



The Effect of Utilizing the PBL Model in Physics Learning on Student Learning Outcomes: A Systematic Literature Review

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Received: December 26, 2022

Revised: May 27, 2023

Accepted: June 25, 2023

Published: June 30, 2023

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DOI: [10.29303/jppipa.v9i6.2741](https://doi.org/10.29303/jppipa.v9i6.2741)

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Abstract: This research examines and describes the use of learning models on student learning outcomes, namely problem-based learning models in physics learning. This research uses a research method in the form of a Systematic Literature Review model. From the search strategy results, 330 articles were found from 2015 to 2021, then were gradually and systematically selected into ten articles relevant to the topic of problem-based learning in physics learning. The results of this study indicate that there is an influence of the PBL model on physics learning, as evidenced by the ten articles studied being able to answer research questions, namely: (1) How is the achievement of student learning outcomes in learning physics based on the results of a systematic literature review articles regarding PBL? (2) Does the PBL model affect the achievement of students' 21st-century learning outcomes in learning physics? The results and findings in this article indicate that there is progress in obtaining student learning outcomes after practicing the PBL model in learning physics., namely: (1) increasing student learning independence, (2) Upgradecreative thinking skills, (3) critical thinking skills, (4) argumentation skills, (5) science process skills, (6) problem-solving skills and (7) analytical thinking skills.

Keywords: Physics; Problem-based learning; Systematic literature review.

Introduction

A systematic literature review on the use of the PBL model in learning physics on student learning outcomes can provide new insights in terms of an effective physics learning approach and provide better alternatives in learning methods. In addition, the research results can help prove that the PBL model can help improve student performance significantly, encourage active participation of students in the learning process, improve students' skills, and contribute to the development of better learning methods. Therefore, this research has an important impact on the development of more effective learning approaches, especially in terms of applying the PBL model in physics learning.

Natural Sciences or often abbreviated as IPA, is a science that discusses the entire universe and its contents. However, science has limited knowledge, namely, things that can only be understood by the five senses (vision, hearing, taste, touch, and feel). One of the

disciplines of natural science is physics. Physics is a science that discusses physical objects described in mathematics so that humans can easily understand them and implement them in their daily lives (Winter & Airey, 2022; Huseby & Bungum, 2019). Learning Physics in the 2013 curriculum requires students not only to be able to understand the material well but also to develop their process skills. To develop process skills in learning, it is necessary to have aspects that must be considered in the teaching materials used by the teacher. Teachers need to analyze the material and learning objectives to obtain the expected results according to the demands of the 2013 curriculum. Permendikbud No. 69 of 2013 concerning SMA and MA Curriculum states that the core competencies of this material include factual, conceptual, and procedural knowledge to be applied in the fields of technology, arts, culture, and humanities (Rizaldi & Syahlan, 2022; Fatmawati, 2021). Assessment of learning outcomes in physics teaching and learning activities is is a multilevel work of measurement and

How to Cite:

Nurmahasih, U., & Jumadi, J. (2023). The Effect of Utilizing the PBL Model in Physics Learning on Student Learning Outcomes: A Systematic Literature Review. *Jurnal Penelitian Pendidikan IPA*, 9(6), 81-88. <https://doi.org/10.29303/jppipa.v9i6.2741>

assessment related to measuring physics learning outcomes, evaluating physics learning outcomes, and inferring physics learning outcomes (Fatmawati, 2021). Based on this, learning physics can be connected to mastering concepts, applying them in solving physics problems, and working scientifically. However, currently learning physics in the classroom tends to emphasize mastery of concepts and overrides students' skills (Hudha et al., 2019).

At this time, the use of technology in the field of learning is constructive for teachers in improving the quality of student resources (Suharyat et al., 2022). Students in the generation Z era grew and developed after the world war and the recession, so they were more inclined to be entrepreneurial, innovative, and independent learners (Wiyono et al., 2021). Students' independent learning through technology can make students quickly get learning information. Knowledge is obtained from various sources (Ferry et al., 2020; Santosa et al., 2021). It can be concluded that understanding the use of technology in education can foster students' 21st-century skills.

