Re-evaluating and reinventing Bloom's taxonomy using an internet-based application

S Kurniawati*, B Budiyono and D R S Saputro

Department of Magister Mathematics Education, Faculty of Teachers Training and Education, Universitas Sebelas Maret, Jalan Ir. Sutami 36, Surakarta, Indonesia

*srikurniawati.sk1@gmail.com

Abstract. The development of mathematics learning today requires students to improve their thinking skills. One of them is the Higher Order Thinking Skill (HOTS). HOTS in this study is based on the revision of Bloom's Taxonomy, namely C4 (analysing), C5 (evaluating), and C6 (creating) with the indicators that are differentiating, attributing, checking, critiquing, planning and producing. This research is a quantitative descriptive study that aims to determine the ability of students to solve HOTS problems in the matter of straight-line equations. The research was conducted at SMPN 3 Surakarta, SMPN 16 Surakarta, and SMPN 20 Surakarta, each of which included high, medium, and low category schools with 77 students. Data obtained using HOTS questions on the topic of straight-line equations with the reliability of the item is 0.746. The conclusion obtained is that differentiating indicators are at a high level. Medium level indicators are attributing and producing. Indicators at low levels are checking, critiquing, and planning. In the differentiating indicator, from 77 students there are 36 students with differentiating abilities at a high level. Whereas in the other 5 HOTS indicators, the ability of students is mostly at medium and low levels.

1. Introduction

Education in Indonesia so far has not reached the expected target. One of the guidelines for the progress of a nation is education [1]. High-quality education is very important in the development of individuals who are ready to face the challenges of globalization [2]. Quality education can create competent human resources and be able to compete for the future. Quality human resources in terms of spirituality, intelligence, and skills are one of the characteristics of an advanced nation [1]. The development of the quality of education can be done by developing mathematics learning in schools, one of which is on mathematics.

Mathematics has an important role in daily life [1]. Mathematics is a basic science that has an important role in efforts to master science, technology, and also in daily life [3]. Mathematics is integrated into one field of education that encourages students to think in a more connected and holistic way [2]. The importance of mathematics has not been totally realized by students, especially for middle school students. To learn mathematics, it requires thinking skills in solving the problems presented. There are two kinds of thinking skills, namely high-level thinking skills and low-level thinking skills. What is needed to be improved by students is high-level thinking skills. Mathematics is one of the means to form high-level thinking (analysing, evaluating, and creating) [4]. The ability of high-level thinking is important to be mastered because it is useful when it forms a connection between knowledge that have been learned and what will be learned [5].
An important aspect of learning is high order thinking skill (HOTS) [6]. HOTS can be taught and can be learned [7]. HOTS is a skill that must be presented in every learning [8]. Regular questions or routine questions that are usually given to students cannot increase HOTS [9]. But broader knowledge is needed and given questions that encourage students to interpret, analyse, and manipulate information [7]. HOTS is to understand the facts and use these facts to obtain other knowledge so as to obtain solutions to the questions or commands on the questions presented [5]. Another definition of HOTS is the ability to make judgments, to analyse content, and to synthesize information into a coherent form of communication and present information to others [10]. So, the HOTS abilities of students in learning mathematics need to be known so that they can organize quality mathematics learning [6]. To find out students’ HOTS, research needs to be done. Students’ HOTS can be measured by HOTS indicators based on the revision of Bloom's Taxonomy. Similarly, [11] uses the revised bloom taxonomy, namely analysis, evaluating, and producing. The teacher can use Bloom's Taxonomy and integrate HOTS in mathematics learning in order to create students who master HOTS elements [12].

