Analysis of junior high school students' errors in solving HOTS geometry problems based on Newman's error analysis

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Abstract. Geometry is the most important material to be learned in school. But the fact that there are still many students often makes errors in resolving the problems of geometry. This research focuses on analysis students’ errors in solving Geometry problems among junior high school students in every higher order thinking skills level. This research used a qualitative descriptive method aimed to identify the students’ errors based on Newman’s error analysis. The errors are associated with planes and related problems. Data collection was done based on students’ work through test and interview. The errors were analyzed according to Newman’s Error Analysis Model consisting of reading, comprehension, transformation, process skills, and encoding. The result revealed that the students having errors according to Newman’s error analysis in every higher order thinking skills level, they are analyzing, evaluating, and creating.

1. Introduction
Mathematics is the most important part of the development of the science and technology world. In the primary to secondary education, mathematics is one of the subjects that is studied by the students [1]. Mathematics remains the most dreaded subject for many students in primary and secondary schools.[2] Based on the mathematical materials which has to be learned in school, geometry is one of them [3].

The analysis results of the 2016 National Examination are in line with the result from the Qini’ah research about the 2013-2015 National Examination. They indicate that geometry is the most dominant material on National Examination questions. It fulfills the HOTS perspective of the students. [4] Higher-order thinking skills is the ability of students in using critical and creative thinking skills through some activities such as: analyze, synthesize, produce, integrate, evaluate and create.[5]

Based on that, it means that the ability of the students on 3 Wonosari junior high schools in resolving the HOTS questions is still low. This statement supported by the result of the interview with the teacher of the grade VIII on 3 Wonosari junior high schools. He of states that the students often make errors especially when they work on resolving the problems related to the planes and related problems.[6] The students’ errors usually occur due to the lack of their understanding of learning the material. [7]

The central goal of education is not just leading to read and write but to develop the abilities to think and reason. The reasoning is the heart of education. This is more explicit in the education of Science and Mathematics than in other fields. All branches of Science and Mathematics thrive on reasoning logical explanation and thinking ability of Science and Mathematics take the pride to the top list. [8]
“One of the teaching strategies that promote HOTS is problem-solving. Problem-solving is an activity that involves various actions in the mind of thought including accessing and using knowledge and experience” [9,10]. Thus, teaching strategies that involve the use of non-routine problems in the classroom give students the opportunity to develop higher order thinking skills in the process of understanding, exploring and applying mathematical concepts.[11] *HOTS (High order thinking skills)* level such as analyzing, evaluating, and creativity. Mathematics teachers should create opportunities for students to relate word problems to mathematical ideas and concept to enable the students to connect or relate everyday real life situations and problems mathematical ideas and concepts. [12]

Newman’s procedure is used to analyze the students’ error in resolving the *HOTS* tasks on the planes and related problems. It has been proven as a reliable model for mathematics teachers to be used on classifying and categorizing the students' errors in solving mathematical problems which are involving *HOTS*. According to Effandi and Siti Mistima, Newman’s Error Analysis Model has the hierarchy that categorizes types of error based on the levels of problem-solving by the students [13, 14]. The Newman’s procedure in this research is also developed by Natcha P. And Satochi with the classification as follows: (1) reading, (2) comprehending (3) transforming, (4) processing skill, and (5) encoding. Therefore, the error types based on this procedure are: (1) reading errors, (2) comprehending errors, (3) transforming errors, (4) processing skill errors, and (5) encoding errors [13,15].

The following error indicators are given by Newman so researchers are easier and structured in identifying Newman’s error. (See Table 1)[9]

| Types of Errors          | Indicator of Errors                                                                 |
|--------------------------|-----------------------------------------------------------------------------------|
| Reading Errors           | a. Wrong in reading matter related material equations of straight line and does not understand the meaning of the sentence in question.  |
|                          | b. Not being able to read properly reserved related material equations of a straight line.   |
|                          | c. Can read correctly but could not take the information important in the matter of material equations of a straight line.               |
| Comprehending Errors     | a. Could not determine exactly what is known and what is asked of reserved related material equations of a straight line.   |
|                          | b. Wrong in determining what is known and what is asked of reserved related equations of a straight line.                          |
|                          | c. Do not use the information or have not yet captured the information contained material related problem of the equations of a straight line. |
| Transforming Errors      | a. Wrong in determining settlement measures and steps which take precedence in resolving a matter related material equations of a straight line.  |
|                          | b. Wrong in determining the formula that is used in the steps of completion of the related question of material equations of a straight line. |
| Processing Skill Errors  | a. Wrong calculation in operating in resolving a                                     |
matter related material equations of straight line regardless of previous errors.
b. Wrong in determining the settlement of related problem material systematics equations of a straight line.

