Characteristics of seventh grade students’ pseudo thinking in solving mathematical reasoning about number operation based on mindset

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Abstract. Pseudo construction thinking occurs when students assume that true/false belief is actually not totally true/false. The study aimed to describe the characteristics and causes of students’ pseudo thinking in solving mathematical reasoning about number operation based on mindset. This research was descriptive qualitative research. The subjects of this study were 30 Junior High School students in Kebumen. Data collection techniques used mathematical reasoning test, questionnaire mindset, and interview. The mathematical reasoning test was constructed with making a conjecture as indicators. Questionnaire of mindset adapted from Mindset Work. Interviews were used to support the validity of data related to subjects indicated to have pseudo. Based on the result of the research: (1) there are 20 students with growth mindset and 10 students with fixed mindset; (2) fixed mindset students do false pseudo, 3) growth mindset students do both types of pseudo and 4) the cause of these pseudo are conceptual and procedural error.

1. Introduction
Mathematics learning is a continuously learning. It can be seen in mathematics curriculum in that uses mathematics as compulsory lesson. It is taught from elementary school until university. Because of this property, students have to know a concept to understand other new concepts. Understanding mathematical concept needs mathematical reasoning skill. Mathematical reasoning is identified when students think and solve a problem [1]. One of mathematical reasoning indicator is making a conjecture [2]. Making a conjecture is not easy because it needs a construction of concept in mathematics. Students not only give their claim but also they must prove their claim. This process is needed mathematical reasoning skill. Curriculum 2013 as Indonesian curriculum is trying to accommodate how students apply mathematical reasoning skill but it still doesn’t make a significant progress. It is supported by data from TIMSS 2015 and PISA 2015 that student in Indonesia have a struggle in reasoning problem [3,4]. The students having low skill in mathematical reasoning makes they don’t understand totally mathematics’ content. They mostly make an error. These mistakes can be caused by their wrong conception as name as pseudo thinking [5].

Pseudo thinking is a thinking process to answer and construct a concept but it doesn’t represent the actual thinking [6]. There are two types of pseudo thinking: true pseudo and false pseudo. The true pseudo can happen when students can solve the problem but their thinking process is wrong. Meanwhile the false pseudo happens when students make an error but they are able to give the right reason and
actually realize the error. It's important that teachers must know how student think to make mathematical learning better. Unfortunately, they are still having problem to detect children's cognitive abilities [7]. Number operation was selected because this topic is foundation of mathematical learning. Without learning number operation, we can’t study and solve mathematical problem. It’s basic and fundamental for student.

There are so many researches who study pseudo thinking in different way. A previous study studied the pseudo analytic versus analytic in a routine problem solving [8]. The other study also explored the process of pseudo thinking in Piaget’s way [5,6]. There is also another term used to replace pseudo term like Direct Translation Approach [9]. All of previous studies study how students think and their error process in solving mathematical problem. It can be concluded that research of student’s thinking is very important.

Although there are many previous studies about it, they don’t have description about the psychological factor yet. One of psychological factor is student perceptions about mathematics, in psychology term, called mindset [10]. There are two kinds of mindset: fixed mindset and growth mindset. The fixed mindset occurs when someone has perception that something is hardly changing although he has tried to change it. Otherwise the growth mindset is a perception that something can be change if we want or try to change it. It must be different for one student to others. So it is important to make a study that combines analysis of pseudo thinking and mindset because this combination can provide information about students’ cognitive and psychological aspect.

2. Method
This study was a descriptive research. The population in this study was grade 7th student in a school in Kebumen, Indonesia. To collect the data, the research used three instruments. They are mathematical reasoning test, questionnaire of mindset, and interview guideline. Mathematical reasoning test used an indicator that is making conjecture. The students’ worksheet of this test was analyzed to know what pseudo students have. Student must give their reason in each problem. Here were the problems:

- Estimate the result of \((-2)^2 \times (-2)^3 \times 2^5\) whether positive number or negative number? Give your reason?
- Estimate the result of \(2^3 \times (-3)^4 \times 4^5\) whether positive number or negative number? Give your reason?

