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Literature Study on Learning Physics with Problem-based Learning (PBL) Models to Improve Students' Problem-Solving Skills

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Abstract

Problem solving skills must be possessed by students in order to find solutions or get answers to problems to be solved by methods based on their understanding, especially in the field of physics. One alternative that can be used to improve problem solving skills is the Problem Based Learning (PBL) model which is integrated with interactive media by presenting authentic problems. This study aims to compare the implementation of learning using the Problem Based Learning model and to determine the effect of learning using the Problem Based Learning model on problem solving skills. The research method uses ex post facto. Data collection was carried out using library research techniques and a number of five related articles were obtained after going through data reduction, namely between 2018 and 2022. The existing data was analysed using qualitative and quantitative descriptive analysis. The results showed that there was a relationship between the PBL model and the problem solving skills of the experimental class and the control class. This is indicated by the results of the experimental class being higher than the control class on the results of the pre-test and post-test scores, increasing problem solving skills, and increasing per indicator of problem solving skills. The value of problem solving skills is in the moderate category for the experimental class and the control class is in the low category. Based on the data obtained, it can be concluded that the results of the PBL model have a higher value than the conventional model and the PBL model is able to improve students' problem-solving skills so that students are able to remember learning in the long term and solve authentic problems.

Keyword: Problem-Solving Skills, Problem-Based Learning, Physics

Abstrak

Keterampilan pemecahan masalah harus dimiliki oleh peserta didik guna mengetahui solusi atau mendapatkan jawaban atas masalah yang hendak diselesaikan dengan metode berdasarkan pemahamannya khususnya pada bidang fisika. Salah satu alternatif yang dapat digunakan untuk meningkatkan keterampilan pemecahan masalah adalah dengan model Problem Based Learning (PBL) yang diintegrasikan dengan media interaktif dengan menyajikan permasalahan autentik. Penelitian ini bertujuan untuk membandingkan pelaksanaan pembelajaran menggunakan model Problem Based Learning serta mengetahui pengaruh pembelajaran dengan model Problem Based Learning terhadap keterampilan pemecahan masalah. Metode penelitian menggunakan expost facto. Pengumpulan data dilakukan menggunakan teknik library research dan didapatkan sejumlah lima artikel terkait setelah melalui reduksi data yaitu antara tahun 2018 hingga 2022. Data yang ada dianalisis menggunakan analisis deskriptif kualitatif dan kuantitatif. Hasil penelitian menunjukkan bahwa terdapat keterkaitan antara model PBL dan keterampilan pemecahan masalah kelas eksperimen dan kelas kontrol. Hal ini ditandai dengan hasil kelas eksperimen lebih tinggi daripada kelas kontrol pada hasil nilai pre-test dan post-test, peningkatan keterampilan pemecahan masalah, serta peningkatan per indikator keterampilan pemecahan masalah. Nilai keterampilan pemecahan maslah dalam kategori sedang untuk kelas eksperimen dan kelas kontrol pada kategori rendah. Berdasarkan data yang didapatkan dapat disimpulkan bahwa hasil model PBL memiliki nilai yang lebih tinggi daripada model konvensional serta model PBL mampu meningkatkan keterampilan pemecahan masalah peserta didik sehingga peserta didik mampu mengingat pembelajaran dalam jangka panjang serta menyelesaikan permasalahan autentik

Kata Kunci: *Keterampilan pemecahan masalah, Problem Based Learning, fisika*

INTRODUCTION

Education is a program for developing the potential of students with an conditions and a systematically ordered learning process (Astutik & Jauhariyah, 2021; Depdiknas, 2003). In the current 4.0 era, students are required to have contemporary skills: creativity, critical thinking, communication, and collaboration (Astutik & Jauhariyah, 2021). The appropriate alternative for practicing these skills is to implement them in the world, of education both inside and outside of the classroom. The solution offered is by consists in the implementation of a study plan with modifications and developments according to the needs of the times.

Problem-solving skills will be used in every aspect of life, especially in education. Environmental phenomena or problems cannot be separated from the role of science, one of which includes physics. Physics is one of the subjects that must be mastered by students. Because physics is one of the natural sciences that studies natural laws, behaviour, and the relationship between phenomena in everyday life (Rosmasari & Supardi, 2021).