The cognitive taxonomy or division carried out by Benjamin S. Bloom is to facilitate the process of formulating or forming questions according to their objectives so that they can find out the success of students [13]. Bloom's Taxonomy consists of six levels of cognitive domains, namely knowledge, comprehension, application, analysis, synthesis, and evaluation. Then the Bloom Taxonomy is revised based on the demands of the development of education so that the six levels of cognitive domains are remembering, understanding, applying, analysing, evaluating, and creating [14]. The first three levels are called Low Order Thinking Skill (LOTS), namely remembering (C1), understanding (C2), and applying (C3). While the next three levels are analysing (C4), evaluating (C5), and creating (C6) are Higher Order Thinking Skill (HOTS). Figure 1 shows the HOTS indicator based on the revision of Bloom's Taxonomy [14].

![HOTS Indicator](image)

**Figure 1.** HOTS is based on the revision of Bloom's Taxonomy.

Based on Figure 1, the analysis is divided into three indicators, namely differentiating, organizing, and attributing. Differentiating occurs when students sort out relevant or irrelevant information from a given material. Organizing is the process of identifying an element and determining how these elements function in forming a structure. Whereas attributing occurs when students are able to determine ideas or the core of a given material. At the level of analysis, students need to have the ability to break the whole into parts and how to connect these parts to become a single entity [11]. Evaluating consists of checking and critiquing. Checking is needed to determine internal errors in operation or result and detecting the effectiveness of a method or procedure that is being used. Whereas critiquing is detecting whether the
results obtained based on outside criteria or the procedure to solve a problem have approached the correct answer. Creating consists of generating, planning, and producing. Generating is the ability to involve finding hypotheses based on certain criteria given. Planning is the ability to design a method or method that can be used to solve problems that fit certain criteria. While producing is that students are given an overview of a product and students must make a product.

HOTS can improve students’ performance and reduce students’ weakness [15]. Therefore, training students’ HOTS can improve the quality of mathematics learning. Heong et al conducting a study to find out the HOTS level in engineering education students, it was found that no student had HOTS in the high category [7]. HOTS students are based on the research at medium and low levels. Other researchers conduct research that is developing learning design in high school students [16]. Before learning design is applied, students are given a pre-test to find out students’ HOTS. The pre-test shows that students’ HOTS only 31.36%. Analysing, evaluating and creating skills are important to improve so students can solve problems in daily life [16]. Other research on the level of knowledge and practice of mathematics teachers in the application of HOTS was carried out by Abdullah et al [17]. The conclusion of the study is that the implementation of HOTS can be seen from three important aspects, namely curriculum, pedagogy, and assessment. Similarly, Abdullah et al [17] and Kamarudin et al [18] it was also conducted a study to identify activities and the role of teachers in embedding HOTS in students in learning Arabic. The results of the study indicate that HOTS must be applied in the process of learning Arabic. The other study was examining science teaching on biology subjects to develop HOTS students [19]. Based on the research, the development of HOTS students is the goal of educators and curriculum developers.

Based on several studies and explanations regarding HOTS above, there is no research in junior high school students in the matter of straight-line equations. By some of the research above is not done on mathematics subjects. Therefore, researchers conducted a study to increase the HOTS of junior high school students in the material of straight-line equations. This study aims to determine the level of HOTS of junior high school students.

2. Research method
This research is descriptive quantitative. The population in this study are junior high school students in Surakarta with three schools as samples. The samples were taken randomly based on the categories of each school. The three schools are SMP Negeri 3 Surakarta, SMP Negeri 16 Surakarta, dan SMP Negeri 20 Surakarta. Then from each of the three schools, one class was taken with 77 students. The HOTS data of students were obtained in the matter of straight-line equations. HOTS questions were given to 77 students which consisted of six essay-shaped questions. The HOTS instrument used has been validated and tested by three experts. Students work on HOTS questions on the answer sheet provided by the researcher. The data obtained were then analysed by the descriptive method.

