METHODOLOGY

This study was a descriptive research. The research was conducted in the 7th grade of junior high school in one of the schools in Kebumen, Indonesia. The instruments used were deductive reasoning test, questionnaire mindset, and interview guide. Questionnaire of mindset was adopted from Dweck's Mindset Quiz (2006). The results of the deductive reasoning test would be elaborated in terms of achievement of the deductive reasoning indicator and the type of error while the questionnaire was used to know the group of students had fixed mindset. The interview guide was a confirmation of what was found during the analysis of the deductive reasoning test results.

Selection of the subject used purposive sampling technique. This study used 32 students who would be grouped based on the type of mindset. The type of mindset in this research was the fixed mindset. The questionnaire results showed that there were 3 students having fixed mindset. This study focused on these

three students. The researchers analysed the tendency of errors committed by all of them. Error analysis used was factual errors, procedural errors, and conceptual errors. Information obtained from the analysis of the work of the three students had been confirmed by the interview process.

3. RESULTS DAN DISCUSSION

Based on the mindset questionnaire results, there were only 3 students having a fixed mindset and . The three students still considered that they had limits in understanding mathematics. The complete results of the questionnaire were listed in Diagram 1

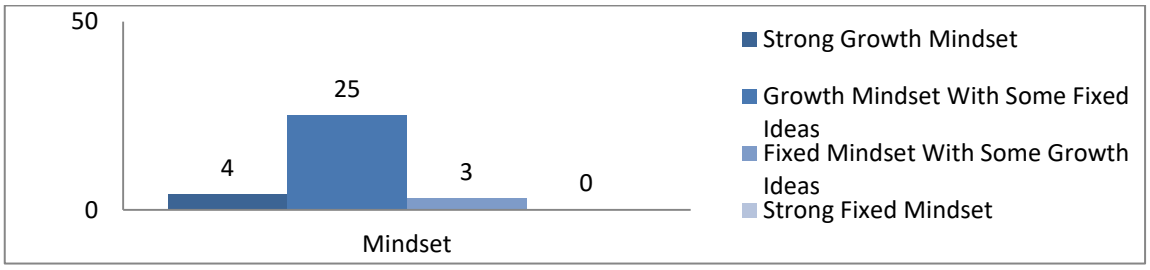

Figure 1. Result of Mindset Questionnaire

Based on Figure 1, the fixed mindset students were only three students. The three students were included in the fixed mindset with some growth ideas category. Two of the three subjects were women. Female students tended to have a fixed mindset (Macnamara & Rupani, 2017). This means there are still some aspects of these three students that were evolving. One aspect of developing in fixed-mindset students was that they realized that the efforts and objectives of mathematics learning can still be improved. Smarter friends could also be used as learning how they learn math. The three students were the focus of research in exploring what kind of error they were likely to do on the deductive reasoning test. The three subjects were S05, S17, and S03. Here were the results of deductive reasoning tests and the tendency of errors made by them.

Table 1. Result and Tendency of Error

No	Subject	Mindset score	Mathematical Deductive Reasoning	Type of Error			Tendency
				F	C	P	
1	S17	0,52	43	0	4	4	Conceptual & Procedural
2	S05	0,51	57	2	2	2	Factual, Conceptual, & Procedural
3	S03	0,41	40	0	3	4	Procedural

Based on the Table 1, it appeared that each type of error was showed. The most common error was procedural error. This error indicated that the student with the fixed mindset tended to do wrong in preparing steps and strategies. In addition they were also indicated to make miscalculations.

3.1 Factual Error

In this study, factual errors are indicated in irrelevant student responses to the context of the question. Based on the work of the three students, only S05 indicated a factual error. A factual error is found in problem number 4. Problem number 4 has indicators proving two statements, they are

Determine whether the revelation is true or false! Prove it and give a reason!

a. *If a number is divisible by 6 then the number is divisible by 12.*
b. *A fraction has a numerator and denominator that are equally positive. If the value of the numerator is less than the denominator, then the fraction is less than one*

Both statements above are the elaboration of the students' reasoning ability in determining of a statement. Here is the S05's answer