Encoding Errors

| Types of Newman’s errors | Result |
|--------------------------|--------|
| Reading                  | Students are able to read, understand, and take the principal information from the questions |
| Comprehending            | Students are able to explain what they know and what is asked from the questions. |
| Transforming             | Students are able to explain steps to resolving the given questions. |

2. Methods
This study uses a descriptive qualitative technique. The purpose of this research is to find out and to analyze the students’ error types on the planes and related problems based on Newman’s analysis. The subjects of this study are one student with high ability from grade VIII on 3 Wonosari junior high schools, Gunungkidul Regency, Indonesia. This is chosen based on the mathematics result of their report cards on the previous semester or on grade VIII. The procedures of this research consist of the analysis of the result of the planes and related problems test, interview, and the analysis of the interview.

The instrument of the research is a set of test questions to identify the students’ error types. It includes the HOTS questions on the geometry topic, especially planes and related problems. The identification of the error types is based on Newman’s procedure and is classified into five which are reading, comprehending, transforming, processing, and encoding errors. [16].

3. Result and Discussions
Planes and the related problems are the geometry materials which connects to daily life activity. Therefore, students are expected to understand the material quickly. They are also expected to solve the problem or task easily. In fact, based on the interview result with the teacher, there are still many students who make the errors. Moreover, in this study, the questions used are HOTS type questions, which demand the students to think more about resolving the given tasks. In line with this statement, Thomson says that “HOT involves solving tasks where an algorithm has not been taught or using known algorithms while working in unfamiliar contexts or situations.” [17].

Based on the research that has been conducted, the results of the identification and the analysis of the high ability students’ error types based on Newman’s procedure are given in Table 2 [18].

| Types of Newman’s errors | Result |
|--------------------------|--------|
| Reading                  | Students are able to read, understand, and take the principal information from the questions |
| Comprehending            | Students are able to explain what they know and what is asked from the questions. |
| Transforming             | Students are able to explain steps to resolving the given questions. |
Processing Skill: Students have the mistake on their answer of a calculation.

Encoding: Students give not a conclusion.

Based on the result, students with high ability in analyzing the level of HOTS have processing skill and encoding errors types based on Newman’s procedure. Students have an error or mistake on their answer of calculation and they give not the best conclusion. Students can explain steps to resolving questions, but they can give the steps to calculate the answer. (Table 3) [19]

| Types of Newman’s errors | Result |
|--------------------------|--------|
| Reading                  | Students are able to read, understand, and take the principal information from the questions |
| Comprehending            | Students are able to explain what they know and what is asked from the questions. |
| Transforming             | Students are not able to explain steps to resolving the given questions. |
| Processing Skill         | Students have the mistake on their answer to the processing system and the operation. |
| Encoding                 | Students give not final answer well. |

Based on the result, students with high ability in the creative level of HOTS have a transforming, processing skill and encoding errors types based on Newman’s procedure. Students are not able to explain steps on resolving the problems. Students have an error or mistake on their answer of the processing system and the operation and they give not final answer well. (Table 4) [20].

Table 4. Result test and interview with students in creativity level of HOTS in every types of procedure Newman’s errors

| Types of Newman’s errors | Result |
|--------------------------|--------|
| Reading                  | Students are able to read, understand, and take the principal information from the questions |
| Comprehending            | Students are able to explain what they know and what is asked from the questions. |
| Transforming             | Students are not able to explain steps to resolving the given questions. |
| Processing Skill         | Students have the mistake on their answer to the processing system and the operation. |
| Encoding                 | Students give not the final answer and conclusion well. |

Based on the result, students with high ability in the creative level of HOTS have a transforming, processing skill and encoding errors types based on Newman’s procedure. Students are not able to explain steps to resolving the given questions. Students have an error or mistake on their answer of the processing system and the operation and they give no final answer and conclusion well.
From the data analysis based on the HOTS level and based on Newman’s procedure, the students have the transforming, processing skill, and encoding errors [21]. This result is relevant to Abdullah’s research result which shows that the high-achieving students still have the error on transforming, processing, and encoding to solve the HOTS questions on fraction [22]. Therefore, based on the results above it can be concluded that the subjects or the high-achieving students still have the transforming, processing, and encoding errors on resolving the HOTS questions on the topic geometry especially planes and related problems.

