Analysis of difficulties in mathematics learning on students with deictic gesture type in problem-solving HOTS algebra test

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Abstract. HOTS is a real-life based assessment of everyday life, but in practice, the students are having trouble in completing the HOTS issues. Learning difficulty is also influenced by gesture type. Edward (2008) explains that gesture with speaking skill is data resources about thinking in mathematics. Besides, gesture is part of integral idea in mathematics. McNeill classifies the gesture into 4 types, namely iconic, metaphorical, deictic, and beat. The researcher focuses on the type of deictic gesture that is the type of gesture to show object, event, or point out people. This study aims to describe the difficulty of learning mathematics of students with a type of deictic gesture in the completion of Algebra materials especially in solving HOTS. This research type is descriptive qualitative research. The results showed a total of 3.22 % difficulties of number fact skill, 7.52 % difficulties of arithmetic skill, 35.50 % difficulties of information skill, 30.10% difficulties of language skill, 23.70 % difficulties of visual-spatial skill.

Keywords: deictic gesture, learning mathematics, algebra

1. Introduction

Students are able to solve a problem only if they understand the problem and apply their knowledge into that new situation. This is known as high order thinking skills (HOTS) [1]. Assessment of the 2013 Curriculum is adapted from international standard assessment models which hopefully encourage students with high-level thinking to think broadly and deeply about the matter [2]. Bloom’s Revision of Taxonomy is used to measure high-order thinking skills (HOTS). Anderson & Krathwohl classified the cognitive process to measure high-level thinking skills by category of analyze, evaluate and create [3]. According to Trends in International Mathematics and Science Study (TIMSS) survey in 2015, Indonesian mathematics achievement ranked 45th out of 50 countries [4]. By the Organization for Economic Co-operation and Development (OECD) in 2015 using the Program for International Student Assessment (PISA), Indonesia stayed in the 64th from 72 nations [5]. According to Totok Suprayitno, the head of Badan Penelitian dan Pengembangan (Balitbang) Kemendikbud, in 2015 Indonesia’s mathematics quality scored 386 which is under 490 as the mean score [6]. Applying HOTS question according to PISA will increase it [7]. The high-level thinking ability should have been begun by schools in Indonesia in order to meet the demands of the 21st century which need more developed skills [8].
The results of National Examination of Senior High School in 2015/2016 in Tulungagung obtained from the BSNP PAMER program show that the absorptive capacity of the students in mathematics was low. SMAN I Rejotangan Senior High School was one of one of them with Dual Variables Linear Equation System (DVLES) at 33.56% which is under the mean score of the city which scored 67.13%, province 58.08% or even national with 49.85%. DVLES material had the lowest absorption score, so the students must have difficulties on it. Many high school students are not able to find the alternative solution through the DVLES problem. The difficulty is coming from the lack understanding of Linear Equation System (LES) concepts that ultimately inhibit the further learning process. Kazemi (2002) said that students tend to be reckless in the calculation process. As the example + sign is understood as – sign. They are also confuse in substituting the variable with the x or y which will be a blunder in multiple choice question. Specifically, mistakes are found because students did not change the sign while adding or subtracting with another equation, merging the variable with Constanta, reversed in writing the division result and adding or subtracting number before divide it.

In dual coding theory, Pavio has been stated that information someone got is processed by verbal (text and voice) and non verbal (diagram, picture and animation) channel. By studying DVLES, students will increase their visualization, critical thinking, intuition, perspective, problem-solving, conjecturing, deductive reasoning, logical argument and proofing skill.

The difficulty of learning mathematics is not only because ineffective learning but may also by differences in gesture type. Roth & Welzel (2001) stated that gesture become a vital resource in learning mathematics. Gesture is important to support a heavy, general and abstract material explanation. McNeill classified the gesture into 4 types namely Iconic, Metaphoric, Deictic and Beat classified by the body language differences as the evidence that body are involved in thinking and speaking about ideas.

Gesture shows how someone thinks mathematics. Besides, gesture is part of integral idea in mathematics. Students with deictic gesture are tend to point or show a body gesture rather than explain a complex thing. By studying it, we will understand the student mind. Roth (2002) stated that deictic gesture is an integral part of mathematics idea communication, but there is only a few educational study about the role of gesture in learning especially for abstract fields like science and mathematics.

Many students have not acquired the basic skills needed. Ineffectiveness in learning process will adversely affect the mathematics acquiring skills. Understanding the difficulties students’ experienced in improving mathematics skills will help them in the learning process. Researcher will analyze students’ difficulties with deictic gesture type on the algebra HOTS with LES material. Like Nathan, this study focused on the difficulties in mathematics learning in number fact, arithmetic, information, language, visual-spatial skill. Inspired by both Nathan and Roth, this study wants to analyze the difficulty of learning mathematics at students with deictic gesture type in LESHOTS problem-solving.

