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Motoric mechanism with problem-based learning: impact on students' higher-order thinking skills

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ABSTRACT

This study aims to determine the effect of problem-based learning (PBL) model on higher-order thinking skills (HOTS) of Eleventh-grade students on motoric mechanism topic in (Senior High School (SMA) Negeri 1 Indralaya Utara. The research method used was quasi-experimental with the research design of Non-equivalent Control Group Design. The sampling method used was Saturated Sampling Techniques. The instruments of data collection are higher-order thinking skills test questions in the form of multiple choices with five answer choices in twenty-five questions. Observation instrument of learning implementation used checklist with twelve observation items. The response instruments of students use questionnaires with a Likert scale. Higher-order thinking skills data were tested using the Mann-Whitney test, and then the learning implementation data and students' response data were analyzed descriptively. This data processing uses SPSS twenty-three. Based on the results of the hypothesis test, the sig value is 0.00 (sig <0.05), which shows an effect studied was significant. The implementation of learning has a good category, while the response of students has excellent and good categories of the two types of the response of students measured. Based on the hypothesis test result, it can be concluded that the PBL's model can significantly influence higher-order thinking skills of Eleventh-grade students on motoric mechanism topic.

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INTRODUCTION

The learning process adopted in Indonesia is the 2013 curriculum. The 2013 curriculum has goals that are in line with the standards of the educational process that good learning from students is told to be learners to find out (Minister of Education and Culture, 2016). Based on the 14 principles that according to Law Number 22 that state the learning process covers planning, implementation, and assessment. The learning process is successful if the learning objectives are achieved. Learning objectives refer to the bloom taxonomy and are related to higher-order thinking skills. Higher-order thinking skills start from C4-C6 (Anderson & Krathwol, 2001). Excellent thinking skills are used to apply knowledge and develop students' skills in the context of their time so that they are used as evaluations in assessments (Nugroho, 2018).

The learning process in schools has not been maximized in improving higher-order thinking skills, because students do not have the skills to process and apply the information learned yet (Purnamaningrum, 2012; Julistiawaty and Bertha, 2013). Though thinking can gain experience, involve mental, and develop cognitive processes in solving problems (Arends, 2008). This lack of thinking skills involves evaluations given by teachers in schools. Evaluation still refers to low-level thinking and questions were taken from old documents (Anwar et al., 2017). Also, this relates to the method used by the teacher in the class, namely the lecture method. The lecture method is a factor that makes students thinking skills become low, so students only memorize and think concepts (Ichsan, et al., 2019a; Kawuwung, 2011; Barak & Dori, 2009). The learning process that only uses the lecture method causes the learning material received is not the result of the findings and thoughts of the students themselves that make higher-order thinking skills low (Hugerat & Kortam, 2014; Lestari, 2018). This is because the learning is focused on the teacher, so students are less brave to express their opinions and ideas in learning science.

Science learning includes biology learning, which has three domains; they are cognitive, psychomotor, and affective that use concepts and abstract presentation (Rustaman et al., 2005; Cimer, 2012; Afflerbach, Cho, & Kim, 2015; Mahoney & Harris-Reeves, 2019). Biology learning material is interconnected in understanding the concept (Santoso, 2014). One of the related materials is a motoric mechanism that has many concepts, is abstract and material interrelated with one another and has material that the phenomenon occurs in our body and is difficult if only using the lecture method (Butar-Butar et al., 2015; Nuriyanti et al., 2013). Besides, this material is one of the material that has contextual problems given to students to solve problems in the community so students can improve their literacy skills. It is clarified that the material of motion systems is one of the socioscientific material that makes students have high-level thinking skills in the process of completion (Lee & Lai, 2017; Murray, 2014; Narayanan & Adithan, 2015; Suwono et al., 2015). The motoric mechanism is the study of organs that perform functions in their movements and abnormalities (Irnaningtyas, 2014). In overcoming the above problems, it is necessary to apply the model offered by the 2013 curriculum, which can improve higher-order thinking skills, namely using the PBL model. PBL can train students independently, train higher-order thinking, and improve student learning outcomes (Sani, 2014; Luthfi, Muharomah, Ristanto, & Miarsyah, 2019).