Physics learning with carries a variety of authentic problems requires problem-solving skills from students. In line with physics learning objectives, to prepare students to solve problems (Sukmawarti et al., 2022). Problem-solving skills are the main skills of students to be able to solve problems by receiving and giving responses in the form of solutions (Santi et al., 2022). Skills in solving problems are not just material that already exists, but a process that students must understand in various contexts with the concepts, principles, and skills being taught (Pramita et al., 2022). The process of learning physics makes students hard work in understanding the impact of natural science on life and problems. This explains that problem-solving skills are important in learning physics.

Having problem-solving skills allows students to easily provide predictions for answers and processes of solutions based on predetermined methods (Khairani et al., 2023). Students' problem-solving skills can be increased by carrying out thought processes to find answers to problems. Students' problem-solving skills can be trained by individually discovering concepts from direct experience (Widiawati et al., 2022). These skills can provide direction in solving problems by knowing the facts and problems raised (Sukmawarti et al., 2022). This will improve students' ability to think systematically about problem-solving and enhance their sense of collaboration (Pramita et al., 2022).

Students who have been trained to solve problems in everyday life will find it easy to make decisions about problems. This is because the skills to gather information and conducting evaluations after solving these problems are inherent in themselves based on their soft skills (Sihombing et al., 2023). According to Wagner (2008) an example of soft skills is the ability to think critically and solve problems (Fakhriyah, 2014). Student's skills in the process of solving problems can improve their thinking skills, apply policies or methods, and strengthen their conceptual understanding (Siagian et al., 2019).

Indira Santi, Nahor Murani Hutapea, dan Atma Murni (2022) stated that students' problem-solving skills were indeed in the low category. The low results were caused by several factors such as students feeling difficulty in understanding questions, solving problems, and drawing conclusions about the problems posed (Sukmawarti et al., 2022). This is because students think that physics is an abstract subject (Chasanah et al., 2019). Most students consider physics to be a difficult subject because the learning process that has taken place so far is still conventional (Lutfa et al., 2014). Dominant teachers use printed books, blackboards, and LKS rather than using media for other learning. This makes teaching and learning physics less effective (Chasanah et al., 2019). The problems that arise will harm students' academic achievement.

The fact that physics students have low problem-solving skills of students in solving physics problems demands efforts to improve them (Santi et al., 2022). An alternative to solving problems in physical education is to improve the quality of learning using appropriate learning models (Nasution et al., 2023). The learning that takes place in the learning process must be consistent with and follow the requirements of the curriculum. The diverse models of learning models make teachers' pay attention to the characteristics of students and learning objectives that will be applied to teaching and learning activities. Prayogi (2020) states that teachers can apply PBL, PjBL, and collaborative learning models can be applied by teachers as learning alternatives to improve 21st-century skills (Astutik & Jauhariyah, 2021).

Problem-solving skills can be created by encouraging stimulation to students toward learning (Mayasari et al., 2022). These skills can be trained using appropriate learning models, including the problem-based learning model (PBL). PBL is a learning model imparted by presenting a problem, asking questions, facilitating investigations, opening conversations and solving problems, and applying different concepts and

principles that are stimulated to be learned and incorporated into the subject curriculum (Effendi et al., 2019; Sani, 2014). The use of the PBL models is highly recommended which aims to generate enthusiasm for learning, motivation, and an active role in teaching and learning activities (Aulia & Budiarti, 2022).

The PBL model that is applied will train students to solve problems by being confronted with a problem which is followed by extracting information independently or in groups (Santi et al., 2022). Learning in the classroom must be able to overcome problems by giving students an active role in solving problems in everyday life, not only mastering the material (S. Lestari & Winanto, 2022).

Research results on the topic of the PBL model have been published in many national and international journals. Astutik & Jauhariyah (2021) in their research found 998 articles regarding the PBL model in the 2015 – 2020 range. The search was carried out with the keywords “problem-based learning” and “physics” using publish or perish using the Google Scholar search engine. Where as in this research it was carried out by exploring using publish or perish on the Google Scholar search engine, obtaining 659 articles from 2018 to 2022. The keywords used were "Problem-Based Learning”, “Problem-Solving”, “Physics”, and “High School”.

The explanation above shows the importance of developing classes with learning models that are integrated with authentic problems in order to improve students' problem-solving skills. Therefore, the aim of this study is to compare the implementation of learning through problem-based learning models in previous research and to determine the influence of learning with problem-based learning models on problem-solving skills.

