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The Effect of Problem Based Learning (PBL) Model on Students' Critical Thinking Ability in Sound Wave Material

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ABSTRACT

Education is a process of fostering and developing human resources that are directly beneficial for educating the nation's life. This study aims to describe the critical thinking ability of students in class XI of Senior High School with the application of problem-based learning (PBL) physics learning model. The results of the research are in the form of learning implementation, critical thinking ability, and students' responses. The type of research used is Quasi exsperimental design with Non-equivalent control group design. The research instruments consisted of test observation sheets, critical thinking ability test sheets, and response questionnaire instrument sheets. The results showed the results of the implementation of physics learning with a problem-based learning (PBL) learning model on critical thinking ability, which was implemented with a score of 91.11% and 92.85% in the first meeting and second meeting respectively in the very good category. The problem-based learning (PBL) learning model has a significant effect on the critical thinking ability of students on sound wave material by 81.27%. Students' responses after applying the physics learning of the Problem Based Learning (PBL) model to critical thinking ability get an average percentage of 85.90% in the very good category.

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INTRODUCTION

Education is a process of fostering and developing human resources that directly benefits the intellectual life of the nation (Windari & Yanti, 2021). Education does not only aim to provide subject matter, but emphasizes more on how students carry out learning activities on their own to find and build their own knowledge, so that they have the ability to think critically and are ready to face problems in everyday life (Wijayati, 2018). The development of critical thinking ability can also train students in analyzing problems, elaborating to find ideas in problem solving. These problem-solving activities will increase students' sensitivity to problems (Aripin et al., 2021). The problem that is often faced by schools is that students are less motivated to develop critical thinking skills and are only directed to memorize information conveyed by the teacher resulting in a weak learning process (Supriyanto et al., 2022). The educational process does not depend on what is done in the classroom. Cooperation between teachers and learners determines learning activities (Satumah, 2017). Therefore, new ideas or creativity are needed to change the way subject matter is presented in schools. In this case, creativity is the teacher's ability to choose the right strategies, approaches and media to deliver the subject matter (Sawitri et al., 2016).

Physics is one of the subjects most often considered difficult by most students. Physics is a field of study that studies phenomena and events related to everyday life. As it plays an

important role in technological innovation, physics is also one of the fields that help nations progress (Shishigu et al., 2018). Physics education helps students understand, think, and analyze various symptoms and problems that arise in everyday life (Nursita et al., 2015). One of the branches of science, physics studies real things and can be proven mathematically with formulas. Therefore, many students are not happy and even avoid physics classes (Amiruddin, 2020). One of the problems that students often face when learning physics is a poor understanding of the subject matter. As a result, students are lazy to learn, do not ask questions, and do not feel interested or curious about what the teacher teaches. As a result, most learners do not understand the subject matter. One of the subject matter that is considered difficult is sound waves. This is in line with Sutopo's research which states that wave material is still little done by researchers so that understanding of wave concepts needs to be studied further (Imiati et al., 2016). Research conducted by Wittmann also shows the results of distributing questionnaires on sound wave material, namely 77.7% of students stated that sound wave material is material that is difficult to learn (Maulida et al., 2019). As a result of this difficult material, so that students participate less in learning (Halim et al., 2017). One of the factors that support successful learning is the ability to think critically. Many people believe that one of the characteristics of smart people is the ability to think critically (Wayudi et al., 2020).

Critical thinking is the use of abilities and strategies to improve outcomes in accordance with individual goals and values (Nastiti et al., 2021). Critical thinking ability is one of the systematic processes when students make decisions about what they think and do (Sujanem et al., 2020). Critical thinking is a way of reflective and reasoned thinking that focuses on the purpose of what a person does or believes (Ennis, 2015). Strong and cautious beliefs, articulating problems clearly through questions and judgements, employing logical justification and proof, and drawing conclusions by deftly resolving issues are all traits of critical thinking (Budhi & Suwarni, 2019). When viewed from the ability to think critically, it can be said that students are still in the low category. It is also in accordance with the results of previous research (Neswary & Prahani, 2022) Students' critical thinking ability are included in the low category and no students are included in the medium and high categories. In line with research conducted by (Permata et al., 2019) which shows that students in Indonesia have a level of critical thinking at a level that can be categorized as low to provide basic explanations 36.80%, build basic ability 40.80%, conclude 32%, provide further explanations 30.67%, strategies and techniques 36.80% so that the average percentage of students' critical thinking ability is 35.41% (Tanjung et al., 2023). So that a learning model is needed that can provide solutions to these problems.