2. Research Methods
The research used qualitative method with descriptive approach. In this research, it is formed a description of difficulty learning student mathematics with deictic gesture at solving LES HOTS issue. This method was carried out by analyzing oral tests and interviews with students. Subjects in this study were students with deictic gesture based on low (S1), medium (S2) and high (S3) achievement in SMAN I Rejotangan Tulungagung regency. Selection of subject in this research used purposive sampling technique. The classification was based on previous semester achievement and consultation with teacher while the deictic gesture data was taken from the McNeill gesture test. The data in this study was based on the results of the written exam on LES HOTS. Interviews were processed in such a way so it could be concluded that the learning difficulties of students with the deictic gesture of each student's ability. Research step according
to Moelong (2007) are: (1) pre activity, (2) activity, (3) data analysis, (4) evaluation and report [23]. To ensure that the data is valid, data credibility test was completed using triangulation technique.

3. Research Results and Discussion

The data collection was conducted by giving Mc Neil gesture type test to 38 students of Senior High School at SMAN I Rejotanganto categorize students’ gesture type. The result is on the table 1.

| Hots Question | Types of difficulties mathematics skill | Total |
|---------------|----------------------------------------|-------|
| Question 1    | Number fact skill | Arithmetic skill | Information skill | Language skill | Visual-spatial skill |       |
| 1             | 0 | 14 (15.05%) | 10 (10.75%) | 7 (7.50%) | 31 (33.30%) |
| 2             | 3 (3.22%) | 9 (9.70%) | 11 (11.83) | 33 (35.50%) |
| 3             | 0 | 10 (10.75%) | 9 (9.70%) | 33 (35.50%) |
| Total         | 3 (3.22%) | 7 (7.52%) | 33 (35.50%) | 28 (30.10%) | 22 (23.70%) | 93 (100%) |

Table 2 shows the students difficulties on each mathematics skill from the sample in solving LES HOTS. The highest number of difficulties was in question 3. Meanwhile, the lowest number of difficulties was in question 2. In addition, information skill is the most difficult skill.

3.1. Analysis of problem-solving HOTS Question 1

Cognitive Levels: Analysis and Evaluation

There are 4 three solid figures which each of the equation is a plane figure in the solid figure. Each plan can intersect each other in many ways which produce different set completion. Which figure with only one solution is? Explain it!

Figure 1. Illustration of solid figure

S1 on the solution of the HOTS1is in cognitive level of analysis and evaluation. He answers A which is correct, but the arguments given are not correct. Based on the interviews and answers analysis on the solution of the HOTS question 1, he analyzes the problem correctly, but he is failed at the evaluation stage. In information skill, there are difficulties in problem-solving planning. Actually he is too lazy to write down the answer. He is also unable to remember the formula and understanding the concept of linear equation system. As the result, he cannot provide a good reasoning. In language skill, there are difficulties in understanding question. In visual spatial skill, S1 could not manipulate LES in form of picture. According to Polya, understanding problem is the first phase of problem-solving process [24]. During that phase, first of all, students need to know the story from the information given and the objective of the problem.
Figure 2. The answer of S1 with low ability on HOTS question 1

Figure 3 shows S2 answers all question correctly but the arguments given in each answer are less precise. This means that in the category of analysis, he has difficulties in information skills on problem-solving planning. S2 is less precise in writing information about questions and arguments written on each answer option. In figure 4, S3 answers it all correctly but he does not provide an argument in every answer. This means that on the category of cognitive and analysis he has difficulties in the information skills on the problem solving planning. It shows that there is oblivious information. S3 are also unable to provide a reason related to the answer.

**Figure 3. The Answer of S2 with Moderate Ability on HOTS Question 1**

**Figure 4. The Answer of S3 with High Ability on HOTS Question 1**

3.2. Analysis of problem-solving HOTS Question 2

Cognitive Level: Evaluation

Look at Figure 5 below!

Mr. Doni has a picture frame illustrating koi fish. Its circumference is 44 cm. If the width is 6 cm lower than the length, find the measurement of the frame!

**Figure 5. Illustration of picture frame**

The question of HOTS 2is on the cognitive levels evaluation to S2. He encountered difficulties in solving. Below is the answer of S2 who has moderate ability with deictic gesture types [25].

**Figure 6. The Answer of S1 with Moderate Ability on HOTS Question 2**

**Figure 7. The Answer of S2 with Low Ability on HOTS Question 2**

Seeing Figure 6, S1 answer incorrectly. He did not finish the work until the end. He has difficulties in understanding the category of HOTS question 2. In computational and mathematical working procedure, S1 responded incorrectly. He did not write the information received on the question. He was failed in substituting the length and width of the picture into symbols. It looks like he had done it carelessly. This means that S1 has difficulties on arithmetic, information, language and visual-spatial skill. As a result student was failed to carry out the problem-solving correctly. Students are faced with difficulties in problem-solving due to their lack in visualizing mathematics problem and concept [26]. The affect of
mathematics difficulties is cumulative because the development of mathematics skills is based on the previous skills [27].