RESEARCH METHODS

The research method is a process of carrying out observations (Nugrahutama, 2017). As shown in Figure 1, the research process is carried out as follows:

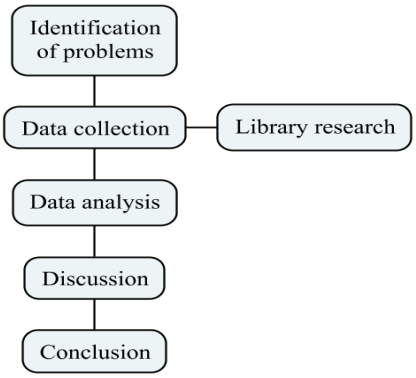

Figure 1. Research design

This research was conducted with the type of descriptive research method after the fact based on five research articles. Research is conducted by associating activities to get meaning for each variable that is used by researchers to respond to the problem formulation. The research was conducted by analysing the application of problem-based learning models in education, especially for high school students in physics learning. The data in this study were obtained through a technique known as terminology library research or literature study. Literature study is carried out with various sources of literature to obtain research data, namely data sources are only used as library collection documents, without field work required (Khoiri & Sunarno, 2018).

The study material in this study was the results of previous research on applying the PBL model of physics learning to improve the problem-solving skills of high school students. The data obtained is determined by a search process on Google Scholar and other national journals. The search process is carried out by determining the main keywords related to the research objectives which include "Problem-Based Learning”, “Problem-Solving”, “Physics”, and “High School”. The data was filtered for the last 5 years, namely from 2018 to 2022. On Google Scholar the initial data obtained some 14,500 results and then carried out the selection of data according to the needs so that several five data were obtained. The data obtained are articles written by Raja M. T., Sehat S., and Mariati P. S.; Diva A., Rita J., and Sri M. Winda R., Juniar H., and Mariati P. S.; A R Asuri, A Suherman, and DR Darman; and C Umamah and H Jufri Andi. The sample for the five data is two classes in senior high school (SMA).

The analysis technique used is descriptive qualitative and quantitative. Researchers conducted an assessment of the data that had been obtained from the results of the literature study at the initial stage. The activity is then continued by reducing and reviewing all the data collected, by categorizing and matching based on the data needed by the researcher to answer the problem. The final stage is data analysis through descriptive review, namely describing all aspects related to the subject matter based on the objectives of the philosophical review. The final result of the technical analysis is to conduct a study of the data and proceed with data processing to categorize and analyse it in a systematic, structured, and orderly manner (S. A. Lestari et al., 2022).

RESULTS AND DISCUSSION

Results

The data described in this study includes data

library research which is the result of research from Raja M. T., Sehat S., and Mariati P. S.; Diva A., Rita J., and Sri M. Winda R., Juniar H., and Mariati P. S.; A R Asuri, A Suherman, and DR Darman; and C Umamah and H Jufri Andi include data on the impact of the physical problem-based learning model on improving students' problem-solving skills. Based on the research conducted by researchers, various data were collected, including the results of the experimental class and the control class before and after the test, the results of improving problem-solving skills, as well as the results of increasing student indicators Problem-Solving skills in both the experimental class and the control class.

Test of students' initial problem-solving skills (pre-test) and post-test given to find out whether or not the student's initial abilities are the same as the final abilities after being given the treatment that has been designed by the researcher. The two samples were given in each study conducted in two classes with different treatments. Results pre-test and post-test experimental and control classes are detailed in Table 1.

Table 1. Results Pre-test and Post-test Experiment and Control Class

Research Results	Pre-test		Post-test	
	Experiment Class	Control Class	Experiment Class	Control Class
Raja Mahmud Tanjung, Sehat Simatupang, dan Mariati Purnama Simanjuntak (Tanjung et al., 2021)	29,30	28,00	70,00	57,00
Diva Almira, Rita Juliani, dan Sri Mulyasih (Almira et al., 2019)	18,42	17,03	74,42	69,95
Winda Risnawati, Juniar Hutahaean, dan Mariati Purnama Simanjuntak (Risnawati et al., 2019)	44,00	41,67	70,33	62,83
A R Asuri, A Suherman, dan D R Darman (Asuri et al., 2021)	-	-	-	-
C Umamah dan H Jufri Andi (Umamah & Andi, 2020)	42,50	47,50	90,00	85,25

