



The profile of students HOTS at Malang, Indonesia in responding to higher-thinking biology questions

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ABSTRACT

Higher order thinking skills (HOTS) is one of the primary 21st-century skills that Indonesian schools have not optimally developed. The present study was aimed at 1) presenting the profile of students' HOTS in Malang, Indonesia and 2) investigating the influence of grades on students' HOTS. This quantitative study involved 559 students from 18 schools in Malang municipality as the participants. The data were collected using ten essay questions as the instrument and analyzed through descriptive statistics and one-way ANOVA as the data analysis techniques chosen in this study. This study revealed that first, the students of Junior High School in grades VII, VIII, and IX at Malang, Indonesia acquired a low level of HOTS. Second, the students of Senior High School performed an excellent level of HOTS. Third, there was a significant influence of the student's grades to the level of the students' HOTS in which senior high school students accomplished a higher level HOTS than junior high school students. Therefore, to improve this essential skill, the students in Indonesian schools should be given as much exposure to teaching and assessment based on HOTS.

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INTRODUCTION

HOTS is an essential thinking ability for a person in an unfamiliar situation. When a person is in such a situation, he will rely on his memory recall and activate his critical thinking, creativity, and problem-solving ability (King et al., 2011). Through the acquisition of HOTS, the students are expected to analyze and evaluate a phenomenon based on the right concept that they learn. This skill is essential to be mastered by students as a modal to encounter the situation and development of the world nowadays (Valeeva & Bushmeleva, 2016). Hence, because of the urgency of HOTS acquisition, the commitment of promoting these thinking skills has spread out in some countries such as Malaysia (Adnan et al., 2017; Yen & Halili, 2015), Australia (Fensham & Bellocchi, 2013), and North Ireland (Murphy et al., 2013). The curricula in those countries consider HOTS as the basic competence in designing teaching-learning and students learning outcomes.

The newest Indonesian curriculum has been developed and changed based on the demand of the world. The new curriculum is one of the changes in the learning objectives that the students should accomplish. Then, it is followed by the construction of questions of national examination based on HOTS (Putra & Abdullah, 2019). In responding to this, some Indonesian education experts are interested in studying and offering appropriate models of learning that could be implemented in the classroom. As a result, there are many studies examining the influence of those learning models on the development of students' HOTS, such as the studies carried out in Kandangan (Ramdiah et al., 2018), Samarinda (Tindangen, 2018), and Kendari (Ahiri et al., 2015).

Studies have revealed that the choice of appropriate learning models will surely optimize the achievement of learning objectives. Some studies carried out in Indonesia have informed those models of learning which are also used to promote the students' HOTS by some countries in the world, i.e., problem-based learning (Ramdiah et al., 2018), inquiry-based learning (Tindangen, 2018), and contextual teaching-learning (Ahiri et al., 2015). Moreover, problem-solving and scientific learning are included in the models mentioned earlier; the two elements significantly improve the student's HOTS (Baharin et al., 2018). In addition, to maximize the development of students' HOTS, some studies recommend the availability of proper learning resources (Li et al., 2016; Margana & Widyantoro, 2017) and assessment (Abosalem, 2016; Mohamed & Lebar, 2017; Netri et al., 2018; Widana, 2017).

One of the most compelling subjects in developing the students' HOTS is Natural Sciences, especially Biology. The nature of the Natural Science subject requires teachers to train their students to perform an inquiry process that is considered effective in developing the students' HOTS (Hugerat & Kortam, 2014). This statement is supported by several studies revealing that through the proper implementation of learning models, the students' HOTS will effectively improve when studying Biology (Haryati et al., 2017; Ramdiah et al., 2018; Tindangen, 2018; Zulfiani et al., 2018). Also, contextual problems included in the teaching process by the teachers will encourage students to activate their higher-order thinking in solving the problems.

However, Indonesian schools are rarely implementing student-centered learning (Kurniati & Surya, 2017; Zulfikar, 2013) and critical thinking-based assessment in the process of teaching. They are still performing traditional learning and conventional assessment to their students (Hadi et al., 2018; Netri et al., 2018). Moreover, the learning system in the Indonesian education context is exam-oriented; meaning the highest exam scores are considered as the final goal of the learning process for the stakeholders; students, parents, teachers, and schools. Besides, the questions used in the exam are only evaluating students' lower-order thinking skills (LOTS) (Hadi et al., 2018; Netri et al., 2018). As a result, the teaching and learning process is dominated by learning methods that encourage students to memorize several facts and concepts.

