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Effect Size Analysis of the Problem Based Learning Model on Students' HOTS Ability and Conceptual Understanding

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ABSTRACT (10 PT)

Students' high ability is needed in their learning and daily life. However, students' high-level skills and conceptual understanding were still low. The purpose of this study was to determine the effect size of applying the problem-based learning (PBL) model to students' HOTS skills and conceptual understanding. This type of research is meta-analysis research. The subjects of this study were 20 articles published by several Sinta accredited journals concerning the effects of the problem-based learning model on HOTS skills and students' conceptual understanding. The research instrument is coding. Methods of data analysis using quantitative descriptive analysis with guidelines for effect sizes. After getting the effect size value, the value can then be entered into the effect size level or category. From the results of data analysis, it can be stated that the application of the PBL model has a positive effect on various student abilities based on educational level and type of ability. Thus, the application of the PBL model is effective for increasing mastery of Hots concepts and skills based on educational level.

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INTRODUCTION

Science and technology in the era of globalization are developing very quickly and sophisticatedly, so that to adapt to these circumstances the demands for competence on students are even greater. A nation whose people are not ready for technological developments will almost certainly fall due to the enormity of natural changes and the rapid progress of science. Educators are expected to be able to produce outputs in the form of graduate students who are full of creativity who are able to compete in navigating intense world competition (Sanjayanti et al., 2020). Learning in the 21st century emphasizes the ability of students to formulate a problem, find out something, from various sources, think analytically and work together and collaborate in solving a problem so that they can solve the problem (Suratno et al., 2020). The quality of education must also be improved.

Schools as educational institutions are required to have 21st century skills which are commonly called 4C. The 4Cs include creative thinking skills, critical thinking and problem solving, communication, and collaboration (Simanjuntak et al., 2019). Critical thinking skills are reflective and reasoned ways of thinking that are focused on making decisions to solve problems. Creative thinking skills are skills to find new things that have not existed before, original ideas, develop new solutions for each problem, and involve the ability to generate new ideas that are varied and unique. Communication skills are skills that enhance the ability to transfer information orally and in writing. While collaboration skills are skills possessed in achieving common goals, working productively with others, synergizing with each other, respecting others, teamwork while generating shared ideas (Simanjuntak et al., 2019).

The 2013 curriculum has undergone many changes, especially in Permendikbud No 20 of 2016. These changes are about the skills needed by the nation's children. Every student is expected to have the ability to answer the demands of the times. The implementation of learning is expected to be able to foster and develop 21st century skills and competencies in students (Asrizal et al., 2019). The 4C skills are the abilities to be addressed in the 2013 Curriculum (Simanjuntak et al., 2019). An important issue in education, especially science education today, is how to design curricula and teaching that can enhance scientific investigations and offer the ability to find and build knowledge with the aim of being able and ready to solve existing problems (Deta et al., 2013; Simbolon & Sahyar, 2015).

Physics is a natural science, or the study of the universe. Nature which is the object of study in the study of physics is composed of a collection of objects and events related to complexes. Physics is very closely related to natural phenomena and their applications in everyday life. The aim of learning physics in the 2013 curriculum is for students to master concepts and principles and have skills in developing knowledge and self-confidence as a provision for continuing education to a higher level, as well as developing science and technology in everyday life (Haji & Syukri, 2018). Physics learning should be aimed not only at emphasizing concept mastery but also at containing four things, namely content (product), process (method), attitude and technology so that students' understanding of physics becomes intact and useful for overcoming the problems they face. Physics learning must emphasize higher order thinking skills or commonly known as Higher Order Thinking Skills (HOTS) (Flamboyant et al., 2018).

HOTS (Higher Order Thinking Skill) is one of the abilities that is of concern to the 2013 curriculum. HOTS is a higher order thinking skill that is used to solve a problem. The 2013 curriculum which is oriented towards HOTS with problem-based learning accompanied by learning evaluations is prepared for students to be trained in answering questions at a higher level (Syamina et al., 2021). This higher-order thinking ability aims to improve students' abilities at a higher level, especially in critical thinking skills, being creative in solving problems and making decisions in complex situations. HOTS abilities include the ability to think critically, systematically, reason logically and analytically, the ability to make decisions quickly and the ability to create new products according to what is learned. In general, questions that have international standards have the characteristics of being able to measure higher-order thinking skills, based on contextual problems, and use various forms of tests (Direktorat Pembinaan SMA, 2015). In general, the ability of students in Indonesia is very low in several ways, namely in understanding complex information, analysis theory and problem solving, how to use research tools and procedures, and in the process of carrying out scientific investigations (Flamboyant et al., 2018).

