Improving Student's Mastering of Concepts and Activity Using Higher Order Thinking Skills Exercises

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***Abstract*—High quality online learning continued to be pursued to provide good mastery of concept and to encourage student activities to learn. One way to achieve this is by providing exercises of type Higher Order Thinking skills (HOTs) for students. This research was conducted on grade IX students at a private school in Bekasi on magnetism subject. The type of this research is Quasi-Experimental research with Pretest-Posttest Only Control Group Design. The dependent variables in this research are mastery of concepts and students' learning activities. F-test and t-test were used to obtain conclusions on the effect of HOTs type questions on the dependent variables. The students were divided into two groups, which are control and experimental group. Control group was given non-HOTs type exercises, while experimental group was given HOTs type exercises. The results from the data analysis show that the mastery of concepts and learning activities from the experimental group were higher compared to the control group.**

***Index Terms*—Concept mastery, higher order thinking skills, online learning, student activity**

I. Introduction

A high quality, effective, and creative learning process certainly requires not only a good equipment and a conducive learning environment but also the competence of both students and teachers. Two indicators of learning quality are student activities and mastery of concepts. Felder and Bren argued that active learning is anything course-related that all students in a class session are called upon to do other than simply watching, listening, and taking notes [1]. Hartikainen *et al.* [2] concluded that active learning is a wide concept, most often referring to student-centered and activating instructional methods and instructor-led activities. It is generally not a concept of learning but a concept of instruction. Active learning is defined as changes in behavior or emotions that lead to learning efforts [3]. Oktaviani *et al.* [4] listed some indicators of student activities: working on the learning assignments given by the teacher,

1) being able to solve problems;
2) asking the teacher and friends if they don't understand something;
3) finding information on their own;
4) actively participate in group discussions;
5) measure one's own abilities through the results obtained;
6) develop themselves to practice working on questions;
7) use opportunities and apply their own ideas in completing assignments.

It could be seen that several indicators are related to metacognitive thinking such as being able to solve problems, finding information from their own and developing themselves by practicing on exercises. It might lead students to improve mastery on the subject being taught. Mastery of concepts is an effort that must be made by students in recording and transferring back information, so it can be used in solving problems, analyzing, and interpreting certain events [5].

Teacher can initiate the students' activeness in learning process by using varied and exiting methods in delivering learning materials. Active learning as an instructional approach can include various form of activities, such as increased physical activity, interaction, social collaboration, deeper processing, elaboration, material exploration, or metacognitive monitoring [6]. These could be in the form of

1) Visual activities: reading, observing experiments, doing demonstrations, observing the performance of others, and observing pictures.
2) Oral activities: expressing opinions, doing interviews, asking and answering questions, and having discussion.
3) Listening activities: listening to other people's explanations, listening to the material presented, listening to music, and listening to discussion.
4) Writing activities: taking notes, writing reports or stories, and writing homework.
5) Drawing activities: making pictures, diagrams, maps, graphs, or painting.
6) Motoric activities: conducting experiments in the laboratory, performing movements in sports, and making projects or models or games.
7) Mental activities: analyzing, solving problems, linking cause and effect, memorizing, and making decisions.
8) Emotional activities: building enthusiasm, courage, composure, or other positive expression, and showing interest.

Online learning has advantages and disadvantages compared to face-to-face or onsite learning [7]. One of the weaknesses in online learning is that teachers cannot fully monitor the students. In particular, they cannot observe students' activities and progress on the mastery of concepts from the material presented during the learning process. Therefore, improving these two learning indicators in the current COVID-19 pandemic situation definitely becomes a concern because of the use of online learning.

To discover the effect of online learning on students' activities and mastery of concepts, one of the authors collected the data, which was the final assessment for the even semester. The data was collected from class IX Science

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Subject at a certain school in the city of Bekasi, Indonesia, where the author works as a Science Subject teacher. The data in Fig. 1 shows the assessment scores for two academic years. Data year 2018/2019 represents the academic year before COVID-19 pandemic, whereas data year 2019/2020 represents the academic year during the pandemic. The end-of-year test was designed by all Science Subject teachers at that school.