In terms of the assessment, many teachers are still more accustomed to evaluating LOTS than HOTS. The assessment applied in biology learning also often uses one type of question. The culture of question drilling before the national exam also causes students to memorize questions and answers without empowering their thinking skills. The teachers' difficulty in designing a learning method and assessment based on HOTS is also becoming one of the main factors contributing to this problem (Setyarini et al., 2018).

The information presenting students' ability to perform HOTS is essential to improve teaching quality and learn in Indonesia. That is why some previous studies have highlighted the profile of Indonesian students' higher thinking skills. Those studies for instances involved junior high school

students in Bandung (Diputera et al., 2018), senior high school students in Malang (Permatasari et al., 2018), Jayapura (Budiarti et al., 2017), and Jogjakarta (Hadi et al., 2018). However, there has not been any single study examining the influence of grades on the level of students' competencies in responding to higher-thinking questions. Also, this kind of study is considered important as the basis to evaluate the implementation of curriculum 2013 in Indonesia. Therefore, by involving more subjects and the scope of the population, the aimed of this study was to figure out the influence of grades on the students' higher thinking skills. This makes the study quite different from the previous one.

METHODS

Research Design and Procedure

The present quantitative study aimed to present the junior and senior high school students' abilities to respond to biology questions based on HOTS. The study was carried out from June 2018 to March 2019 with secondary school students in Malang municipality as the participants. It was begun by developing HOTS-based questions that were designed to ask biological concepts in general. Then, the instruments were validated by the experts in materials, and the question item analysis was conducted after the instruments were piloted to 89 secondary school students. The data were collected by administering tests using the instruments in the form of questions set in the secondary schools that were randomly selected. The test administration involved the Biology students of the Teacher Education Program of the University of Muhammadiyah Malang (UMM), who joined teaching apprentices at some schools in Malang. After the test was finally conducted, the students' responses were checked and analyzed.

Population and Samples

The population of this study was all students of secondary schools in Malang municipality, East Java, Indonesia yang menjadi mitra praktik pembelajaran mahasiswa UMM. Five hundred fifty-nine students from 18 schools (9 Junior high and 9 Senior High) were randomly selected as the participants. The participants consisted of 119 students in grade VII, 109 students in grade VIII, 110 students in grade IX, 109 students in grade X, and 112 students in grade XI. The criteria for the schools selected in this study were high school, and the students' academic level was at a moderate level.

Instrument

The data were collected through a test consisting of 10 essay questions, four cognitive questions (C4), and six cognitive questions (C5). All question items were validated (Pearson Correlation <.05), and the instrument was very reliable (Cronbach's alpha = .431). Table 1 presents an outline of the test instruments used to measure students' HOTS in this study.

Table 1.

The outline of test instrument

Item	Concept	Cognitive level	Pearson Correlation
1	the role of Biology in human life	Evaluate	.396**
2	the relation of Biology with other sciences	Evaluate	.246*
3	methods and scientific attitude	Analyze	.231*
4	cell as the smallest unit of life	Analyze	.633**
5	level of life organization	Analyze	.436**
6	the role of viruses in human life	Evaluate	.377**
7	the component of the ecosystem	Analyze	.215*
8	the characteristics of fungi and plants	Evaluate	.482**
9	biodiversity as the evidence of evolution	Evaluate	.422**
10	nutrition for human life	Evaluate	.529**

** . Correlation is significant at the 0.01 level (2-tailed).

* . Correlation is significant at the 0.05 level (2-tailed).

Data Analysis Techniques

The scores obtained from the students' responses were analyzed by using descriptive and parametric statistics. Firstly, the average scores in each grade were calculated. The level of students'

abilities was determined by the categories presented in [Table 2](#). Secondly, the data of students' competencies were analyzed through a one-way analysis of variance (ANOVA) to find out the influence of students' grades on the level of their competencies. In addition, Least Significant Difference (LSD) test was chosen as additional analysis after ANOVA. The result of the LSD test is presented in the bar graphs form.

Table 2.

The categories of students' HOTS based on their score achievement

Categories	Scores
Very good	86-100
Good	76-85
Sufficient	60-75
Bad	55-59
Very Bad	0-54

RESULTS AND DISCUSSION

The student's ability to answer HOTS questions is one of the indicators used to measure the success of learning sciences in this 21st century. The average of students' scores in each grade as the data in this study was presented in [Table 2](#). Based on [table 2](#), it was shown that the students' higher thinking skills in all grades of Junior High School were categorized as very bad, while the skills of the students of Senior High School were categorized as sufficient. Moreover, the finding revealed that there were no grades categorized as good or very good.