The potential of the PBL model in improving higher-order thinking skills is expressed by several researchers who get good results if applied in learning because students can find and solve problems, so it stimulates to analyze, evaluate and create (Abdurrozak et al., 2016; Sucipto, 2017; Astuti, Nurhayati, Ristanto, & Rusdi, 2019). This is because the syntax of PBL is in line with the indicators of higher-order thinking skills. PBL is one of the models in the scientific approach that has the highest significance than the other models and problem based (Haryati et al., 2017; Wafroturrohmah and Suyatmini, 2013). Huang (2012) states that problem-based learning (PBL) is a curriculum design that is identified by students not as passive recipients of knowledge but as problem solvers who can develop knowledge. Based on the problems that have been formulated, the purpose of this study is to obtain information on the effect of application of PBL for higher-order thinking skills of students in the motoric mechanism of SMA Negeri 1 Indralaya Utara, Indonesia.

METHODS

Design of the Study

This study was conducted using the quasi-experimental with the research design of non-equivalent control group (Sugiyono, 2016) with a quantitative approach to obtain an overview of the skills process of students. This research was conducted in SMA Negeri 1 Indralaya Utara. The time of the study was conducted on October - November 2018. For more details, see Figure 1.

O_1	X	O_2
O_3		O_4

Figure 1. Non-equivalent Control Group Design (Sugiyono, 2016)

Population and Sample

In this study, the population of two classes were from the XI IPA class of SMA Negeri 1 Indralaya Utara that used as a research sample, called as a saturated sampling technique. The number of students in each class was 28 and 29.

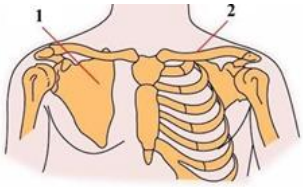
Instrument

The instruments of data collection were higher-order thinking skills test questions in the form of multiple choices with five answer choices in 25 questions. The questions given in the form of discourse are contextual problems that can be solved by students after learning the motoric mechanism with the PBL model. Indicator distribution in the instrument can be seen in Table 1.

Procedures

Research procedures were divided into three stages, namely the preparation, implementation, and completion stages. At the preparation stage, the researcher identifies the problem being studied in the research. Next, compile learning tools that will be used in research such as syllabus, lesson plans, student worksheets, and questions. Make observations to schools, choose samples, and arrange research permits. The implementation stage was carried out in the classroom according to the learning design. The completion stage was done to analyze the data that has been obtained so that conclussion can be made.

Table 1.
Example of instrument

Cognitive level	Question	Example
C1	1	 Look at the picture below! From the picture above, the bone name pair with the number in the picture is ... a. Axial skull b. Axial shoulder bracelet c. Ribs - Appendicitis d. Lower-Appendicular limb e. Appendicular bracele
C2	3	In bone growth is often the presence of bone loss that occurs in the community; one of the causes is due to lack of food supplies that contain calcium, phosphate, protein, vitamin A, and Vitamin D. from illustrations above, what factors need to be noticed by sufferers ... a. Heredity factor b. Health factor c. Endocrine factor

		d. Nervous system factor e. Nutrition factor
C3	5	A doctor takes medication by attaching braces as early as possible to a baby so that no severe deformities occur. The baby is suspected of having a disease a. Osteoarthritis b. Dislocation c. Congenital scoliosis d. Osteoporosis e. Hydrocephalus
C4	8	During sports lessons, fina feels pain in feet when seen there is freezing and bruising on the foot where the pain is heard when the foot sounds. What do you think Fina is suffering from the disease? Explain why? a. Rickets. Because bone softening in children with vitamin D deficiency b. Rickets. Because unusual movements, forced or moved suddenly c. Tetanus. Because the muscles contract continuously until they cannot contract again d. Sprain. Because the muscles contract continuously until it cannot contract again e. Sprain. Because unusual movements, forced or moved suddenly
C5	6	Cramps are words that are familiar to your medical world. Every year there is news covered about a bone disorder called cramping. Every year many accidents eliminate a person's soul due to this disorder. To overcome and reduce this occurs every year, the wise actions that you will take are a. Leave it alone because it has nothing to do with us b. Indifferent to the situation and the news that has been aired every year c. Socialize the dangers of cramps and how to deal with cramps while swimming d. Make strict regulations in the pool swim e. Hire people to guard around the poo

Data Analysis

The data analysis technique used in this study was descriptive statistics using SPSS 23. This analysis was conducted to describe higher-order thinking skills after the application of the PBL model. The value of high-level thinking skills obtained to determine students 'learning outcomes was the summation of the students' scores (Sudijono, 2015; Arikunto, 2013). After this was done, we decided the higher-order thinking skills by looking at the difference in learning outcomes after the PBL model was applied. Also, the analysis of questionnaires and implementation was seen based on the categories obtained. Gains value was the difference between the results of the final test scores and the initial tests obtained by each student regarding cognitive abilities. This value was then used to find out the improvement in learning after implementation with PBL.