Source: (Almira et al., 2019; Asuri et al., 2021; Risnawati et al., 2019; Tanjung et al., 2021; Umamah & Andi, 2020)

Table 1. shows that result pre-test and post-test the experimental class is higher than the control class which is marked by an increase in scores in each study. Differences in problem-solving skills of high school students between the experimental class using the PBL model and the control class using the conventional learning model can be tested by gain test to determine the increase in problem-solving skills. Apart from testing gain, the increase is known based on the results test given problem-solving. The results of increasing problem-solving skills are listed in Table 2.

Table 2. Improved Problem-Solving Skills

Research Results	N-gain		Score	
	Experiment Class	Control Class	Experiment Class	Control Class
Raja Mahmud Tanjung, Sehat Simatupang, dan Mariati Purnama Simanjuntak (Tanjung et al., 2021)	-	-	76,00	63,00
Diva Almira, Rita Juliani, dan Sri Mulyasih (Almira et al., 2019)	-	-	57,48	14,80
Winda Risnawati, Juniar Hutahaean, dan Mariati Purnama Simanjuntak (Risnawati et al., 2019)	0,47	0,36	-	-
A R Asuri, A Suherman, dan D R Darman (Asuri et al., 2021)	0,36	0,15	-	-
C Umamah dan H Jufri Andi (Umamah & Andi, 2020)	0,83	0,72	-	-

Source: (Almira et al., 2019; Asuri et al., 2021; Risnawati et al., 2019; Tanjung et al., 2021; Umamah & Andi, 2020)

Table 2. shows that there is an increase in problem-solving skills between the experimental class and the control class. This is evidenced by the value obtained N-gain or the score of the experimental class being higher than the control class in each study. Improved physics problem-solving skills with Problem-Based Learning models to the four stages of problem-solving skills that have been tested by test N-gain. The results of the increase per indicator of problem-solving skills are listed in Table 3 and Table 4. The description of each indicator includes:

1 = Identify relevant concepts (Tanjung et al., 2021) / understand the problem (Asuri et al., 2021)
2 = Planning a problem-solving strategy (Tanjung et al., 2021)
3 = Implementing the strategy (Tanjung et al., 2021)
4 = Evaluating solutions (Tanjung et al., 2021)

Table 3. Improvement Per Indicator of Problem-Solving Skills with N-gain Test

Research Result	Experiment Class				Control Class			
	1	2	3	4	1	2	3	4
Raja Mahmud Tanjung, Sehat Simatupang, dan Mariati Purnama Simanjuntak (Tanjung et al., 2021)	0,95	0,92	0,47	0,52	0,81	0,62	0,26	0,48
A R Asuri, A Suherman, dan D R Darman (Asuri et al., 2021)	0,31	0,34	0,53	0,36	0,30	0,23	0,27	0,15

Source: (Asuri et al., 2021; Tanjung et al., 2021)

Table 4. Improvement Per Indicator problem-solving Skill with Score

Research Result	Experiment Class				Control Class			
	1	2	3	4	1	2	3	4
Diva Almira, Rita Juliani, dan Sri Mulyasih (Almira et al., 2019)	61,07	58,39	55,45	55,00	20,54	16,07	14,47	08,13

Source: (Almira et al., 2019)

Table 3 and Table 4 show that there is an increase in each indicator of problem-solving skills between the experimental class and the control class. This is evidenced by the value obtained N-gain or the score of the experimental class being higher than the control class in the three studies.

Discussion

The results of the study on research conducted by Raja M. T., Sehat S., and Mariati P. S.; Diva A., Rita J., and Sri M.; Winda R., Juniar H., and Mariati P. S.; A R Asuri, A Suherman, and DR Darman; and C Umamah and H Jufri Andi show that there is a model influence problem-based Learning (PBL) on the problem-solving skills of high school students in physics lessons. This can be proven by the acquisition of the average value post-test which is written in Table 1 where the average value post-test of the experimental class is higher than the control class. This proves that the problem-solving skills of high school students in physics lessons use models of problem-based Learning higher than the conventional learning model.