According to Arends (2017), the learning model is a design of learning activities so that the implementation of learning can run well, interesting, easy, understood, and in accordance with a clear sequence. The problem-based learning (PBL) model is one of the many models that show a good influence on the learning process of students. This is evidenced from several problem-based learning (PBL) models that have been proven to be able to improve students' critical thinking ability and problem solving ability in physics learning. Based on the results of research and discussion (Meilasari et al., 2020) it can be concluded that the Problem Based Learning (PBL) learning model in learning can increase interest in learning, improve students' problem solving ability, increase students' learning motivation, critical thinking, and improve students' learning outcomes. Meanwhile, according to (Trianto, 2015) problem-based learning has several objectives, namely helping students develop critical thinking ability and problem solving ability; Learning the role of an authentic adult; and Becoming an independent learner. There are many advantages of problem-based learning, such as increasing students' interest and learning activities; Helping students transfer their knowledge to solve problems in everyday life; Helping students to develop their new knowledge and be responsible for the learning they do; Students are involved in learning activities so that their knowledge is really well absorbed (Sanjaya, 2017). Many previous studies have examined the PBL model. Each of the researchers must have characteristics that characterize the learning model. There are many variations of

using the PBL model in the learning process. The implementation of the PBL model using LKPD is based on the PBL model and also includes critical thinking indicators that assist learning and the use of research techniques that few prior researchers have used. Therefore, to train students' critical thinking ability, the application of the Problem Based Learning model is expected to improve students' critical thinking ability can be optimized. Based on the background above, the authors are motivated to conduct research with the title: "The Effect of Problem Based Learning (PBL) Learning Model on students' critical thinking ability on sound wave material".

RESEARCH METHOD

This research was conducted in the even semester of the 2022-2023 school year. Data collection was carried out from February to May 2023. The place for this research was at SMAN 2 Jombang, which is located at Jalan Doctor Wahidin Sudirohusodo No.1, Sengon, Kec. Jombang, Kab. Jombang, Province East Java.

This study uses experimental research methods with a quantitative approach. The experimental method used is a quasi-experimental design. The quasi-experimental approach is a sort of study design that includes a control group but is limited in its ability to properly control outside factors that influence how the experiment is carried out (Sugiyono, 2017). The research design used in this study was "Nonequivalent Control Group Design". In this design the experimental group and the control group were not randomly selected (Sugiyono, 2017). Both groups will be given different treatment. For the experimental group, the problem based learning (PBL) learning model was applied, while the control group applied conventional learning. Before being given treatment, both groups will be given a pretest (initial ability test). This aims to determine the initial critical thinking ability possessed by students in sound wave material. Then the two classes were given a treatment. Both groups will receive a treatment, and then the study will come to a close with the administration of a posttest (the last ability test). This aims to determine how much influence a given treatment has (Astuti, 2017).

Table 1. Nonequivalent control group design

Group	Pretest	Treatment	Posttest
Experiment	O_1	X_1	O_2
Control	O_1	X_2	O_2

(Sugiyono, 2017)

Explanation:

O_1 : Pretest in experimental and control classes.

O_2 : Posttest in experimental and control classes.

X_1 : The treatment of physics learning through the problem based learning (PBL) models.

X_2 : The treatment of physics learning through conventional learning models.