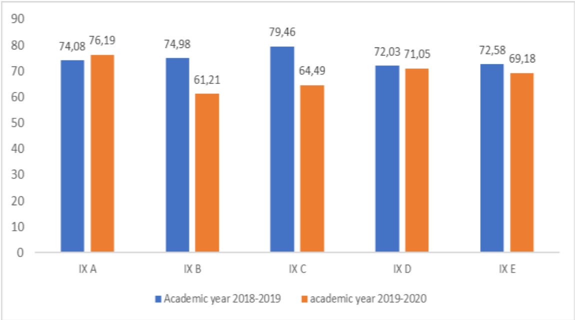


Fig. 1. Year-end assessment of even semester class IX science subjects.

Fig. 1 clearly shows that the score for academic year 2019/2020 is lower than the previous academic year. This can be taken as an indication that there is a decrease in the ability of students in mastering the concepts for knowledge competence. The decrease might happen because online learning was applied in COVID-19 pandemic. The new learning method was unavoidable since teachers were required to carry out the materials without face-to-face meeting to finish all the materials. However, students were not familiar with this learning contingency plan. Students' interest was low during the learning process. It probably affected the mastery of the concept of the material presented by the teacher, and might decreases the activeness of students in learning. The limited activities of students during learning from home could be seen from their tendency to only receive information from the teacher. There was a lack of two-way communication between the teacher and students. In addition, there were indications that some students answer the problem by searching the internet. Therefore, there is no process to understand the material.

This paper aims to improve student learning outcomes by increasing the mastery of concepts and student learning activities in the learning process. Higher Order Thinking Skills (HOTS) is proposed as a way to increase the two indicators. The material chosen is Magnetism for class IX students.

II. State of the Art

The mastery of concepts can be indicated in several ways. According to Krathwohl, the indicators for mastery of concepts in Bloom's Taxonomy are understanding, applying, analyzing, evaluating, and creating [8]. On the other hand, Oktaviani *et al*. categorized the indicators into three areas, namely the ability to do translation, the ability to interpret and the ability to extrapolate [5]. The ability to extrapolate allows students to see beyond what is written. Students analyze information so that they can make estimates, predict a symbol or idea based on their understanding, and draw conclusions with implications and consequences.

HOTS is a person's ability in obtaining new information and then storing it in memory, connecting and/or reconstructing and maximizing existing information in order to achieve goals/targets or to obtain possible answer under any circumstances [9]. There are three aspects of HOTS, namely transfer of knowledge, critical and creative thinking, and problem solving, Fig. 2.

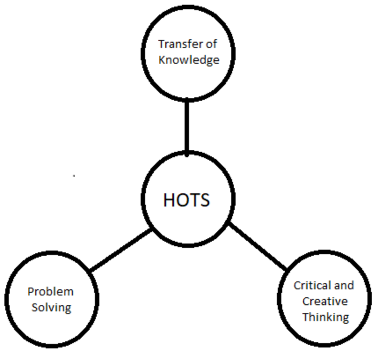


Fig. 2. Three aspects of HOTs.

Transfer of knowledge in the learning process refers to shared understanding between the teacher and students. Although this process depends on the teacher's mastery of learning materials, there are other factors, such as the interaction between the teacher and students, and a conducive learning environment. The two other factors can enhance the students' knowledge either directly or indirectly by first enriching the teacher as the facilitator. The process of transferring knowledge and skills can be carried out in accordance with the learning objectives. The three aspects of learning, which are cognitive, affective, and psychomotor, can then be transferred to the students effectively.

Critical and creative thinking can be broadly interpreted as an imaginative thinking. It generates ideas from various available information and comes up with different possible solutions. Critical thinking is a process that is related to how a learner solves problems, analyzes problems, and makes decisions from the available data [10].

Problem solving is the ability of a learner to solve a given problem. There are six aspects that students need to have to do problem solving: identify the problem, explore the problem, find and plan solutions, implement the plan, check the solutions and evaluate.

Bagarukayo stated that HOTS require the ability to make decisions, solve problems, think critically, analyze, synthesize, and interpret [11]. Meanwhile, Zohar revealed that HOTS-equipped students were able to argue constructively, ask scientific questions, make comparisons, solve complex non-algorithmic problems, classify differences of opinion, and identify implied assumptions [12]. Therefore, to be able to solve HOTS problems, students need high-level thinking skills that involves critical and creative thinking processes in solving problems. To achieve high-level thinking skills, students need the ability to analyze, evaluate, and create. As a result, questions of HOTS type can help develop students' activity. This type of question trains students to ask questions, argue, and communicate the solutions in solving existing problems.