The questionnaire of mindset was adapted from Mindset Work. This instrument was created by New York Education and was adapted from Dweck’s theory [11]. This instrument used to classify students into fixed or growth mindset group. The interview guide was used to make sure which the pseudo students have and what their cause is.

The research involved 30 students that would be classified to two groups: fixed and growth mindset. Once split into two groups, the mathematical data would be classified into four types: totally true, true-pseudo thinking, false-pseudo thinking, or totally false. To know the fourth classification, analysis was done from the common pattern of the student worksheet. After finding the common pattern, the researcher interviewed some selected students to confirm this pattern. From interview, the researcher could also know the cause of pseudo thinking. This study focused on true and false pseudo thinking. The cause of true and false pseudo thinking was also focused to two types of error: procedural error and conceptual error.

3. Result and discussion
Based on the questionnaire, there are 10 fixed mindset students and 20 growth mindset students. It’s interesting because there were lots of students who have fixed mindset. The result of mindset questionnaire can be seen in Figure 1 below.
Based on Figure 1, the growth mindset is a majority mindset. There were 20 students having this mindset (66.7% of total). It is good because student who has growth mindset will learn mathematics more comfortable [12]. After classified into two groups, data from student’s worksheet were analyzed to find out a pseudo pattern. Each problem can be divided into 4 categories: totally true (TT), true pseudo (TP), false pseudo (FP), and totally false (TF). It was used to check how many students have pseudo. Table 1 is summary of analysis problem based on mindset.

Table 1. Analysis problem based on mindset.

| Mindset     | Problem I |         | Problem II |         |
|-------------|-----------|---------|------------|---------|
|             | TT | TP | FP | TF | TT | TP | FP | TF |
| Fixed Mindset | 3 | 0 | 7 | 0 | 6 | 0 | 4 | 0 |
| Growth Mindset | 3 | 5 | 12 | 6 | 6 | 3 | 11 | 0 |
| Total        | 6 | 5 | 19 | 0 | 12 | 3 | 11 | 0 |

Based on Table 1, most of student did pseudo thinking. There were only 6 students that solved the problem correctly. The rest of them did pseudo thinking (5 true pseudo and 19 false pseudo). The result of problem II is better than the result of problem I. There were 12 students that solved correctly and 14 did pseudo thinking. The next step was to analyze the pseudo. This analysis is also used to know what types of pseudo and their reason. Table 2 is summary of type pseudo analysis based on mindset.

Table 2. Type of pseudo based on mindset.

| Mindset     | True Pseudo | False Pseudo | Type of Pseudo | Cause               |
|-------------|-------------|--------------|----------------|---------------------|
|             | Procedural | Conceptual | Procedural | Conceptual | False Pseudo | Procedural and conceptual |
| Fixed Mindset | 0          | 0            | 9           | 2           | False Pseudo | Procedural and conceptual |
| Growth Mindset | 7          | 2            | 14          | 9           | Both of them | Procedural and conceptual |

Based on Table 2, there was a difference between fixed mindset and growth mindset. Student who had fixed mindset only did false pseudo. Meanwhile the growth mindset’s student made both of these pseudo.

3.1. Fixed mindset

Based on mindset questionnaire, there were only 10 fixed students. It was indicated that they did false pseudo thinking. It means that students assumed their answer was wrong but it was not totally wrong because they could explain their reason in the right context. If they are guided in learning mathematics, then their struggles and errors can be solved. Based on Table 1, the fixed mindset student did false pseudo in each problem. They were 7 students who made this pseudo on problem I and 4 students on
problem II. The false pseudo can be indicated from their reason in solving the problem. After checking the student’s worksheet, it was found that there was a similarity error. Here is an example of student’s answer and reason indicated which false pseudo.

Based on Figure 2, the subject did a conceptual error because he calculates (-2)^3 = -6. He didn’t understand the power of number’s concept. His error was also indicated from his answer about calculating (-3)^4 in problem II. His error was same. Although he did conceptual error, he gave a right reason. He estimated that the result of problem I was a positive number because negative number times negative number is positive number. He knows that it is right rules in multiplication. To confirm the indication, researcher also did an interview. The interview was used to check his error and understanding in the power of number’s concept. Here was an interview transcript with code R as researcher and S as subject.