3. Result and discussion
This research used the HOTS indicator from the revision of Bloom’s Taxonomy and had been synthesized into six indicators, namely differentiating, attributing, checking, critiquing, planning, and producing. Organizing indicator was not used because the activities carried out on the organizing indicator can be carried out on the distinguishing indicator, because in attributing, it determines an element that functions and then determines the idea of a problem. Attributing is the sorting of important information from the material presented so that it can simultaneously carry out identifying activities that are determining important elements or information to form a structure. Generating indicators on the revision of Bloom's taxonomy were also not used because in planning, students determined the hypothesis first so that it finally determined planning. Table 1 shows the HOTS indicator level based on the average value.
Table 1. The level of indicator HOTS.

| Item | HOTS Indicators | Mean | s   | p   | D    | HOTS Level |
|------|-----------------|------|-----|-----|------|------------|
| 1    | C5 (checking)   | 2.234| 2.570 | 0.372 | 0.714 | Low        |
| 2    | C4 (attributing)| 2.597| 2.278 | 0.433 | 0.727 | Medium     |
| 3    | C6 (producing)  | 2.896| 2.479 | 0.483 | 0.672 | Medium     |
| 4    | C5 (critiquing) | 2.312| 1.772 | 0.385 | 0.707 | Low        |
| 5    | C4 (differentiating) | 3.896| 2.162 | 0.649 | 0.564 | High       |
| 6    | C6 (planning)   | 2.104| 2.030 | 0.351 | 0.621 | Low        |

Table 1 shows the level for each HOTS indicator based on data obtained by 77 students of the Public Middle School in Surakarta. The reliability of the test is 0.746. The index of difficulty ($p$) of the items in this study uses the criteria of $0.3 \leq p \leq 0.7$. Whereas for discrimination power ($D$) uses the criteria $D \geq 0.3$. A high level is obtained if the mean of each HOTS indicator meets the $\text{mean} \geq 3.005$. The medium level is obtained if the mean of each HOTS indicator meets $2.342 \leq \text{mean} < 3.005$. Low levels are obtained if the mean of each HOTS indicator meets the $\text{mean} < 2.342$. Based on these three levels, a high-level indicator is obtained, namely differentiating. There are two indicators at the middle level, namely attributing and producing. While the low level there are three indicators, namely checking, critiquing, and planning. The HOTS indicator is said to be good if the indicator is at a high level. Almost the same as the research conducted by Nursalam on students SMP in Makassar [20]. The results of HOTS analysis of students obtained that 14.71% were in good category, 38.24% were in adequate category, 32.35% in less category, and 14.71% in very less category.

Research conducted Abdullah et al shows that 83.1% of respondents agreed and strongly agreed to practice implementing HOTS in teaching and learning mathematics [17]. These findings support the results of the research shown in Table 1. There were six essay questions were given to 77 students, only the attributing indicator reached a high level. This means that HOTS still need to be applied and improved in mathematics learning [17]. Based on Table 1 above, Table 2 below will explain the HOTS of 77 students' abilities on each of the HOTS indicators more detail.

Table 2. Ability and number of students in each HOTS indicator.

| Item | HOTS indicator | Mean | The number of students | HOTS Level |
|------|----------------|------|------------------------|------------|
|      |                |      | High | Medium | Low |            |
| 1    | C5 (checking)  | 2.234| 24  | 16   | 37 | Low        |
| 2    | C4 (attributing)| 2.597| 22  | 25   | 30 | Medium     |
| 3    | C6 (producing) | 2.896| 29  | 19   | 29 | Medium     |
| 4    | C5 (critiquing)| 2.312| 13  | 35   | 29 | Low        |
| 5    | C4 (differentiating) | 3.896| 36  | 25   | 16 | High       |
| 6    | C6 (planning)  | 2.104| 19  | 23   | 35 | Low        |