Furthermore, the result of the homogeneity test using Levene's analysis informed that the data variant of HOTS among students' grades was homogeneous ($p\text{-value} = 0.053$). The researcher employed bootstrapping with 1000 samples and a confidence interval of 95% to fulfill the normality assumption. Moreover, the result of one-way ANOVA presented in the table 3 showed that grades had significantly influenced the level of students' HOTS [$F(4,554) = 25.515$, $p < .005$; $\eta p^2 = .156$]. Since the result of ANOVA informed the influence of grades, the data analysis was continued using the LSD test. The results of the LSD test are presented in [Figure 1](#).

Table 1.

The categories of students' HOTS in Malang

Grade	Mean	Categories
VII	53.25	Very Bad
VIII	53.30	Very Bad
IX	50.55	Very Bad
X	63.91	Sufficient
XI	63.54	Sufficient

Table 3.

The summary of ANOVA results on the effect of grade level on students' HOTS

Sources	Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Contrast	17741.241	4	4435.310	25.616	<.005	.156
Error	95924.670	554	173.149			

As seen in [Figure 1](#), the level of the students' HOTS in grades VII and IX is not significantly different. It also can be noticed that the students' HOTS in grades X and XI do not differ remarkably. However, if it is deeply analyzed, we will understand that Junior High School students' HOTS level is significantly different from Senior High School students. This LSD test result indicates that the higher the students' grades, the better their thinking skills.

The finding of this study indicated that the students' HOTS is not optimally developed. The low level of students' HOTS revealed in this study is consistent with some information reported by the previous studies conducted in Bandung (Diputera et al., 2018) and Jember (Irawati, 2018). Surprisingly, the finding of a previous study informed that there were not only students in grade VII (Irawati, 2018) who performed low levels of HOTS but also the students in grade IX (Purbaningrum, 2017). Moreover, the other finding of this study, that was HOTS in senior high school level was not optimally developed,

was also similar to the information reported by the previous studies. Some of them were conducted in Malang (Permatasari et al., 2018) and Jogjakarta (Hadi et al., 2018). In addition, the low level of HOTS profile was also reported by a study involving the students in grade XII as the participants of the study (Ramadhan et al., 2018). This finding strengthens the other studies that report the competence of secondary school students in Malang, but with different thinking skills, such as metacognitive skills (A. Fauzi & Sa'diyah, 2019) and critical thinking skills (Ahmad Fauzi, 2019).

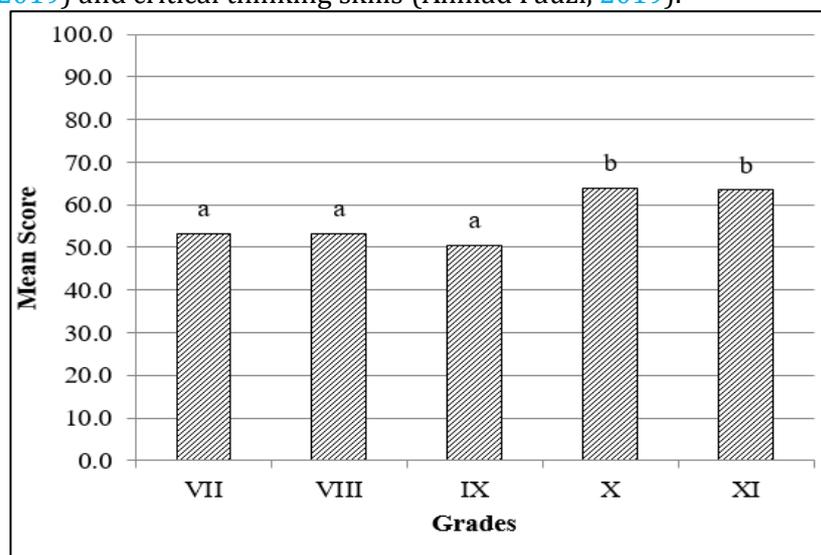


Figure 1. The graph informed the LSD results of the effect of grade on students' HOTS (notes: different notation indicated different achievement at a significant level as high as 5%)

The internal factor of the students is also contributing to the low level of HOTS development. One of the main factors is their preparation to respond to higher thinking questions. As reported in some studies, Indonesian students have not been ready yet to encounter HOTS-based questions (Kusaeri et al., 2019). This condition is strongly caused by the students' lack of exposure to thinking skills (Widana, 2017). It is not surprising when the previous studies examining the profile of students' HOTS in Indonesia informed that they encounter difficulty solving problems requiring HOTS (Hadi et al., 2018; Salsabila et al., 2018). The most effective way to develop our skills is regularly practicing and so are higher thinking skills. The students are required to practice a lot to develop their thinking skills. If not, it is not a surprise when their HOTS are not well developed.