A quasi-experiment conducted in [13] succeeded in showing that there was an effect of using HOTS-based student worksheets in increasing junior high school students' motivation and science learning outcomes. The implementation of HOTS in [14] also showed a positive effect on student achievement and entrepreneurial spirit in Social Studies subjects for class 3 Mi Plus Al-Ihsan, Bogor city. The effectiveness of the application of HOTS for student learning success is also shown in [15]. Therefore, the aim of this study is to discover the effect of applying HOTS by providing HOTS practice questions in the online learning process at a private school in Bekasi to improve students' mastery of concepts and active learning.

III. Research Methodologies

This research was conducted with quasi-experiment using Pretest-Posttest Only Control Group Design. The subjects of this study were students of class IX at a particular private school in Bekasi. The sample was taken from 48 students and divided into two groups, the experimental and control groups, each consisting of 24 students. Each group was given a pretest at the beginning of the study to obtain an initial score and a posttest at the end of study. Exercises were given for both groups, but the exercises for students in the experimental group were of HOTS type question.

The experiment was done from February 2021 to March 2021 by conducting online treatments using Google Suits. The data were obtained by using two different instruments. The first one was written test instruments in the form of pretest and posttest with the mastery of concept as the dependent variable. The second instrument was an observation sheet instrument in the form of a questionnaire to measure the students' activity. The questionnaire was filled by two observers, which were two Science Subject teachers. Since each group had different study schedule, and there were two observers, then each observer filled the questionnaire for only 12 students that were assigned to them. The observer could observe the student activity because students had to open their cameras while studying. Experiment was conducted in four sessions for one material with the topic of Magnetism. In this research, the average score of the observers was treated as the students' activity.

IV. Instrument Design

The instrument for mastery of concept was arranged based on specific instructional objectives for Magnetism. It consists of eight questions that were used to measure students' ability to analyze, evaluate and create. The design of the instrument is shown in Table I. The test's content was created by the science teachers at the school. Meanwhile, the instrument for students' learning activity was arranged in the form of a questionnaire. There were four indicators, each indicator was measured by three Yes-No questions. Design of the questionnaire is shown in Table II and data of this experiment is shown in Table III.

V. Result and Discussion

Validity and reliability of the instruments were tested. The result is depicted in Table IV and Table V for Mastery of concept, and Table VI for students' activity. Both instruments were valid and reliable. Cronbach Alpha for mastery of concept pretest and posttest instruments were 0.65 and 0.63, whereas the score for student activity instrument was 0.65. All instruments were classified as reliable.

TABLE I: Question's Number in Instrument for Mastery of Concept

Ability	Analyzing	Evaluating	Creating
Analyzing the direction of the magnetic field on a magnetic bar.	3	1	7
Analyzing the direction of the magnetic poles in process of making magnets.		2, 6	8
Analyzing the magnetic properties of an object.	4	5	

TABLE II: Design of Student's Activity Instrument

Indicators	Number of questions
Focus on learning materials (I01).	3
Search information outside the given materials (I02).	3
Collaborate in solving the problems (I03).	3
Express their opinions (I04).	3

TABLE III: Experiment Data

Experimental Group			Control Group		
Pretest	Posttest	Activity	Pretest	Posttest	Activity
56	79	92	50	47	33
25	84	75	31	39	67
31	84	75	0	5	38
38	66	83	13	74	75
13	63	92	0	74	71
50	92	92	56	82	92
56	82	88	6	5	50
0	66	54	13	24	38
50	58	79	88	89	96
56	71	92	63	42	46
19	61	83	44	34	58
31	82	83	6	39	79
6	47	79	50	76	88
19	74	75	13	5	46
44	61	58	44	50	50
31	5	54	31	26	33
25	53	63	44	47	50
56	74	58	44	71	92
19	42	63	19	0	58
19	39	58	56	87	92
31	55	79	44	26	75
13	29	71	44	32	63
25	29	79	63	55	58
31	47	79	56	63	92

TABLE IV: Instrument for Mastery of Concept (Pretest)