The reality is that there is still a lot of learning that is not oriented towards HOTS. Physics learning only encourages students to memorize concepts and is less able to use these concepts in real life related to these concepts (Zahara et al., 2021). Several supporting studies state that some students' HOTS abilities are still low. There are still many students who have not been able to do reasoning and problem solving. Students feel learning is less interesting so they are lazy to think or optimize the use of their brains to solve problems (Mukaromah & Ibnu, 2020). In addition, the low HOTS ability is because students are not familiar with HOTS questions and the media and teaching materials used by teachers have not been able to trigger students to think at a higher level. This can be seen when students are given the task of working on a problem, most students are not precise in answering the question so that many students' answers are wrong. Students' critical thinking skills are still not optimal, and students have difficulty understanding physics concepts in classroom learning (Yulianti & Gunawan, 2019). The learning model applied by the teacher should be able to train students' HOTS skills. The learning model that is felt to be in accordance with the aim of increasing students' HOTS abilities is a problem-based learning model.

The problem-based learning model is a learning model that applies a problem and problem regarding life in a lesson. PBL is an atmosphere built in learning that presents everyday problems (Amir & W, 2018). PBL has several advantages, namely students are actively involved in every activity so that the knowledge gained is well absorbed. In addition, students can practice working together and students can gain knowledge from various sources. PBL is a learning approach in which students are able to work on authentic problems with the intention of compiling their own knowledge, developing higher-order thinking skills and inquiry, and developing independence and self-confidence (Rahmadani & Acesta, 2017).

Another advantage found from PBL learning was explained by Lasmawati (in (Azmi & Mufit, 2021)) that PBL is a good technique for understanding lesson content, can challenge students' abilities and provide satisfaction for students to find new knowledge about something. , can increase the activity of students in learning. In addition, PBL can also help students transfer knowledge to understand real-life problems, and can help students take responsibility in the learning they do. The PBL learning model can be interpreted as a learning model where students are given real and contextual problems and then they try to find solutions to these problems (Flamboyant et al., 2018).

Problem-based learning has been advocated as a promising strategy for increasing students' critical thinking, and can significantly improve critical thinking and problem-solving skills. Problem-based learning model (PBL) has steps or syntax namely, Orientation, Presenting problems in groups, Investigation, Presentation, and Analysis. In the classroom implementation, this syntax can be developed, especially regarding the activities of teachers and students in the process of submitting and testing hypotheses, designing, and carrying out experiments or investigations in relation to training and increasing students' understanding of HOTS concepts and skills. According to Alpindo problem solving in PBL is compatible with the steps of the scientific method so that it can provide learning experiences in carrying out good scientific work for students (Alpindo et al., 2014). This will indirectly support students' ability to understand concepts and HOTS abilities.

The PBL learning model influences conceptual understanding and critical thinking skills of class VIII students of SMPN 1 Sumbermalang (Utomo et al., 2014). Tomi also revealed that the PBL learning model can be used as an alternative to learning in class so that students are not easily bored and are motivated to take lessons. there is a positive and significant influence from the application of the PBL learning model assisted by HOTS questions on student learning outcomes. Lestari also revealed that in learning the teacher should be able to use a new learning model so that students adapt easily and don't feel bored while learning (Lestari et al., 2021). Much research has been done on the application of PBL, including looking at the effect of PBL on motivation and the ability to solve physics problems, the effect of PBL on learning achievement and critical thinking skills, and the effect of PBL on learning achievement of physics. (Darman, 2021). Therefore, this research aims to determine the effect size of the problem-based learning model effectize to improve understanding of students' HOTS concepts and skills.

METHODS

The research method used in this study is the method of meta-analysis. Meta analysis is a study by summarizing, reviewing and analyzing data from several studies that have been conducted. This meta-analytic research method examines several articles in national journals that have been accredited by SINTA. The subjects of this study consisted of 20 national journal articles. The criteria for the journal articles analyzed were: first, the articles used examined the effect of the problem-based learning model on HOTS abilities or students' understanding of concepts. Second, this article comes from a national journal that has an ISSN. Third, this article was published within the last 10 years. The variables in this study were the Problem Based Learning (PBL) learning model, students' HOTS abilities and students' understanding of concepts. The steps taken in analyzing the data were (1) identifying the type of research and research variables found, then entering them into the appropriate column of variables, (2) identifying the mean and standard deviation of the experimental group data (before and after treatment) and control class for each subject/sub research that has been tested, (3) calculating effect size values using statistical parameters. Steps or procedures for data analysis in meta-analysis can be seen in Figure 1.