Unusual students dealing with HOTS questions will also lead students to answer HOTS questions with short answers. Interestingly, one of the characteristics of the majority of Indonesian students is that they tend to keep answering with short answers even though they know that the answer to the analysis question should not be short (Yuliati & Lestari, 2018). In addition to being less accustomed to giving complete answers, Indonesian students are less able to understand the information provided in the question and their difficulty finding patterns and relationships (Salsabila et al., 2018). Indonesian students are also still weak in implementing the skills needed in answering questions of analysis and evaluation, such as organizing, differentiating, attributing, critiquing, and checking (Istiyono, 2017).

Another factor influencing the level of students' HOTS is their psychological character. The two main components of psychological characteristics that determine the students' HOTS are motivation and learning attitude (Budsankom et al., 2015). Motivation is persuading the students to optimally achieve learning objectives, including improving critical thinking skills (Vero & Puka, 2017) and encouraging them to participate in the learning process actively. Moreover, the student's attitude toward learning has significantly influenced their level of HOTS (Prasit et al., 2018). Students' attitudes are reflected by their interests in the classroom environment, teachers, learning activities, classmates, and curriculum. Those characteristics are confirmed to directly impact the development of HOTS (Budsankom et al., 2015). In conclusion, the students' lack of acquisition of HOTS in Malang has strongly resulted in their low motivation in joining the classroom activities.

In addition to the various factors mentioned, the students' ability to answer HOTS questions is also determined by factors from their teacher. A teacher has a vital role in academic achievement and

student skill improvement. In this regard, teachers' beliefs about HOTS play an essential role because they will determine the learning objectives, forms of learning, and forms of assessment designed by the teacher (Kusumastuti et al., 2019). Unfortunately, the knowledge and understanding of Indonesian teachers on HOTS are indicated to be very low (Retnawati et al., 2018). Even more alarming, some reports also inform that many teacher candidates and teachers in Indonesia have HOTS that is not yet categorized as high (Albeta, 2018; Suwarna et al., 2018). The teacher will have difficulty teaching a particular skill if the teacher has not been able to master these skills.

The positive effect of students' grades on higher thinking skills confirms the statement that HOTS is a teachable skill (Yen & Halili, 2015). The higher the education, the longer the students learn. The education process undeniably improves and develops a person's competencies, one of which is reasoning ability. Reasoning ability is considered part of intellectual competencies directly affecting critical thinking skills (Budsankom et al., 2015). It will generate the students' thinking skills, such as criticizing and finding the relation between cause and effect.

This finding is consistent with the statement of Puchta (2012) that stated thinking skill does not automatically appear; that is why it has to be developed through consistent and regular training. In the other direction, these findings also reinforce previous research that informs that the thinking skill of students develops hand-in-hand with maturity (Larsen & Luna, 2018; Toppin & Chitsonga, 2016). As the student gets older, their executive functions will develop more (Best et al., 2011). Executive functions are a group of cognitive processes critical in cognitive control of behavior and are proposed to correlate with higher-level cognition (García-Madruga et al., 2016). In line with this information, as students grow, their cognitive development will also be higher (Galotti, 2011). In line with that information, students will also find it easier to use complex high-level thinking processes as they mature (Galotti, 2011; Greiff et al., 2015). The learning conditions can facilitate the development.

To optimize students' thinking skills, students have to be continuously exposed to the education process involving experiences, training, resources, and other supporting components (Roets & Maritz, 2017). Nevertheless, although HOTS is teachable (Nguyễn & Nguyễn, 2017; Wall, 2015), it is considered a challenging skill (Smith, 2015). Hence, the implementation of HOTS-based learning activities is strongly recommended in Indonesian secondary schools.