RESULTS AND DISCUSSION

The data analyzed from this study was the score of students' higher-order thinking skills, students' responses, and learning implementation observation data. The percentage between the initial test and the final test had an excellent increasing after the learning process using PBL was done (Figure 3). This is in line with the research conducted by Haryati et al. (2017) that there was an increase in results in students after the application of PBL was carried out, and the results of tests obtained were higher than the test results using other learning models such as INSTAD and discovery learning.

Table 2.
Average Learning Outcomes of Students with the Application of the PBL Model of Experimental Classes and Control Classes.

Class Average	Score				Category
	Pretest	Posttest	Gain	N-gain	
Experiment	63,31	79,58	16,27	0,36	**Moderate**
Control	55,00	67,00	12,00	0,19	**Low**

Learning in the control class used varied conventional methods, including lectures, question and answer, and discussion. It means the primary method used by the teacher is the lecture method, which is varied by the question and answer method and discussion. Variations are made to complete the shortcomings of each of these methods. It is expected that with the combination of these methods, learning can be better. This is following Wahab (2009), who stated that various lectures were a learning process that prioritized the lecture method to convey material but enriched with other teaching methods/ techniques. The percentage between the initial test and the final test has a sufficient increase after the conventional learning process is carried out (Figure 4). This happens because students are only given material without finding out the problems faced, besides that students only accept all were learning from the teacher (teacher-centered) without being able to give opinions about learning the motoric mechanism that is related to daily life. Conventional methods are learning methods that take place from teacher to student (Vijayaratnam, 2012; Wagner, Baum, & Newbill, 2014; Walsh, Bowes, & Sweller, 2017; Sullivan & Mclntosh, 2001). In the learning process, it is dominated by teachers in transferring knowledge, so the students become more passive in the learning process.

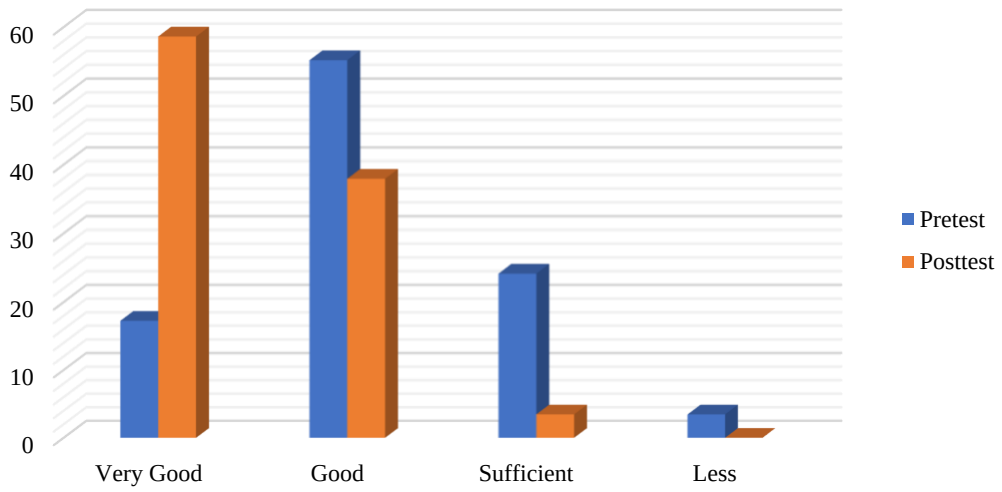


Figure 3. Percentage of Thinking Skills Categories of Students in the Experiment class

The increase in higher-order thinking skills test results using the PBL model in the experimental class has a moderate category on the difference (Table 1). This is due to several factors that in the learning process using PBL students faced on a problem in a discourse prepared by the teacher. In solving these problems, students need higher-order thinking skills because students must analyze various information obtained to find the right solution. Riyanto (2010) states that higher-order thinking skills are categorized into three parts; a form of learning outcomes transfer, as a form of critical thinking, and as a process of problem-solving. PBL learning uses contextual problems that provide challenges for students to be able to give the best solutions to the problems being faced in learning. Students' curiosity is higher because the problems-faced and the material studied is related to daily life. The high level of students' curiosity encourages students to use all their thinking skills

in order to get appropriate problem solving from what students read and analyze. Through PBL, students become more accustomed to think systematically so that questions working, the students will get more comfortable and get better results. Riyanto (2010) also supports this opinion problem-based learning is a model designed and developed to develop students' problem-solving skills. Also, Trianto (2011) states that PBL encourages students to not only think concretely but rather to think of abstract and complex ideas.