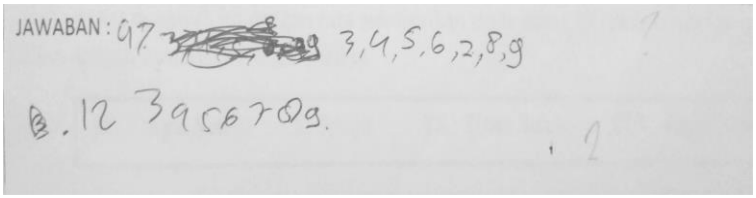

Figure 2. S05's Answer on Problem 4a and 4b

Based on Figure 2, S05 has not determined whether both statements are true or false. S05 tried to answer by giving proof. In the statement 4a, S05 lists some numbers, such as 3,4,5,6,2,8,9 and in the problem 4b, S05 writes 1,2,3,4,5,6,7,8,9,10. Researchers assume that S05 does not understand what is being asked. It's clarified by interview that S05 does not understand the statement because S05 is still not understood the factor of a number. When asked for factors of 6 and 12, S05 answered 3 and 5. It shows that S05 also does not know the term factor. In other cases, S05 is still often error in distinguishing the numerator and denominator in a fraction.

3.2 Conceptual Error

Conceptual error occurs when the concept used in problem solving is still wrong. The three subjects indicated conceptual errors: S17 on questions 4 and 5, S05 on number 2 and 3, and S03 on number 1 and 3. In this discussion, the researchers focused on questions number 1 and 4 caused by error in basic concepts of number operations. Question number 1 is

> *Estimate whether the result is a positive or negative nuber from the multiplication operation below! Give the reason!*
>
> *a.* $(-2)^2 \times (-2)^3 x\, 2^5$ *b.* $2^3 \times (-3)^4 \times 4^5$

To start the analysis, here is S03's answer

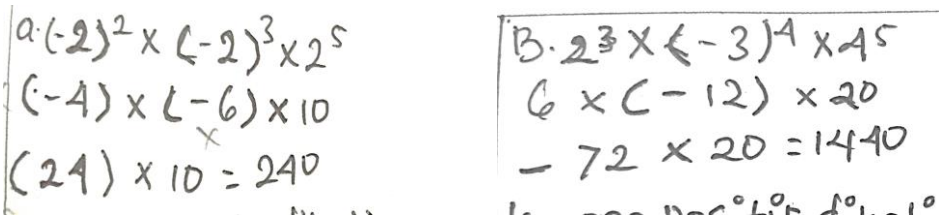

Figure 3. S03's Answer on Problem 1a and 1b

Based on Figure 3, S03 indicated making errors on the concept of the power operation. This was indicated in several steps such as $(-2)^2 = (-4)$, $(-2)^3 = (-6)$, $2^3 = 6$, and $3^4 = 12$. The concept used in S03 was the concept of multiplication. The concept of the power operation is derived from the repeating multiplication. The researcher's initial assumption, the error did in the calculation, but after seen it deeply it can be concluded that there were errors in the power operation. To explore more faulty information and causes, the investigators confirmed by interviewing S03 and providing other questions related to the power of number. The researcher asked whether the calculation was correct. S03 replied that the calculation was correct. When confirmed with another problem 3^3, S03 answered 9. S03 explained that 3^3 meant 3 x 3, so the answer was 9. From the results of work and interviews could be concluded that S03 is still difficult in the power of number concept.

Concept errors are also indicated in question number 4a. Question 4a as above requires an understanding of the factor of a number. Here's the S03's answer