According to Abdullah, who states that “The levels of achievement contribute to the frequency of students making errors. The study found out that many errors were made by the students with low and medium levels of achievement.” (see [22]).

Based on Abdullah’s opinion, the students with moderate or low achievement will have more errors based on Newman’s procedure for resolving the HOTS tasks. This is due to the difference in the thinking level of the students. This is supported by Ismail’s statement who says, “Students make errors in mathematics that are associated with the following characteristics; a) cognitive activities, b) metacognitive abilities, c) attitudes and d) the knowledge possessed by them” [23]. Various levels of the characteristics have led to the different errors made by students and different abilities for them to solve the mathematical problems [24].

From the preliminary research about the errors done by the high-achieving students supported with the statements above, the researcher suspects that the moderate and low achievement students will have more errors compared to the high-achieving students. This allegation will be proved by the researcher on the following research. We will also analyze the reasons and the factors which lead to the students’ errors to solve the mathematics tasks especially on the HOTS questions on the topic of the geometry [25].

4. Conclusion
From the preliminary research that has been done, it can be concluded that the high-achieving students tend to make all of the error types based on Newman’s procedure. These errors are transforming, processing, and encoding the HOTS mathematics tasks on the topic of the geometry. The result leads to a new allegation that the students with moderate and low achievement will make more errors in resolving such tasks. Based on the analysis, the students are not able to solve the tasks well. It might be because the tasks that are different from the tasks that usually given by the teacher.

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References
[1] Utami A K 2017 AIP Conf. Proc. 1868
[2] Ekwueme C O and Ali A 2012 J of Em. Trends in Ed. Re. And Pol. Stud. 3 600
[3] NCTM 2000 Principles and Standards for School Mathematics (Reston VA: NCTM)
[4] Loc N P and Uyen B P 2016 Asian J of Manag. Sc. And Edu 5 2
[5] Susanti E, Kusumah Y S, Sabandara J , and Darhim 2014 J of Edu. and Prac. 5 18
[6] Sari Y M and Valentino E 2016 J of Res. And Adv. In Math Edu 1 2
[7] Rohmah M and Sutiardo S 2018 EURASIA J of Math., Sc. And Tech. Edu. 14 671
[8] Chamundeswari S 2014 Inter J of Inn. Sc. Eng. And Tech 1 8
[9] Fitriani H N, Turmudi T and Prabawanto S 2018 Inter. Conf. on Math and Sc. Edu. 3 2655
[10] Lester F K and Kehle P E 2003 From Problem Solving to Modeling: The Evolution of Thinking About Research on Complex Mathematical Activity (Mahwah, NJ: Lawrence Erlbaum Associates).
[11] Loc N P and Tongi D H 2017 European J of Edu. St. 3 6
[12] Adu E, Assuah C and Asiedu- Addo S K 2015 African J of Ed. Stu. In Math and Sc. 11

5
[13] Prakitipong N and Nakamura S 2006 *J. of In. Co. in Edu.* 9 111
[14] Zakaria E and Maat S M 2010 *Inter. Edu. Studies.* 3 105
[15] Zamzam K F and Patricia F A 2017 *Adv in Soc. Sc., Edu. And Human. Res.* 160
[16] Newman N A 1977 *Ed. Re.s Bull.* 39 31
[17] Thompson T 2008 In *Elec. J. of Math. Edu.* 3 96
[18] Rahman A A and Fauzina 2018 *IOSR J of Re. & Meth in Edu.* 8 6
[19] Abdullah A H 2015 *J of Asian Soc. Sc.* 11 21
[20] Raduan I 2010 *Proc. Soc. and Behavioral Sc.* 2 3836
[21] Hoard M K, Geary D C, Byrd-Craven J and Nugen, L 2008 *Mathematical cognition in intellectually precocious first graders* (Developmental Neuropsychology) 33 251
[22] Junaedi I, Suyitno A, Sugiharti E and Eng C K 2015 *Inter. J of Edu.* 7 4
[23] Zuhroh N 2018 *J MATHEdunesa* 1 7
[24] Sumule U, Amin S M, and Fuad Y 2018 *J. Phys.: Conf. Ser.* 947 012053
[25] Sulistyorini Y 2017 *Adv in Soc. Sc., Edu. And Human. Res.* 160