Ability	Correlation	Variance	Validity
Analyzing the direction of the magnetic field on a magnetic bar.	0.85	2.09	Valid
Analyzing the direction of the magnetic poles in the process of making magnets.	0.87	1.57	Valid
Analyzing the magnetic properties of an object.	0.55	0.43	Valid

TABLE V: Instrument for Mastery of Concept (Posttest)

Ability	Correlation	Variance	Validity
Analyzing the direction of the magnetic field on a magnetic bar.	0.75	1.91	Valid

Analyzing the direction of the magnetic poles in the process of making magnets.	0.90	7.50	Valid
Analyzing the magnetic properties of an object.	0.55	0.78	Valid

TABLE VI: INSTRUMENT FOR STUDENT'S ACTIVITY TEST

Indicators	Correlation	Variance	Validity
I01	0.57	0.47	Valid
I02	0.80	0.69	Valid
I03	0.88	1.14	Valid
I04	0.57	0.18	Valid

TABLE VII: PRETEST-POSTTEST RESULTS FOR MASTERY OF CONCEPTS AND STUDENT'S ACTIVITY

Remarks	Experimental group			Control group		
	Pretest	Posttest	Activity	Pretest	Posttest	Activity
Average	31.00	60.13	75.17	36.58	45.50	64.17
Sd	16.63	21.09	12.60	23.26	27.34	20.73
Min	0	5	54	0	0	33
Max	56	92	92	88	89	96

TABLE VIII: ABSORPTION PERCENTAGE OF STUDENTS' UNDERSTANDING FOR EACH QUESTION ON PRETEST AND POSTTEST

Indicators	#Q	Pretest		Posttest		Difference	
		Exp	Control	Exp	Control	Exp	Control
Analyzing	3	0.58	0.29	0.71	0.50	0.13	0.21
	4	0.29	0.29	0.46	0.25	0.17	–0.04
Creating	7	0.19	0.31	0.60	0.51	0.41	0.20
	8	0.14	0.43	0.64	0.44	0.50	0.01
Evaluating	1	0.75	0.21	0.96	0.50	0.21	0.29
	2	0.29	0.29	0.38	0.46	0.09	0.17
	5	0.21	0.13	0.54	0.33	0.33	0.20
	6	0.58	0.52	0.52	0.50	–0.06	–0.02

Table III shows pretest and posttest scores for each student from both experimental and control group. The results are summarized in Table VII. Activity score was collected from two observers. There were four data for each student from each observer. Since there were 12 questions, and each question was answered with 1 for positive respond or 0 for negative respond, then the maximum score was 12. It was then converted to 100 scale.

The pretest data shows that the average mastery of concepts score in the experimental group was slightly lower than the control group, which was 31.00 against 36.58. The experimental standard deviation was slightly smaller than that of the control group. On the other hand, the activity of the experimental group after the experiment was better than that of the control group. All data followed normal distribution.

The first test was carried out by looking at whether the distribution of the pretest data for the experimental and control group were identical or not. Testing was done by checking whether the mean and variance of both data were the same. The results of t calculation using two-ways t-test for the mean of the two data was –0.9364. It could be concluded that both data had the same mean with $\alpha = 5\%$. Furthermore, the variance test that was done using F calculation gave a result of 0.5108 with $\alpha = 5\%$. It could be concluded that both data had the same variance. Therefore, it could be said that the pretest data for both the experimental and control group had an identical distribution.

The second test was conducted to test whether the average posttest for the mastery of concept in the experimental group was better than the control group. The test was carried out with one-way t-test, and the value of t calculation was 2.0311. It could be concluded that the average mastery of concepts for the experimental group was higher than that of the control group with $\alpha = 5\%$. This proved that the treatment, which was giving practices with HOTS type questions, given to the experimental group resulted in a better mastery of concepts than that of the control group.

The analysis of students' mastery of concepts was also done by looking at the absorption percentage of students' understanding for each question in the test, Table VIII. The data shows that for the experimental group, there was a significant increase in the absorption for each indicator in analyzing, creating, and evaluating between posttest and pretest, except for question six where this group experienced a slight decrease. Question six was related to determining magnetic poles when making magnets. The increase in the absorption percentage of students' understanding in general between posttest and pretest of experimental group is shown in Fig. 3, where the x-axis represents the question's number. The result was higher than that of control group. It indicated that the experiment was successful in improving students' mastery of concept in the subject of Magnetism.