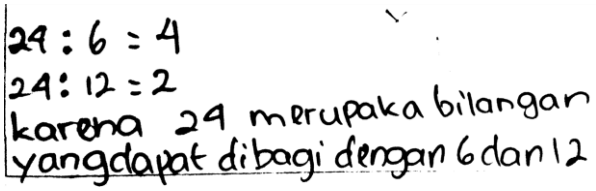

Figure 4. S03's Answer on Problem 4a

Based on the Figure 4, S03 made an error about the concept of multiplicative number. S03 tried to answer by giving example that 24 is a divisible number of 6 and 12. The statement 24 could be subdivided 6 and 12 was true but it doesn't enouh answer the question. The meaning of "*if a number divisible by 6 then can be divided by 12*" in question 4a could be interpreted that the students were asked to find the multiplicative number of 6 and 12. Multiplicative number of 6 is such as 6, 12, 18, etc. while multiplicative number of 12 is such as 12, 24, 48, etc. There is a number such as 18 that is divisible by 6 but is not divisible by 12. It indicates the statement above is false. Based on the interview, S03 confessed that 24 was one of the proof statement number 4a. The researcher attempted to contradict with mentioning 18 as a proof of a false statement. S03 just realized there was concept error. With guidance, S03 understood the factor of number and multiplicative number.

3.3 Procedural Error

A procedural error occurs when a student does error in steps or calculations. In this research, procedural error occurred on all three subjects : S17 & S05 on number 1 and S03 on the numbers 1a, 3, and 5. The procedural error discussion would focus on the numbers 1, 3 and 5 because there was a unique discovery related to the errors in determines the completion step. In question 1, S17 indicated a procedural error that was a wrong using of positive and negative as showed in Figure 5 below

Figure 5. S17's Answer on problem 1a and 1b

Based on Figure 5, S17 indicated errors in step 1a that was result of $(-2)^2 = -4$ and in step 1b that was result of (-3) 4 = - 81. From these two findings, the initial assumption for this case was S17 still had problems in determining the negative and positive number. Question number 1 actually did not require students to count. The expectation was students only needed to use an understanding of the concept of power and multiplicative number. After being confirmed through interview, S17 realized procedural errors related to positive and negative number operation. At beginning, S17 did not realize his error. When asked to answer another problem that was $(-5)^2$, S17 answered -25. However, after being confirmed what was the meaning of $(-5)^2$, S17 explained the meaning of $(-5)^2$ was (-5) x (-5). The researcher asked whether the result of negative number multiplied negative number was negative number. S17 realized the error and corrected the answer to 25. This showed that S17 actually already understood but the error step was still a routine that needed to be repaired immediately.

Other procedural error was detected on number 3. Problem number 3 had an indicator to estimate a case. Here's the problem number 3

> *There is a race of two cars namely SINO and DINO. The SINO car speed is 25 meters per second and the DINO car speed is 80 kilometres per hour. Which is faster between the two cars? Give the explanation!*

The above problem can be solved by comparing the measurements between the two cars. S03 indicated a procedural error. Here is the S03's solution for this problem

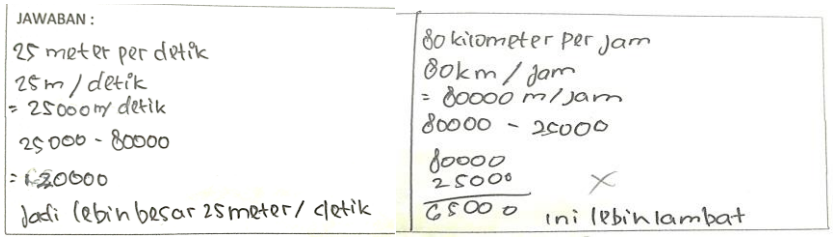

Figure 6. S03's Solution on Problem 3

Based on Figure 6, S03 made a procedural error in step comparing the two measurements of speed. S03 made a subtraction as a comparison solution. It should convert the speed of both cars in the same measurement and compared them. The initial assumption was S03 had constraints on the measurement conversion process. The measurement of speed was combined between length and time. The combination of both measurements was still a difficult thing. This was indicated when S03 only converted 80 km to 8000 m and did not change hour into second. For more information, it was done by interview; S03 admitted that he had not understood the correct conversion rules. S03 understood the conversion of km to m and hour to second, but km/h to m/s still being a problem.