R : i want to know, how do you determine that the result of problem I is a positive number?
S : First, i calculate (-2)^2 and (-2)^3 then I get (-4) and (-6). Because (2)^2 must be positive number, so i just calculate (-4) x (-6) then i get a positive number.
R : Are you sure that (-4) x (-6) must be a positive number? How do you get it?
S : Yes, it is because the result of negative number times negative number must be a positive number.
R : Ok, let’s check (-2)^3, how do you get that the result is (-6)?
S : (-2)^3 = -2 x 3 = -6
R : why is it not 6?
S : it’s because -2 is negative number and 3 is positive number, so the result of multiplication between them is negative number.

Data from interview supports the indication of student’s false pseudo. He knew the right rules in number operation but his understanding of the concept was poor. His pseudo was caused by misunderstanding concept between multiply and power of number. Pseudo could be happened when student had less understanding in another concept connected the topic [13]. He can be guided to make a right understanding in the concept. Teacher must know that this subject is a fixed mindset student who has a fixed perception in learning. Teachers need to be aware whether or not the students really understand the concepts being taught [12].

Here is another example which indicated the student’s false pseudo.

[Figure 2. subject’s answer.]

[Figure 3. subject’s answer.]
Based on Figure 3, the subject’s estimation was wrong. However, the subject did an error; the subject just indicated doing a procedural error. Their errors were only found in solving \((-2)^2\) and \((-3)^4\). The subject did a procedural error and claimed that the result of problem I was a positive number and the result of problem II was negative number. Negative concept is main problem for student [14]. From the subjects’ reason, we also know that their reason is absolutely right. After being interviewed, the subject could find to the right answer. Teacher must give suggestion so that students will not be discouraged by the past (bad experiences) in math [15]. Realizing this error, they can improve their mathematical skill [16]

3.2. Growth mindset

Based on mindset questionnaire, there were 20 growth mindset students. They were majority. It is indicated that they did both pseudo. False pseudo was more than true pseudo. False pseudo in this group was the same as fixed mindset student. Commonly, they did false pseudo because they did a procedural and conceptual error like fixed mindset students did. Therefore, in this section, it will only describe a different invention of this group.

The growth mindset did a true pseudo. It’s unique and different from another group. The true pseudo occurred when student can estimate that the result of problem II is a positive number but he couldn’t explain or his reason was wrong. Here is an example of student’s answer.

![Figure 4. Result of mindset questionnaire.](image)

Based on the interview, this is procedural error because the subject can explain that the meaning of \((-2)^4\) was \((-2) \times (-2) \times (-2) \times (-2)\). Although the subject could explain in the right concept, the subject was categorized in doing true pseudo. Multiplication of negative number makes students confused and doing error [14]. It’s just procedural concept error so teacher must give suggestion to students in this group to keep their belief that their effort will improve their mathematics achievement [15]. In other ways, teacher must think to evaluate the explanation and learning strategies because they really contribute the student’s successfull in solving mathematics problem [17,18].

4. Conclusion

Based on the result and discussion, although there were problems in solving mathematics reasoning test, there was a good finding in this research. The majority mindset was growth mindset. It means that most of the students have a good perception in learning mathematics. It’s good for their learning mathematics.
They are sure that learning mathematics can be improved with their effort. Therefore, teacher must give support to fixed mindset student to change their mindset about mathematics. The problem that must be solved in this class is their pseudo thinking in mathematics. There is no big difference between fixed mindset student and growth mindset student. Both of them did false pseudo. It means student actually can solve the problem but they still have a problem in their concept and procedure especially negative number. Meanwhile the true pseudo was only done by growth mindset. They still do an error claim in their mindset. It’s also a problem because they did not clearly understand what they have gained so it is often not logical reason. The study only gives information about pseudo in each type of mindset. It’s not clearly found what the effect of mindset in their pseudo. Further research is suggested to be done regards this case especially deep observation about their behavior. Furthermore, future researcher can increase the number of sample to make sure what is effect and difference between the two types of mindset.

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