Figure 7 shows that the solution given by S2 of the HOTS question 2 is on evaluation aspect. He has difficulties in problem-solving planning. S2 did not write what was known and asked. The answer became unstructured and made many errors in solving. Based on interviews and answers analysis on S2, evaluation started by analyzing the questions appropriately but at that stage, he could not complete the answer correctly. S2 was able to analyze the matter, but S2 was too lazy to write a long answer. This is the cause of the answer to be unstructured so there were many mistakes. It means that the student was in trouble with information skills. The subject S2 also has difficulties in arithmetic skill. The planning procedure of the calculation experienced by subject S2 is not accurate. Furthermore, he is weak in number fact skill. He wrote: \[ \frac{2}{g1876} + \frac{2}{g1877} = \frac{4}{4} : \frac{2}{g1876} + \frac{2}{g1877} = \frac{2}{2} \], means that he made incorrect calculations, although the end result was in line with the correct answers. Incompetency in conceptual knowledge of division caused error in procedural skill. According to Narayanan, students were lack in arithmetic and procedure knowledge as a result from weak conceptual understanding [25]. Besides, S3 has answered it right.

3.3. Analysis of problem-solving HOTS Question 3

Cognitive Level: Analysis

Karno made 3 towers which constructed by rectangles, trapezoids and hexagons. The first tower has 35 cm height. Second tower has 34 cm height. Third tower has 49 cm height. If the rectangle has 2 cm in height, which one of the following tower has more rectangle? Give a logic reasoning!

The answer of S1 is correct, but the argument given is not correct, it is inconsistent between the answer and the question. This means that S1 has difficulties in mathematics skills such as information skill and language skill. The S1 has difficulties in manipulate tower picture with his visual-spatial skill. According to Garderen, deficiency in visual-spatial skill might cause difficulty in differentiating and relating information meaningfully [28]. In another situation, the answer of S2 is wrong. It seems that S2 has difficulties in understanding the problem so that the answer is incorrect. S2 has difficulties in manipulate geometrical shape. Especially S2 has difficulties in visual-spatial skill.

From the figure 9, it seems that the solution of HOTS 3 given by S3 is on analysis level. S3 has difficulties in visual-spatial skill as he is being fooled by the picture. Based on interviews and answers of S3, he started by analyzing questions incorrectly. S3 has difficulties in the visual-spatial skill which is about understanding the problem and the picture. A visual abnormality child is often unable to distinguish Geometry form [29]. Furthermore, S3 also has difficulties in language skill. S3 concluded that the first tower has the most rectangle because he was unable to realize that he needs to find how much rectangle in the third tower using Triple Variables Linear Equation System (TVLES). Factors that cause he experienced this difficulties is lack understanding of the problem.

Based on the results of the analysis, this study found some difficulties for students. These show evidence of earlier studies that show that students have much difficulty in understanding of LES especially if the problem is served in picture. This problem is caused by students’ inability to transform the information on the picture into mathematics words [30]. This is strengthen by previous research conducted by PPG Matematika in 2002 about the difficulties faced by students in 5 province, showing that there are lack of skill and conceptual understanding related to the algebra operation. There are also difficulties in
understanding the problem, error in operation and also translating the story problem and picture into mathematics word [31]. Furthermore, this research also shows difficulties of students who have the deictic gesture type in answering HOTS with dominant material of LES. The difficult parts of this are language, information and visual spatial skill with various causes. One of the causes is students’ limited understanding of information given. So that, students solved the HOTS questions hardly. This research is also strengthened by Tambychik & Meerah's study which showed that the weaknesses of many students are at number fact skill, visual-spatial skills, and information skill [26].

4. Conclusion
This study concludes that students with deictic gesture type have difficulties in mathematics problem-solving HOTS Geometry due to incompetency in acquiring many mathematics skills. They are mostly weak in communicating their mind. They like to show a gesture rather than explain by verbal.

It was found that a total of 93 type of difficulties on mathematics skill which has been identified in the problem solving process involving HOTS. It is also found a total of 3.22% difficulties of number fact skill, 7.5% of arithmetic skill, 35.5% of information skill, 30.10% of language skill, 23.70% of visual-spatial skill. Information skill was found to be the most critical mathematics skill. In HOTS problem with cognitive level analysis and evaluation category, student with high and moderate ability are experiencing difficulties in information skill, while student with low ability in information and visual-spatial skill. In HOTS problem with cognitive level evaluation category, students with high ability only have few difficulties which is found in the last step, students with moderate abilities have in information, number fact and arithmetic skill, while student with low ability have difficulties in information, language, visual-spatial and arithmetic skill. In HOTS problem-solving with cognitive analysis category, students with high ability have difficulties in language and visual-spatial skill, students with moderate ability in visual-spatial skill, while students with low ability have difficulties in information, language and visual-spatial skill. Therefore, teachers should be able to recognize the difficulties faced by students in solving problems related to HOTS. Besides, teacher often give students many exercise to stimulate their creativity in solving the problem. Furthermore, the researcher suggests to study the other type of gesture to compare the students ability between each type of gesture type classified by McNeill, especially on the SPL material.

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