Procedural error occurred on problem number 5. Problem number 5 is

> *Two parking spaces have different tariff rates. Parking A sets the rate for the first hour is 4000 rupiah and then charges 1500 / hour. While parking B set the rate for the first hour is 6000 and then charged 1000 / hour.*
>
> *a. If Budi parked his car for 4 hours, which parking is cheaper for Budi? Give the reason!*
> *b. If Budi parked his car for 8 hours, which parking is cheaper for Budi? Give the reason!*
> *c. from points a and b, what conclusions can you get?*

The problem above asked the student to make conjecture and conclusion. The problem above can be solved by several steps of multiplication and addition operations. For example, parking 4 hours means 1 hour with rate first hour and 3 hours with the next rate. Both of the rates for the 4 hours were compared which one was cheaper. The same strategy was used for 5b. Problem 5c expected students to draw conclusions from the parking rate tendencies A and B. The expected conclusion was that parking rate A would be cheaper if the parking duration is less than 5 hours and the B rate is cheaper if the parking duration is more than 5 hours. Here is S17's solution on promblem 5

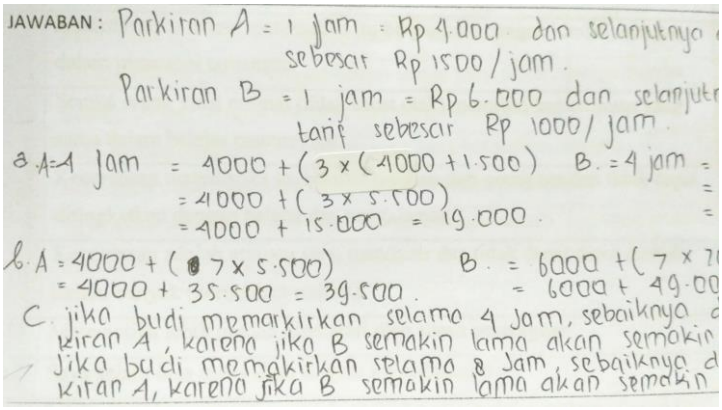

Figure 7. S17's Solution on Problem 5

The Figure 7 showed the strategy was wrong. As an example of problem 5a, S17 described the 4 hour rate for parking A was 4000 + (3 x (4000 + 1500) .The strategies were almost correct but there was error in using Rp 4.000 as rate in the next 3 hours. The same strategies were also done in problem 5b. S17 had not been able to make the right conclusion. It can happen because of misconceptions on the comprehension about problem. After being confirmed through the interview, S17 was still making an error in the using of the first hour rate. S17 considered that 4000 and 6000 were still used as rate even after parking more than 1 hour.

4. CONCLUSION

Based on the results and discussions, students who had the fixed mindset made all three types of errors. The most common error was procedural error. This showed that the fixed mindset students still had problems in determining the strategies. A well-understood concept will remain a problem if students know their inital step used is suistable with the problem given. A lack of understanding and the memorizing mathematics procedure are the major reason for this error (Veloo, Khrisnasamy, & Abdullah, 2015). Procedural errors are often caused by misunderstanding in the topic of numbers and measurement conversions. Student also do the factual and conceptual error. The factual error is caused by lack of capability in solving mathematical proofing. Conceptual error occurs in the concept of factors of numbers and multiplication and power number operation. Conceptual errors are a worrying error and ironically many students and teachers ignore them (Rozelizawati, Sawardi, & Sharill, 2014).

Although there are still many errors, interviews results show that the fixed mindset students are still getting excited and admitting their errors. It can be happened because the subject is a fixed-mindset student with some growth ideas. This developing aspect had to be replicated to make the three students become the growth mindset student. This is important and should be used as a motivation for them. Hopefully, they will make these experiences of error to improve their capability of mathematics concepts. Teachers should be an intensive assistant of this type of mindset student. Teachers hold the main important rule in a classroom to improve student's mindset (Pohl, 2017). There is a significant relationship between the student perception and the teacher's personality characteristic (Heydari, Abdi, & Rostami, 2013). Teacher can improve student having growth mindset. Students who already have a growth mindset will learn math more comfortable and independent of the teacher (Martin & Rimm-Kaufman, 2015)

This study has several limitations. The study found only three subjects with fixed mindset. All three were not a strong fixed mindset. Further research is needed. The researcher can increase the number of subjects and analyse other error factors such as teacher teaching aspects that potentially make the mindset change. In addition other studies such as research about effectiveness of a model in fixing the mindset and error can also be done.

5. ACKNOWLEDGEMENT

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