There was a significant increase with the control class mean in the low category and below mean, while the experimental class was included in the middle category. The PBL model is influential in learning because this model carries out activities that begin with student activities to solve real problems that are determined or agreed upon. This is supported by research conducted by Bakar & Panjaitan (2019) which shows that the model problem-based Learning can improve students' problem-solving skills.

The improvement of problem-solving skills is also due to the application of the PBL model which provides activities in sequence so that students have a personal experience and have their impact. In line with the research results of Rahmi Hayati, Dian Armanto, dan Zuraini (2023) that students have a strong understanding of solving problems because of the actions they do themselves directly. Thus, the knowledge gained by students will be easier to remember compared to students who get knowledge from the teacher.

Gagne has put forward a learning theory that states that intellectual skills are in the high category, which includes mathematical reasoning that can be trained and developed through problem-solving (Arends, 2012). This is reinforced by Anderson's opinion that problem-solving skill that encompasses the process of analysing, interpreting, thinking, predicting, evaluating, and reflecting (Liani et al., 2018; Ulya, 2016). In other words, problem-solving skill to apply previously acquired knowledge to new situations (Ulya, 2016).

Four indicators can be assessed from problem-solving skills according to Docktor and Heller, namely: (1) the usefulness of the description, (2) the physics approach and specific applications, (3) mathematical procedures, and (4) the development of logic (Docktor & Heller, 2009; Hidayah et al., 2018). PBL model is a learning model that has the essence of presenting authentic and meaningful problematic situations to students (Arends, 2007; Hidayah et al., 2018). Being given treatment in two classes, namely the experimental class with problem-based Learning models and the control class with conventional learning models found significant differences between the two classes.

In line with the results pre-test and post-test given to both classes in the form of test items arranged based on indicators of problem-solving skills, thus it can be seen that the problem-solving skills possessed by students in terms of the scores obtained there are differences in the two classes. As for the result score data post-test analysis is carried out so that it is known the value of students' problem-solving skills. This has been written in Table 2 which explains that there is an increase in the problem-solving skills of students who are given different treatment in the two classes.

The results presented in Table 2 show that there are differences in the results before and after the test, which

means that there is an increase in students' problem-solving skills using the PBL model. The large increase in problem-solving skills comes from the calculation N-gain data. The n-gain analysis can provide information that between the pre-test and post-test whether students experience an increase or not. Table 2 has represented an increase in value N-gain or scores on each of the research results in the experimental class and control class.

These data explain that the results of the experimental class are higher than the control class. Supported by Yuli Ifana Sari, Sumarmi, Dwiyono Hari Utomo, and I Komang Astina (2021) the results of students' problem-solving skills in classes that apply the PBL model are better than classes that apply conventional models. This happens because during the teaching and learning process in the classroom using problem-based learning can produce an ideal learning situation based on various steps of the learning model.

In learning with problem-based learning, the problems presented are problems that exist in everyday life but are still related to the concept of physics. In addition, in the learning process, students are formed into several groups which enables them to develop and exchange opinions among friends and help each other in investigating problems. PBL also makes students actively involved directly and get the opportunity to be in direct contact with abstract ideas and theories through observing activities while doing practicums. So that it can help students in understanding scientific concepts and knowledge in depth and critically. Students tend to use their understanding already have to solve problem until they acquire new knowledge that can support them (Suparman et al., 2021).

This indirectly provides an opportunity for students to develop their mindset in solving authentic problems regarding physics based on their experiences and concepts. In addition, in PBL learning, students are required to plan and prepare practicum results that will be a solution to the problems that have been identified. These results are in line with research that was conducted by Hidayah et al. (2018) which explains that the PBL model can train students to use the PBL syntax to solve problems that are common in everyday life. This statement is supported by the opinion of Argaw, Haile, Ayalew, & Kuma (2017) which states that the PBL model can provide good instructional motivation and physics problem-solving abilities (Argaw, A et al., 2017; Togatorop & Sinuraya, 2019).

This is contrary to the learning that is applied in the process of teaching and learning activities in class with conventional learning models. In conventional classes, students listen more to explanations from the teacher and do assignments in the form of practice questions. The teacher is a source of knowledge with students only listening to the material delivered by the teacher (Sulastri & Pertiwi, 2020).