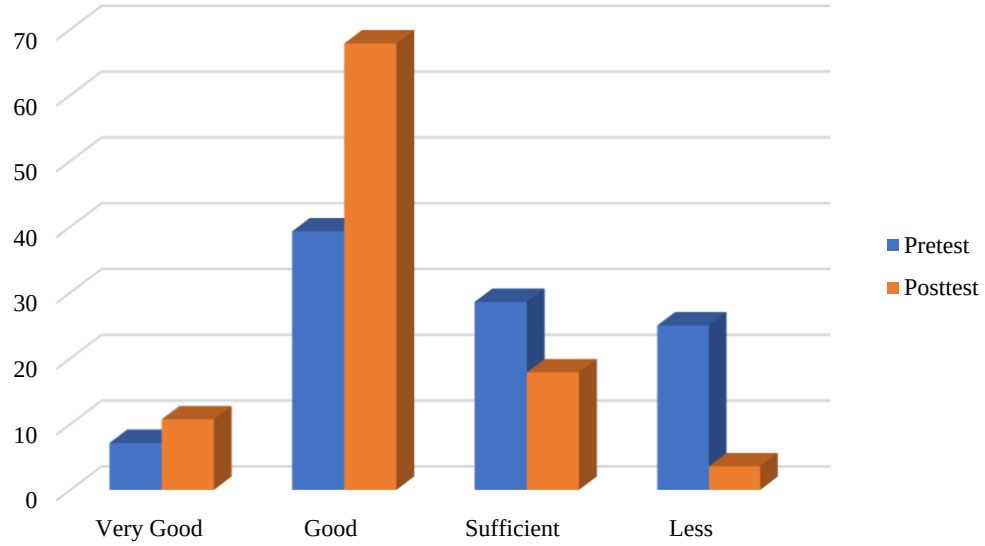


Figure 4. Percentage of Categories of Thinking Skills for Students in the Control class

In the control class, the difference in the average score of higher-order thinking skills is lower than in the experimental class (Table 1). This is because, in the control class, students were not trained to formulate problem-solving. Students only accept learning material delivered by the teacher. Usually, the teacher is only focused on learning related to the development of the C1 - C3 bloom because students were not asked to analyze the material being studied. During the learning process, students are more emphasized to listen to the explanation from the educator, so that the understanding of the material is low. The characteristics of conventional learning include students are more passive for learning individually, theoretical learning; teachers are determinants of the learning, and interaction between students is low. This resulted in students having difficulty when working on the question types C4, C5, and C6 (Smith & Darvas, 2017; Sung, Hwang, & Chen, 2019; Taft, 2015).

The increase in higher-order thinking skills in the suitability of the C4-C6 cognitive domain separately has a little difference between the control and the experiment class (Figure 5). This is because, based on the results of the developmental analysis, think students need high conceptual mastery so they can think complex in solving problems. From Figure 5 it can be seen that the difference in C4 cognitive domains is smaller than the cognitive domains C5 and C6.

The picture above can occur because the control class used the discovery learning model that is often carried out in schools but in the context of the lecture method varies so that in the cognitive domain only has a small difference different from the cognitive domains C5 and C6. In the experimental class, Learners do learning tailored to the PBL syntax, which was given several discourse problems that want to be overcome through several practicums. With this practicum, students improve the cognitive domains of C5 and C6 so that they have a slight difference. This is in line with the statement of Haryati, et al. (2017) that there is an increase in learning outcomes precisely in higher-order thinking skills using PBL models compared to other models, one of which is discovery learning models.