Item question with checking indicator is at a low level with 24 students who are able to solve the problem. While students who are unable to solve the questions were 37 students, the rest are students who are only able to solve questions imperfectly or incompletely. The second item with attributing indicator is at the medium level. The number of students in the high category is 22, which means that 22 students are able to solve the indicators of attributing well. There are 25 students have the problem with incomplete and 30 other students are unable to solve the problem with the attributing indicator. The third question item is the problem with the producing indicator which is at a medium level. There were 29 students who are able to solve the problem, 19 students do the problem incomplete, and 29 other students cannot solve the problem. The fourth question item is a question with a critiquing indicator. In the fourth item, there are only 13 students who are able to solve the problem. The total of 35 students...
and 29 consecutive students are at medium and low levels. The fifth question item with the differentiating indicator. On this question, there are 36 students who are able to solve the problem so that the differentiating indicator was at a high level. Whereas 25 students and 16 other students are at medium and low levels respectively. The sixth item with planning indicators is at a low level. The totals of 19 students are able to solve the problem, 23 students do the problem incomplete, and 35 other students are unable to solve the problem. Research conducted by Mirna also reveals that students’ HOTS are still low, especially in the field of geometry [21]. Students have not understood the geometry concept well. They have not been able to apply concepts to problem-solving, to develop plans to solve problems, and to provide possibilities that can occur. The weakness of students in working on HOTS problems in this study and research is almost the same [21]. Students have not mastered the concept of straight-line equations and they have not been able to argue about the true or false of a solution.

Based on Tables 1 and 2, it can be seen that the HOTS ability of junior high school students in Surakarta is still low. This is almost the same as the results of research conducted by Ahmad et al [6], that PGSD students in the first learning had a low HOTS level because 60% were at very low levels. The research was conducted on PGSD students, while the research discussed in this article was for junior high school students. The following Figure 2 shows one of the HOTS questions with indicators at a low level.

**Figure 2.** The HOTS instrument on the indicator of checking.

Figure 2 shows that questions with checking indicators encourage students to be able to maintain the information on the graph and Mega's statement. So that students are able to provide explanations and evidence to solve the problem. Students are expected to be able to see the errors from existing statements, then examine the correct resolution strategies. The reason of students uses to explain false statements is to be able to use broader thinking by utilizing the concepts of straight-line equations so students can find the right conclusions to answer those questions. Therefore, a higher order thinking skill is needed to solve the problem. Students also need prior knowledge of charts in straight line equations and strategies for obtaining line equations. So, if students have good HOTS, they are more likely to understand the concept in order to solve the problem than memorize the formula.

4. **Conclusion**

The results of this study are that HOTS junior high school students in Surakarta are still low, so the efforts are needed to increase HOTS students. There is only one HOTS indicator that is at a high level, namely the differentiating indicator with 36 students at a high level, 25 students at a medium level, and 16 students at a low level. This means from 77 junior high school students; 36 students have good differentiation skills. The other five HOTS indicators are at medium and low levels. Based on the results
of the research in this article, it can be used as a reference for researchers and other researchers to find solutions that can increase HOTS students, especially junior high school students. The drive to increase HOTS in class is an important skill to have in facing a rapidly changing and technology-oriented world [22]. The reason for developing HOTS is to organize the knowledge learned into long-term memory and encourage the creation of quality human resources so that they can compete with other countries [23]. Therefore, based on the results of this study and other studies, it is expected that there is a solution to increase HOTS students.

Acknowledgment
The authors would like to thank Universitas Sebelas Maret Surakarta for giving the opportunity to conduct this research. The authors also express gratitude to the headmaster, teachers, and students in SMP Negeri 3 Surakarta, SMP Negeri 16 Surakarta, and SMP Negeri 20 Surakarta who had provided the opportunity to conduct the research. Thank you also to the assessment team that has assessed the writing of researchers.