The steps to solve the problem made the experimental class students more skilled in solving problems than the control class which caused the experimental class to have better problem-solving skills. This can be seen in Table 3 and Table 4 which explain the increase in problem-solving skills per indicator with analysis N-gain or the score in the experimental class is higher than the control class. Based on Table 3 and Table 4, it can be seen that the experimental class students have very good scores in identifying what concepts are used to solve the problems given to them, while the control class scored slightly lower than the experimental class.

In the first indicator of problem-solving skills, students are required to use what concepts are used to solve problems so that students can easily determine the concepts used. The syntax used in PBL also influences the results of problem-solving skills in the first indicator, the orientation of students to problems. In this phase, students together with the teacher identify and organize the learning tasks in the Student Worksheets (LKPD) which contain problems or phenomena to be identified (Bakar & Panjaitan, 2019). At this stage, students will play an active role in expressing opinions regarding the issues that have been presented (Togatorop & Sinuraya, 2019). The implementation of the first phase was very good so the results of the increase per indicator of problem-solving skills had an average in the medium category. The reason is probably because students are still used to learning with the lecture method and the material provided has been studied before learning begins.

The second indicator requires students to continue the first indicator, that is, students only need to write down how to solve the given problem according to the concept that has been answered by the first indicator. This step is consistent with the Organize Students to Learning phase, where the teacher provides guidance and encouragement to students to dig up information that is appropriate to problems in problem-solving (Bakar & Panjaitan, 2019). At this stage, the results of increasing per indicator of problem-solving skills have an average in the medium category. This is probably caused by the lack of active students in the learning process.

The third indicator requires students to plan a complete strategy so that the problems given can be solved. In the phase of carrying out the plan, students are expected to be able to carry out procedures or steps that have previously been made to get a solution to the problem (Hidaayatullaah & Dwikoranto, 2019). At this stage, the results of increasing per indicator of problem-solving skills have an average in the medium category.

This is because students still do not link physics problems to the learning process.

The fourth indicator requires students to conclude all answers from the first to third indicators so that students who have worked on the three indicators will find it easy to work on this fourth indicator. The phase of analysing and evaluating the problem-solving process carried out in PBL requires students to carry out analysis and evaluation after carrying out the entire process of solving problems (Togatorop & Sinuraya, 2019). At this stage, the results of increasing per indicator of problem-solving skills have an average in the medium category. The reason is probably because the students were not directly involved in the experiment/trial so they could not understand the lesson properly.

Improvement of problem-solving skills per indicator stated in the analysis N-gain as well as score test has an average in the medium category for the experimental class, while the control class has an average in the low category. In the control class that applies conventional learning, students are less developed in problem-solving and less detailed in solving problems. In conventional/lecture learning, students learn to listen more to explanations in front of the class and carry out assignments if given practice questions. Practice questions put more emphasis on memorization and finding one correct answer, resulting in not being trained to find solutions to problems through various possible paths. These results were reinforced by research conducted by Novianita M, Amiruddin H., dan I Komang W. (2021) which stated that students did not understand and had difficulty solving problems given by researchers without carrying out experimental/trial activities.

Based on the results that have been obtained, it can be seen that the problem-based Learning model is an innovative learning model that can be applied following the 21st-century era. This is because the learning model is following the demands and objectives of the national education curriculum. Learning using the PBL model can effectively improve students' problem-solving skills in learning physics. This is indicated by the results after learning which are higher than before learning. The results have been tested statistically using the N-gain test and analysis of students' problem-solving skills scores.

CONCLUSION

The conclusion obtained in this study is the application of the problem-Based Learning (PBL) models on five studies conducted by Raja M. T., Sehat S., and Mariati P. S.; Diva A., Rita J., and Sri M. Winda R., Juniar H., and Mariati P. S.; A R Asuri, A Suherman, and DR Darman; and C Umamah and H Jufri Andi were able to improve students' problem-solving skills compared to conventional learning models. The results of improving class problem-solving skills with the PBL model were higher than the conventional model class. As well as the increase per indicator of problem-solving skills in the PBL class is greater than in the conventional class. Learning physics with the PBL model can improve students' problem-solving skills.

Based on the results of the literature that has been obtained, the authors suggest physics teachers consider learning problem-based learning models be an alternative way to improve students' problem-solving skills. For schools, learning models' problem-based Learning can be used as an alternative to other learning in schools. Students, it is expected to be able to maximize the learning process in class to improve physics problem-solving skills.

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