One of the recommended learning activities to develop HOTS is Problem-Based Learning (PBL). This kind of learning enables students to directly solve a contextual problem related to the materials being discussed. The students, then, are required to solve the problem in a group after being given a chance to collect information related to the problem. Through this activity, the students are encouraged to think critically and creatively in responding and evaluating the problem. This statement is supported by previous studies that informed that the implementation of Problem-Based Learning positively impacts the development of students' HOTS (Haryati et al., 2017; Ramdiah et al., 2018).

Inquiry-Based Learning is another teaching technique that is strongly recommended to arouse students' critical thinking skills. The implementation of inquiry-based learning should be based on teachers' awareness and integrated into the curriculum. It is due to the design of curriculum emphasizing on inquiry-based learning is one of the most effective ways to improve students HOTS (Dresner et al., 2014). Through this learning model, the students are trained to construct their ideas by doing an inquiry activity and other related activities. As a result, the students get used to performing a higher level of thinking during learning.

Consistent learning and regular practice are essential keys to improve HOTS. The more the students get involved in thinking, the more they will acquire HOTS (Wall, 2015). The implementation of HOTS learning is not sufficient; therefore, it has to be followed by using HOTS-based assessment to measure the students' competencies. Teachers must understand the characteristics of HOTS-based assessment to develop their students' higher thinking skills optimally. The main characteristic is that the assessment has to evaluate the level of students' thought based on the contextual problem (Widana, 2017). Some models of assessments, i.e., authentic assessment (Mohamed & Lebar, 2017) and performance-based assessments (Abosalem, 2016), are highly recommended to measure the students' HOTS. However, those models of assessments may hardly be implemented in Indonesian schools since the teachers are not entirely familiar with designing open-ended questions and do not consistently equip the students with contextual problem-solving skills (Setyarini et al., 2018). In addition, not well-prepared assessment (Abosalem, 2016) and the difficulty in finding appropriate references about HOTS

(Ramasamy et al., 2016) are the additional challenges for Indonesian teachers to develop students' critical thinking skills.

It is not deniable that HOTS is an essential skill that students should master in this 21st century. The low level of students' HOTS profile revealed in this study is homework for all Indonesian education stakeholders; teachers, government, researchers, and education experts. Firstly, the teachers have to continuously design HOTS-based learning and implement it in the classroom activities. Since they play the primary role in the educational process, teachers' competencies should be regularly trained through training and seminars on how to develop their students' critical thinking. Secondly, the government should support by designing a curriculum that integrates HOTS as the primary focus. Last but not least, the researchers are strongly encouraged to consistently conduct studies to evaluate and find the most effective ways to improve Indonesian students' HOTS.

Apart from the findings revealed in this study, some limitations could be an improvement for future studies. One of the limitations is the assessment used as the instrument in gathering the data. The HOTS-based assessment developed in this study only measures the students' skills in evaluating and analyzing certain biological cases. The two abilities, evaluating and analyzing, are higher thinking skills based on Bloom's taxonomy. Further studies are strongly recommended to research HOTS from other variables such as critical thinking ability, creativity, and problem-solving skills. In terms of Biology, the involvement of some cases should be integrated to figure out students' HOTS in general. Besides, considering university students as the subjects of study is also challenging.

To sum up, the present study examines the profile of students' HOTS in Malang, Indonesia. The finding revealed that the Junior High School students' HOTS is low, while the Senior High School students is sufficient. The result of data analysis has also informed that there is a significant influence of grades on the students' HOTS. Senior High School students performed better than Junior High School students. The low level of the students' HOTS founded in this study is expected to be a basis for evaluating the education process in Indonesia. Moreover, it is strongly recommended that Indonesian teachers continuously improve their knowledge and understanding in designing HOTS-based learning and assessment. As the education experts, the Indonesian researchers are also encouraged to consistently conduct research aiming at improving and evaluating the implementation of HOTS-based learning.

CONCLUSION

In this study, HOTS profiles of students from various grades were examined. The analysis shows that the difference in grades can significantly affect the HOTS level of students, where senior high school students are higher than junior high school students. Unfortunately, the analysis results also informed that the HOTS profile of the students did not include good categories. The application of HOTS-oriented learning is highly recommended to be implemented in school. Besides that, teacher competency improvement programs and understanding of HOTS also need to be realized. Besides the education field, recommendations for further research also need to be delivered. First, it is necessary to involve a larger sample and population to obtain a more comprehensive picture of students' HOTS competencies. Second, research in various regions needs to be carried out to map the HOTS of students from various locations. Third, research that focuses on designing and analyzing the HOTS instrument with CFA, EFA, RASCH analysis also needs to produce a higher quality HOTS instrument.

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