The independent variable in this research is the application of the Problem Based Learning (PBL) learning model in physics learning. The variable that becomes the dependent variable is the increase in students' critical thinking ability in sound wave material. Critical thinking ability with a critical thinking ability test in the form of the same pre-test and post-test questions based on indicators of critical thinking ability (Ennis, 2016). In addition, the variable that becomes the control variable is the allocation of learning time, which is 2 × 40 minutes with the same teacher at each meeting.

The data collection technique is the observation method carried out by observers with analytical techniques, namely the analysis of the implementation of the learning model using the percentage rating scale criterion. The data collection technique is by testing the ability to think critically with the analysis technique, namely the analysis of Statistical Test Requirements, namely the Normality Test and Homogeneity Test. Next, a paired t-test, an n-gain analysis, and a basic linear regression test were used to assess the data from the pretest and posttest. The data

collection technique is the student questionnaire method with the analysis technique, namely the analysis of the implementation of the learning model using the Likert Scale percentage criteria.

The research procedure used three research stages, namely the beginning stage, the implementation stage, and the final stage. The details of the research stages can be seen from the following Figure 1.

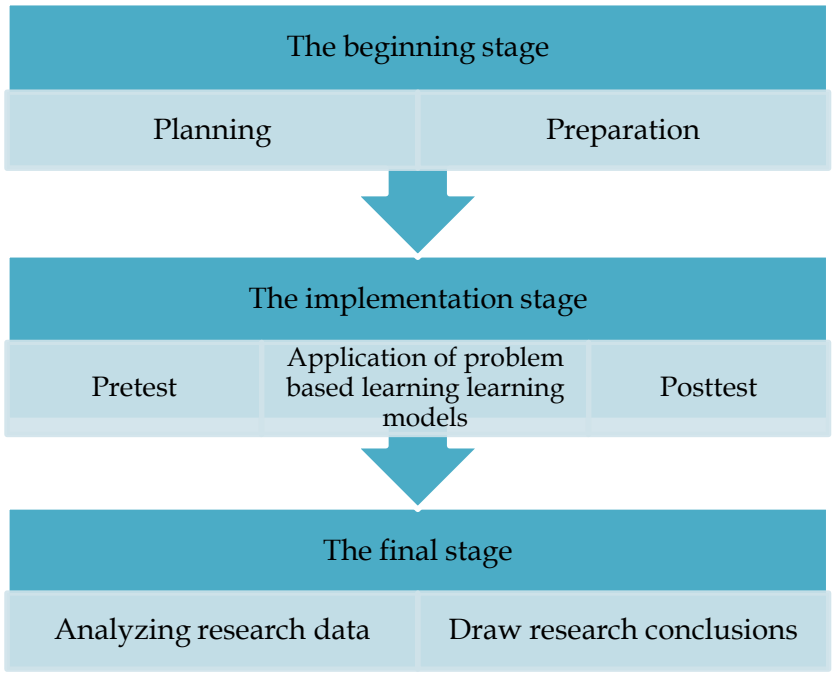

Figure 1. Research stages

RESULTS AND DISCUSSION

Some of the aspects observed in the learning implementation sheet are preliminary activities, core activities, closing activities, and observation of the classroom atmosphere, as well as managing the time the learning activities take place. The preparation of learning implementation sheets is based on each phase of the problem based learning (PBL) learning model on sound wave material.

Table 2. Syntax of Problem Based Learning (PBL)

Fase	Indicator	Educator Steps
1.	Orient learners to the problem.	Explain the learning objectives, explain the logistics required, and motivate learners to engage in problem-solving activities.
2.	Organize learners to learn.	Divide learners into groups, help learners to define and organize learning tasks.
3.	Guiding individual/group experience.	Encourage learners to gather appropriate information, carry out experiments to obtain explanations and solve problems.
4.	Developing and presenting work.	Assist learners in planning and preparing appropriate work such as reports and help them to share their work with others.
5.	Analyzing and evaluating the problem-solving process.	Encouraging students to analyze their research and the methods they employ.