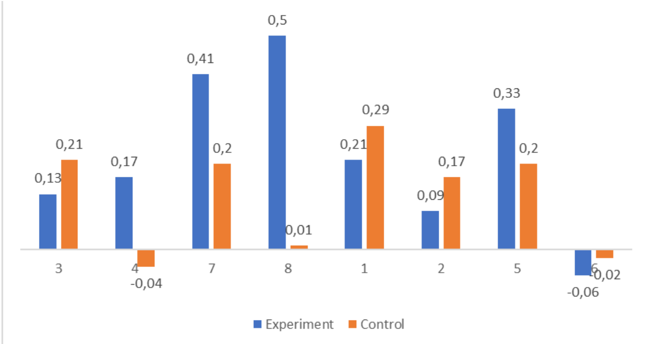


Fig. 3. Difference in the absorption percentage of students' understanding for each question between posttest and pretest.

The fourth test was carried out to test whether the average students' activity in the experimental group was better than the control group. The test was conducted with one-way t-test, and the resulting t score was 2.1752. It was concluded that the average activeness from the experimental group was higher than the control group with $\alpha = 5\%$. This proved that the treatment given to the experimental group, which was giving exercises in the form of HOTS type questions, yielded better result than the control group.

VI. CONCLUSION AND SUGGESTION

Quasi-experimental research was conducted in class IX at a particular private school in Bekasi with a sample of 48 students on the topics of Magnetism. The sample was divided into two groups of 24 students each. It can be concluded that

1) The experimental group, which was given HOTS-type practice questions, had a higher average on the mastery of concept than that of the control group, which was given non-HOTS practice questions.
2) The experimental group also had higher average on learning activity compared to the control group.

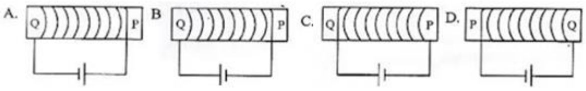
The suggestion from this research for online learning is that it is necessary for teachers to provide HOTS-type practice questions to improve students' quality of learning.

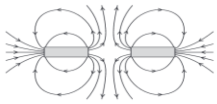
APPENDIX

Some HOTS practice questions

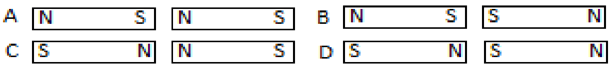
1. 

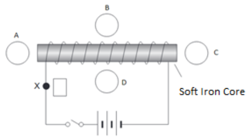
A-B iron rods become magnetized when touched by P-Q steel magnets. Choose the correct process for making P-Q steel magnets and explain why.



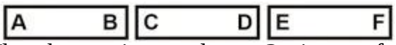
2. 

Which is the correct magnetic pole according to the picture above and explain why.

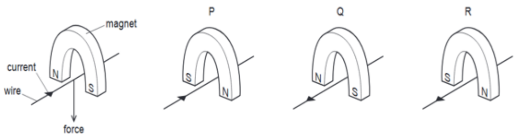


3. 

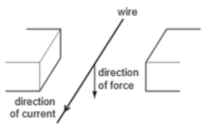
a) If the switch is closed. Draw the direction of the electric current at the X in the box using the arrows.
b) After the switch is closed, the soft iron core bar turns into a magnet. Explain why this happened?
c) Determine the poles formed in the soft iron core above
d) The circle represents the position of the compass. Draw the direction of the compass needle at positions A, B, C and D so that it shows the direction of the magnetic field

4. 

The above picture shows 3 pieces of magnet bars. If C is north pole, B with C repel, and D with E attract. Then determined he type of magnetic poles at A and F and why.

5. 

A wire passes between the poles of a horseshoe magnet. There is a current in the wire in the direction shown. This causes a force to act on the wire. There are three other arrangements, P,Q and R as shown above. Which arrangement or arrangements will cause a force in the same direction as the original arrangement. Explain your answer.

6. 

From figure above, a current passes through the wire in the direction shown. The current causes a downward force on the wire. Determine the poles of the magnet above. Explain your answer.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

AUTHOR CONTRIBUTIONS

Samuel Lukas made the experiment design and supervised the whole process of the research; Pujianto Yugopuspito did the literature review and wrote the paper; Dion Krisnadi analyzed the data and made the conclusion of the research; Heru collected the data; all authors had approved the final version.

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