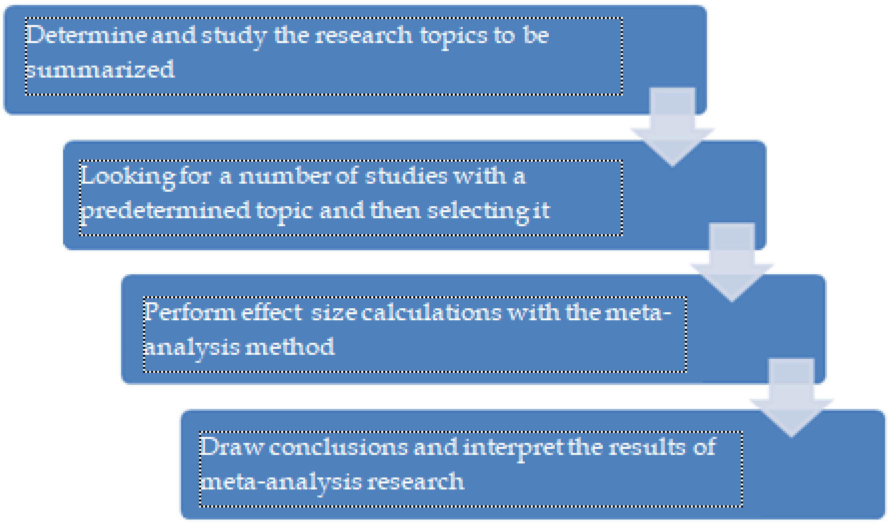

Figure 1. Meta Analysis Research Procedures (Mayasari et al., 2023)

Statistical parameters used in the meta-analysis research are described as follows.

1. Mean and standard deviation in one group *(pre test-post test)*

$$ES = \frac{\overline{X}_{post} - \overline{X}_{pre}}{SD_{pre}} \quad (1)$$

2. Mean and standard deviation in each group *(one group post test only)*

$$ES = \frac{\overline{X}_{post} - \overline{X}_{pre}}{SD_{pre}} \quad (2)$$

3. Mean and standard deviation in each group *(two group pre-post test)*

$$ES = \frac{\left(\overline{X}_{post} - \overline{X}_{pre}\right)_E - \left(\overline{X}_{post} - \overline{X}_{pre}\right)_C}{SD_{preC} + SD_{preE} + SD_{postC}} \quad (3)$$

4. Chi-Square

$$ES = \frac{2r}{\sqrt{1-r^2}}, \quad r = \sqrt{\frac{x^2}{n}} \qquad (4)$$

5. t count

$$ES = t\sqrt{\frac{1}{n_E} + \frac{1}{n_C}} \qquad (5)$$

6. P value
   Using CMA (Comprehensive Meta Analisis Software) (6)
   (Mayasari et al., 2022)

Where ES = effectsize value, X_{post} = average posttest value, X_{pre} = average pretest value, SD = Standard Deviation value, X_E = average of experimental group, X_C = average of control group, X_{postE} = average of the posttest of the experimental group, X_{preE} = average of the pretest of the experimental group, X_{postC} = average of the posttest of the control group, X_{preC} = average of the pretest of the control group, SD_E = Standar Deviation of the experimental group, SD_C = Standar Deviation of the control group, t = Result of t test, n_E = total member of the experimental group, n_C = total member of the control group, r = Correlation Value. The effect size criteria can be described as follows. If the effect size is 0.15 then it has a very low effect. If at intervals of 0.15 < the effect size is 0.40 then it has a low effect. If the interval is 0.40 < the effect size is 0.75 then it has a moderate effect. If the interval is 0.75 < the effect size is 1.10 then it has a high effect. If the effect size is ≥ 1.10 then it has a very high effect.

RESULTS AND DISCUSSION

This meta-analysis research was conducted by determining the effect size value of 20 articles published in national journals about the effect of the problem-based learning model on HOTS skills and students' understanding of concepts. To be able to understand how to effectsize the effect of the problem-based learning model on HOTS skills and students' understanding of concepts, it is necessary to do general grouping of the results of data analysis as follows.

Table 1. Article Grouping in General

Article Codes	Skills	ES	Category
J1	Concept Understanding	0.51	Moderate
J2	HOTS	0.66	Moderate
J3	HOTS	1.87	Very High
J4	HOTS	1.47	Very High
J5	Concept Understanding	1.55	Very High
J6	Concept Understanding	2.27	Very High
J7	Concept Understanding	0.36	Low
J8	HOTS	0.53	Moderate
J9	HOTS	0.25	Low
J10	HOTS	0.84	High
J11	HOTS	0.92	High
J12	HOTS	0.81	High
J13	Concept Understanding	2.00	Very High
J14	HOTS	1.05	High

J15	Concept Understanding	0.72	Moderate
J16	HOTS	2.05	Very High
J17	Concept Understanding	0.30	Low
J18	Concept Understanding	1.00	High
J19	HOTS	2.00	Very High
J20	HOTS	1.14	Very High
	Average	**1.115**	**Very High**

From Table 1 it can be seen that the overall average value of the effect size of the effect of the problem-based learning model on HOTS skills and students' understanding of concepts is 1.115 in the high category. These results indicate that there is a strong influence arising from the use of the Problem Based Learning model on HOTS skills and students' understanding of concepts. The Problem Based Learning model as emphasized in Permendikbud No 22 of 2016 makes students more active and critical thereby increasing HOTS skills and students' understanding of concepts.