References
[1] Hasibuan A M, Saragih S and Amry Z 2019 Development of learning material based on realistic mathematics education to improve problem solving ability and student learning independence International electronic journal of mathematics education 14 243-252
[2] Hassan M N, Abdullah A H, Ismail N, Suhud S N A and Hamzah M H 2019 Mathematics curriculum framework for early childhood education based on science, technology, engineering and mathematics (STEM) International electronic journal of mathematics education 14 15-31
[3] Saragih S, Napitupulu E E and Fauzi A 2017 Developing learning model based on local culture and instrument for mathematical higher order thinking ability International education studies 10 114-122
[4] Wahyuni Y and Fauziah 2018 Higher order thinking skill instrument design of student American Journal of Engineering Research (AJER) 7 84-87
[5] Singh R K A, Singh C K S, Mohtar T M T, Mostafa N A and Singh T S M 2018 A review of research on the use of higher International Journal of English Linguistics 8 pp 86-93
[6] Ahmad S, Prahmana R C I, Kenedi A K, Helsa Y, Arianil Y and Zainil M 2017 The instruments of higher order thinking skills J. Phy.: Conf.Ser 943 012053
[7] Heong Y M, Widad, Jailani, Kiong T T, Razali and Mohaffyza M 2011 The level higher order thinking skills among technical education students International journal of social and humanity 1 121-125
[8] Sulaiman T, Muniyan, V, Madhvan D, Hasan R and Rahim S S A 2017 Implementation of higher order thinking skills in teaching of science: a case study in malaysia International research journal of education and sciences (IRJES) 1 1-3
[9] Newmann F M 1990 Higher order thinking in teaching social studies: a rationale for the assessment of classroom thoughtfulness Journal of Curriculum Studies 22 41-56
[10] Narayanan S, Vellore, Nadu T and Adithan M 2015 Analysis of question papers American Journal of Engineering Education 6 1-10
[11] Pratama G S and Retnawati H 2018 Urgency of higher order thinking skills (hots) content analysis in mathematics textbook J. Phys.: Conf.Ser 1097 012147
[12] Thompson, T. 2008. Mathematics Teachers’ Interpretation of Higher-Order Thinking in Bloom's Taxonomi. International Electronic Journal of Mathematics Education 3 96-106
[13] Krathwohl D R. 2002 A Revision of bloom’s taxonomy: an overview. Theory into practice 41
[14] Anderson L W and Krathwohl D R 2001 A taxonomy for learning, teaching, and assessing: A Revision of Bloom's Taxonomy of Educational Objectives (New York: Longman) p 30-1
[15] Tanujaya B 2016 Development of an instrument to measure higher order thinking skills in senior high school mathematics instruction Journal of education and Practice 7 144-148
[16] Apino E and Retnawati H 2017 Developing instructional design to improve mathematical higher order J. Phys.: Conf. Ser 812 012100
[17] Abdullah A H, Mokhtar M, Halim N D, Ali D F, Tahir L M and Kohar U H 2017 Mathematics teachers’ level of knowledge and practice on the implementation of higher-order thinking skills (hots) Eurasia Journal of Mathematics Science and Technology Education 1 pp 3-17
[18] Kamarudin M Y, Yusoff N M R N, Ahmad H Y and Ghani K A 2016 Inculcation of higher order thinking skills (hots) in arabic language teaching at malaysian primary schools Scientific research publishing 7 307-314
[19] Hugerat M and Kortam N 2014 Improving higher order thinking skills among freshmen by teaching science through inquiry Eurasia Journal of Mathematics Science and Technology Education 10 447-54
[20] Nursalam, Anggriani A D, Darmawati, Bharuddin and Aminuddin 2018 J. Phys.: Conf. Ser. 1028 012169
[21] Mirna 2018 Errors analysis of students in mathematics department to learn plane geometry IOP Conf. Ser. Mater. Sci. Eng. 335 012116
[22] Ramos J L S, Dolipas B B and Villamor B B 2013 Higher order thinking skills and academic performance in physic of collage students: a regression analysis International Journal of Innovative Interdisciplinary Research 48-60
[23] Samo D D, Darhim and Kartasasmita B 2017 Developing contextual mathematical thinking learning model to enhance higher-order thinking ability for middle school students International Education Studies 10 17-29