(Rusman, 2018)

The experimental physics class that was given treatment showed an increase in learning implementation from the first to the second meeting, demonstrating how structured and comfortable classroom activities are for both teachers and students. At the first meeting, the average percentage was 91.11%, and at the second meeting, it was 92.85%, indicating a very good category. Each aspect of learning is carried out in accordance with the arrangement of the lesson plan that has been made and adjusted previously. In line with research (Yovianda et al., 2019) who were able to implement learning with the PBL model with a good category. Improved implementation after reflection and evaluation so that the next meeting will be better. This is in accordance with the results of the study which state that the activity of students in the experimental class has increased, namely at the first to fourth meetings, 62%, 66%, 77% and 83% respectively (Sagala & Simarmata, 2021).

Table 3. Analysis of learning implementation according to PBL stages

Stages of PBL	Skor (%)		Category	
	Meetings		Meetings	
	1	2	1	2
Orient learners to the problem.	91,67	94,00	Very good	Very good
Organize learners to learn.	88,89	89,00	Very good	Very good
Guiding individual/group experience.	91,67	95,75	Very good	Very good
Developing and presenting work.	91,67	91,75	Very good	Very good
Analyzing and evaluating the problem-solving process.	91,67	93,75	Very good	Very good

According to observers, students were still unaccustomed to voicing their ideas during discussion sessions for issue solving as well as during the orientation phase of the first meeting because they had not had much experience doing so. So that there are still most of the students who are passive, even though the target of this research is to increase the competence of students to think critically. From the deficiencies that have been described, reflection is needed at the first meeting in order to overcome the problems found and it is necessary to increase the implementation of the second meeting. The second meeting resulted in a success of teacher activities as evidenced by an increase in the percentage of teacher activities that achieved research success indicators. The increase in teacher activity can be influenced by the teacher's preparation to start learning so that in practice it can be maximized in the use of problem-based models. In accordance with research conducted (Dewi, 2021) which adds that increased teacher activity makes the learning atmosphere more active and attracts students' attention. So that the effect can also be felt on persistence in carrying out learning.

Before receiving treatment, the average level of students critical thinking ability in both classrooms was still low. The experimental class got an average score of 30.86 which means the score of the experimental class was lower than the control class which got a score of 32.25. Similar to the average score, the standard deviation for the control class was 7.10, while the standard deviation for the experimental class was 6.82. The standard deviation indicates how far the data tends to widen from the average value. The average value of students' critical thinking ability in both classes is high as a result of being given treatment. The experimental class got a higher average score than the control class. The average score for the control class was 80.83 with a standard deviation of 6.40. Meanwhile, the average score for the experimental class was 83.61 with a standard deviation of 7.05.

Table 4. Recapitulation of Pretest and Posttest Score Data

Data Centering and Dispersion	Control Class		Experimental Class	
	Pretest	*Posttest*	*Pretest*	*Posttest*
Biggest Score	48,00	96,00	48,00	96,00
Smallest Score	20,00	68,00	20,00	68,00
Average	32,25	80,83	30,86	83,61
Median	32,00	80,00	32,00	84,00
Mode	32,00	76,00	36,00	80,00
Standard Deviation	7,10	6,40	6,82	7,05

Based on Table 4, it can be seen that the experimental class score is lower than the control class score on average. The experimental class's average posttest score, however, was greater than the control class's. Based on the posttest results, both classes experienced an increase in critical thinking ability after being given different treatments. The control class was given conventional learning treatment while the experimental class was given learning treatment with problem-based learning model. The difference in the average pretest and posttest scores of the control class was 48.58 while the experimental class had an average difference in pretest and posttest scores of 52.75. These results show that the increase in critical thinking ability of the experimental class is higher than the control class.