Effect size values can also be compared based on different levels of education. Each level of education certainly has a different value because the factors that influence it are different. Each level of education also has different needs. So if the results of the effect sizes in table 1 are grouped by level of education, the results will look like Table 2 below.

Table 2. Results Effect size of the Problem Based Learning learning model on HOTS skills and Students' Conceptual Understanding Based on Educational :evel

Educational Level	Article Codes	ES	Average	Category
Elementary School	J9	0.25	0.603	Moderate
	J12	0.81		
	J14	1.05		
	J17	0.3		
Junior High School	J1	0.51	1.394	Very High
	J4	1.47		
	J6	2.27		
	J13	2.00		
	J15	0.72		
Senior High School	J2	0.66	1.175	Very High
	J3	1.87		
	J5	1.55		
	J7	0.36		
	J8	0.53		
	J10	0.84		
	J11	0.92		
	J16	2.05		
	J18	1.00		
	J19	2.00		
	J20	1.14		

From the data in Table 2 the calculation of the effect size of the effect of the Problem Based Learning model on HOTS skills and students' conceptual understanding based on educational level, an effect size value of 0.603 is obtained in the medium category for elementary school level; 1.394 in the very high category for the junior high school level and 1.175 in the very high category for the high school level. These results indicate that the use of the Problem Based Learning learning model is more effective and influential at the junior and senior high school levels than at the elementary level. Teaching materials with the PBL model at the junior and senior high school levels have good effectiveness with a high effect size category (Syamina et al., 2021). This is because the PBL model requires independence, activeness and a good cooperative attitude from students to achieve maximum results. In this case junior and senior high school students are superior to elementary school students.

The effect size value will be different if we compare it based on each skill possessed. The skills measured here are HOTS skills and students' understanding of concepts in each article. If the results of these effect sizes are grouped based on the skills they measure, in this case, namely High Order Thinking Skills (HOTS) and understanding of concepts, the results will be seen in Table 3 below.

Tabel 3. Results Effect Size Learning Model Problem Based Learning Based on Skills

Skills	Article Codes	ES	Average	Category
HOTS	J2	0.66	1.13	Very High
	J3	1.87		
	J4	1.47		
	J8	0.53		
	J9	0.25		
	J10	0.84		
	J11	0.92		
	J12	0.81		
	J14	1.05		
	J16	2.05		
	J19	2.00		
	J20	1.14		
Concept Understanding	J1	0.51	1.09	High
	J5	1.55		
	J6	2.27		
	J7	0.36		
	J13	2.00		
	J15	0.72		
	J17	0.30		
	J18	1.00		

The data in Table 3 shows the calculation of the effect size of the influence of the Problem Based Learning model on HOTS abilities and Students' Concept Understanding based on the skills it measures, a value of 1.13 is obtained with a very high effect size category on HOTS skills and a value of 1.09 with a high effect size category on concept comprehension skills. These results indicate that the use of the Problem Based Learning model effectively improves HOTS skills and students' understanding of concepts.

Discussion

The results that have been obtained strengthen the theory that the problem-based learning model is suitable to be applied because learning contains real problems related to physics so that learning can be more meaningful. Learning will be meaningful if students experience an event directly so that the information obtained is stored for a long time in their memory. The PBL model is a model that has been proven to have a positive influence on students' HOTS skills in the classroom (Shabrina, 2021). In addition, scientific work and learning using the PBL model are more focused and the concept development is broader (Trihastuti et al., 2019). The application of the IT-assisted PBL model in learning can also improve student learning outcomes (Sulaiman et al., 2018).

CONCLUSION

Physics learning should be aimed not only at emphasizing concept mastery but also at containing four things, namely content (product), process (method), attitude and technology so that students' understanding of physics becomes intact and useful for overcoming the problems they face. Problem-based learning has been advocated as a promising strategy for increasing students' critical thinking, and can significantly improve critical thinking and problem-solving skills. Based on the analysis performed, it can be concluded that the problem-based learning model has an effect on HOTS skills and students' conceptual understanding with a mean effect size value of 1.115 with a very high category. The Problem Based Learning model is more effective and influential at the junior and senior high school levels with an effect size of 1.394 and 1.175 compared to the elementary school level with an effect size of 0.603. Then the use of the Problem Based Learning Model effectively improves HOTS skills and students' understanding of concepts because they are in the very high and high categories with effect size values of 1.133 and 1.089 respectively.

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