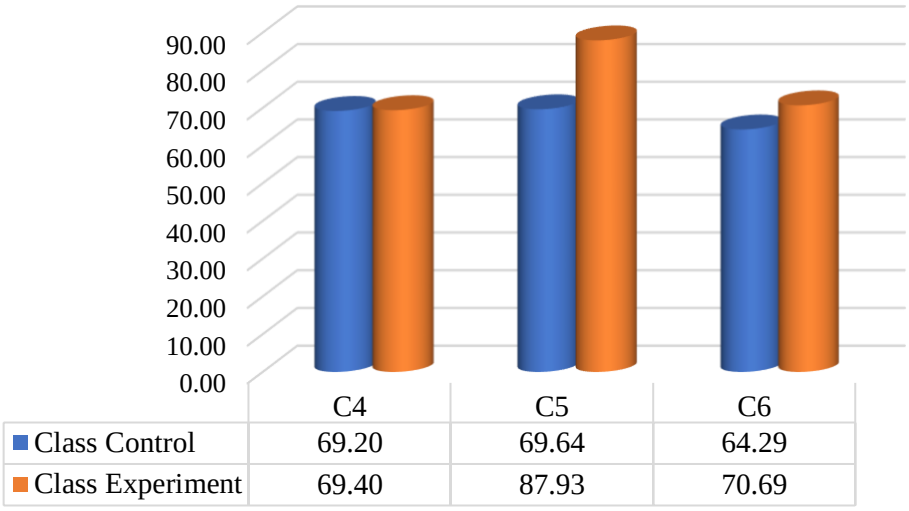


Figure 5. Comparison of average Higher-Order Thinking Skills score Classroom Control and Experiment in Cognitive Domains C4-C6

Based on the Mann-Whitney test results obtained a value of 0,000 that when the probability is below 0.05, then H_0 is rejected. This shows that the application of the PBL model has a significant effect on higher order thinking skills in the motoric mechanism topic. By looking at the score of the pre-test and post-test, it was explained that after learning with the application of the PBL model, it turned out that higher-order thinking skills students had increased (Table 1). In line with the research conducted by Mayasari et al. (2015), which states that learning using the PBL model has a positive influence on students' higher-order thinking skills. Besides that, Higher Order Thinking Skills of students taught with the Problem Based Learning model were significantly higher than conventional learning (Syarifah, et al., 2014; Ritter & Mostert, 2017; Dubas & Toledo, 2016; Copley, 2013).

Implementation of PBL model and response of students

higher-order thinking skills improvement of students is also related to learning planning and student responses to learning both in the category of the process and application of the PBL. Based on the results of the analysis of the learning implementation observation sheet, it can be seen that the implementation of the PBL model in the experimental class is well implemented in the total. However, if it is categorized according to activities, the preliminary activities have a top category, content activities have functional categories, and closing activities have good categories as well (Table 2). If learning planning runs well, then it affects the learning outcomes of students. Learning planning has a significant influence on the teaching quality of educators and student learning outcomes (Martono, 2014; Wing, Piaw, & Chang, 2014; Zohar & Alboher Agmon, 2018).

Table 3.
Percentage of Learning Implementation in the Experiment class

Aspect	Meeting					Average (%)	Category
	1	2	3	4	5		
Preliminary	100,00	75,00	100,00	75,00	100,00	90,00	Very good
Content	66,70	83,30	75,00	83,30	83,30	78,32	Good
Closing	50,00	75,00	75,00	75,00	75,00	70,00	Good
Average						79,44	Good

Learning by applying the PBL model has been conducted and received responses from students through questionnaires. The results of questionnaire data analysis (Table 3) show that 96.5% of the responses of students have excellent and good criteria in the category of applying the learning model,

while the learning process has a significant percentage of criteria of 38% and good at 62%. Based on Table 3, the application of the PBL model can make students actively involved in conducting learning activities and to build their knowledge so that they can improve students' high-level thinking skills. If the students are active in the learning process, it means that students show good response in learning and influence the results of the higher-order thinking skills of students. Students' responses influence higher-order thinking skills results of students during the learning process (Muchtadi, Hartono., & Oktaviana 2017; Ichsan, Sigit, & Miarsyah, 2019b).

Table 4.
Percentage of Answers to Students' Response to the PBL Model per Questionnaire Sheet

Questionnaire Sheet Category	Response Valuation Criteria (%)			
	Very Good	Good	Bad	Very Bad
Model PBL Application	31,00	65,50	3,50	0,00
Learning Process	38,00	62,00	0,00	0,00
Average	34,50	63,75	0	0

CONCLUSION

Based on the results of the research that has been done, it can be concluded that the application of the PBL has a significant effect on higher-order thinking skills in the motoric mechanism topic. The response of students to the application of the PBL model shows that the application of the PBL model can increase curiosity, pleasure in answering problems and can improve students' communication skills to be very good. While the response of the learning process shows students' enthusiasm for learning because of the teacher. The teaching skills possessed by the teacher are excellent in response so that it supports the learning process.

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