The increase in critical thinking ability is calculated using N-gain, but before an N-gain test is carried out a prerequisite test consisting of normality test and homogeneity test. Normality test, the decision whether the data is normally distributed or not is based on the opinion (Sugiyono, 2017) which states that if the calculated Chi-Quadrat price is smaller or equal to the Chi-Quadrat table price $\left({X_h}^2 \leq {X_t}^2\right)$, then the data distribution is declared normal, and if it is greater (>) it is declared abnormal. The ${X_h}^2$ value of the pretest in the control class and experimental class is 2.19 and 2.66, respectively. The ${X_h}^2$ value of the posttest in the control class and experimental class is 1.88 and 3.58, respectively. The value of ${X_t}^2$ is 7.81 so it can be seen that the normality test of the two classes is normally distributed. In line with research conducted by Anggi Wulan Sekar Tanjung who got data on the results of students' critical thinking ability normally distributed (Tanjung et al., 2023).

The next step uses the homogeneity test. Homogeneity test for further parametric statistical tests used if the data is normally distributed (Jauhari et al., 2017). The calculation results get an F_{count} value of 1.024 while the F_{table} is 1.757. Similarly, the calculation results obtained an F_{count} value of 1.410 while the F_{table} is 1.757. The results of the above calculations obtained that the value ($F_{count} \leq F_{table}$). Then the homogeneous test decision H_a is rejected and H_0 is accepted, so it can be concluded that the sample comes from a homogeneous population and can continue the next test. (Muharromah et al., 2023).

In the paired t test using posttest scores from two classes, namely the experimental class and the control class, shows the results of the learning process. The reason why the posttest scores of students in all classes are higher than the pretest scores based on the paired t test is because before getting lessons related to sound waves, students did not understand the concept or material at all so that the scores obtained when doing the pretest were in the low category. However, after being taught with a problem-based learning (PBL) model related to sound waves, even though they were in a control class that used a conventional learning model (lecture method), the knowledge they gained still made their scores change significantly when doing the posttest. The results of pretest and posttest hypothesis testing in the control class get the value of $t_{count}$and t_{table} of 55.134 and 1.690, respectively. So it can be said that the value ($t_{count} \geq t_{table}$). The results of pretest and posttest hypothesis testing in the experimental class get the value of $t_{count}$and t_{table} of 97.453 and 1.690, respectively. So it can be said that the value

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($t_{count} \geq t_{table}$). From the results of both classes, it can be concluded that H_0 is rejected for all classes. That is, the posttest value is higher than the pretest value statistically in all classes. This shows that the initial hypothesis is rejected, so it can be concluded that there is a significant difference in the results of critical thinking ability between the two classes, especially in the experimental class.

The minimum N-gain average value is in the medium category. Therefore, an N-gain analysis is needed to see that the average increase is in the low, medium or high category. In the experimental class that applied physics learning with the PBL learning model, it obtained an N-gain value in the high category, which was <g> 0.75, while in the control class, which was not given the treatment of physics learning with the PBL learning model, it received an N-gain result of <g > 0.69 which is in the medium category. There is a change or increase in the value of students' critical thinking ability in the experimental class caused by the application of the problem based learning (PBL) learning model. Based on Table 4.9 which shows the results of calculating the average N-gain of the two classes, it can be seen that the experimental class is in the high category, while the control class is in the medium category. This is in line with research (Yusuf & Ardhuha, 2022) which says that students' critical thinking ability have increased with the average results of the N-Gain test of 0.51 and 0.43 in the medium category.

Results of a simple linear regression test to determine the degree to which the problem-based learning (PBL) instructional approach affects students' capacity for critical thinking (Bestiantoro, 2019). The percentage of the effect of the problem based learning (PBL) learning model on improving students' critical thinking ability in the experimental class was 81.27%.

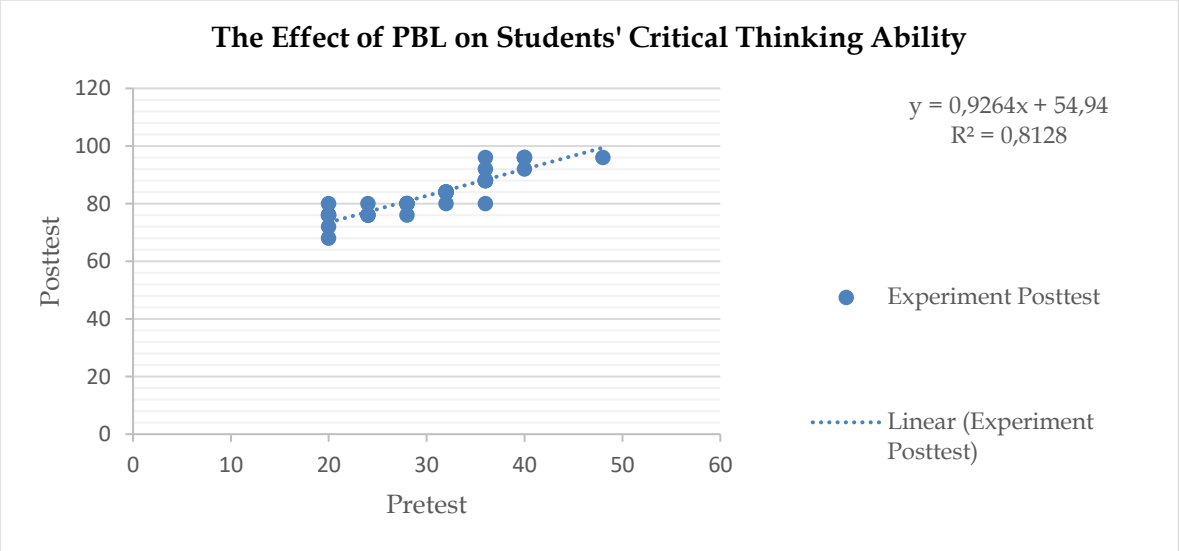

Figure 2. Graph of the effect of PBL on critical thinking ability

It is also clear from the graph in Figure 2 that the impact of PBL is strongly correlated with students' capacity for thinking critically. From the research conducted, it can be concluded that the problem based learning (PBL) learning model has a significant effect on students' critical thinking ability in sound wave material. So that it can be said that the problem based learning (PBL) model meets the criteria as a learning model that can improve students' critical thinking ability. This is also in line with Samadun and Dwikoranto's research which concluded that the application of a problem-based learning model had an effect on increasing the critical thinking ability of high school students in physics material (Samadun & Dwikoranto, 2022). In line with the research conducted by Aqila Insani who concluded that there were significant differences in learning outcomes, it was suggested that Physics teachers should be able to use the Problem Based Learning (PBL) model as a reference in a more effective learning process for the future (Insani, 2023).

The response of students after applying the physics learning model of Problem Based Learning (PBL) model to critical thinking ability gets an average percentage of 85.90% with a very good category. The results of this response value prove that the problem-based learning (PBL) model is effective when applied in physics learning. The findings of Trisnawaty Junus Buhungo's study, which showed that teachers' and students' reactions to the learning process were seen from a number of indicators and received a good response, were corroborated. Because they are directly involved in learning activities, students can learn utilizing a problem-based learning model and a contextual learning method, which can increase their excitement for learning (Buhungo et al., 2023). In line with Desy Triana Dewi's research which said that the response of students seen from the average score of 89.06% meant that the model had a very strong effect on the success of learning and received a positive response from students. Based on the learning outcomes obtained by students, it can be seen that the application of problem-based learning can increase the level of critical thinking of students based on cooperation and active roles by educators and students to achieve the goals of learning (Bektiarso et al., 2021).

CONCLUSION

The results of the implementation of physics learning with a problem-based learning (PBL) learning model on critical thinking ability are implemented with a score of 91.11% and 92.85% in the first meeting and second meeting respectively in the very good category. The problem-based learning (PBL) learning model has a significant effect on the critical thinking ability of students on sound wave material by 81.27%. The increase in students' critical thinking ability in the experimental class is higher than the control class. This can be seen from the average N-gain of both classes. The experimental class obtained an average N-gain of 0.75 (high category) while the control class obtained an average N-gain of 0.69 (medium category). (3) Students' responses after applying the Problem Based Learning (PBL) physics learning model to critical thinking ability get an average percentage of 85.90% in the very good category.

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