Judging from the competitive map of the world of work which is getting tougher, of course, it is not enough if students are only equipped with cognitive abilities; for this reason, it is necessary to develop the concept of 21st Century learning in the world of education (Arianto & Kurniawan, 2020). 21st-century skills, often known as 4C skills, are abilities that someone must possess, including critical thinking, creativity, collaboration, and communication skills (Syaputra & Sariyatun, 2020; Andrian & Rusman, 2019 dan Jang, 2016). Several studies state that these four skills must be instilled in students (Khamdit & Siridhrungsri, 2022). That is because these skills will help them solve life problems (KULOĞLU & Karabekmez, 2022).

The learning outcomes of students in 21st-century learning are learning and innovation skills, creativity and innovation, critical thinking and problem solving, communication and collaboration, information, media and technology skills, life and career skills, social and cross-cultural skills, as well as leadership and responsibility (Redhana, 2019). In addition, learning with the demands of 21st-century skills, it is expected to improve student skills and make it easier for students to understand science learning. To achieve all of this, of course, cannot be separated from the role of a teacher. A teacher can make efforts to create effective learning by applying 21st-century learning methods. 21st-century learning is characterized by student-centered learning. One of the learner-centered learning models is the problem-based learning model or PBL model.

The PBL model involves students actively solving problems systematically according to the stages of the

scientific method (Newhouse, 2017). To prove scientifically that the PBL model affects learning outcomes and students' skills in learning physics by utilizing previous research results relevant to this study's topic. Then the appropriate research method is a Systematic Literature Review. A systematic literature review can be defined as a research study that uses a narrow and coherent research system to respond to research problems (Zawacki-Richter et al., 2019).

Method

This research uses a research method in the form of a systematic literature review model. A systematic literature review is an evidence-based research model. Several research disciplines have stated that data evidence has gained high credibility in recent years, as has been the case in education. The design of the Systematic Literature Review research procedure used in this research can be seen in Figure 1 (Zawacki-Richter et al., 2019).

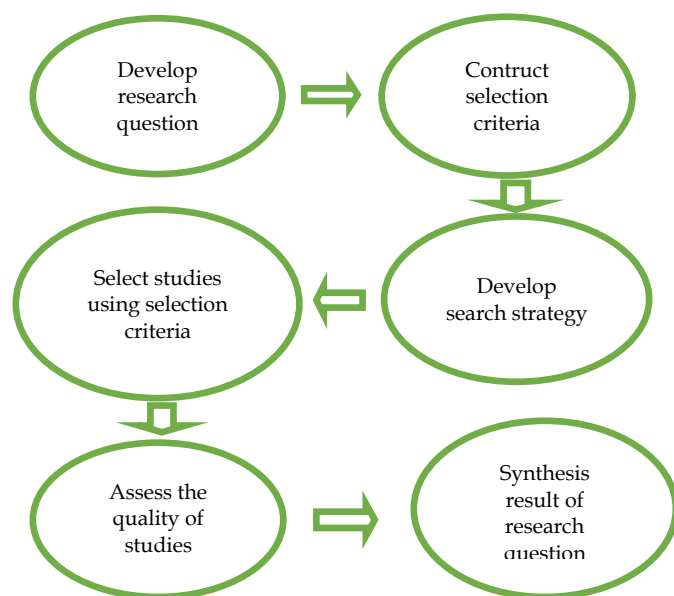


Figure 1. Systematic Literature Review Procedure Diagram (Zawacki-Richter et al., 2019)

The detailed explanation is as follows:

Develop Research Questions

At this stage, the researcher develops questions as the basis of the research, as follows:

- RQ1. How is the achievement of student learning outcomes in learning physics based on the results of a review of research articles regarding the problem-based learning model?
- RQ2. Does the PBL model affect the achievement of students' 21st-century learning outcomes in learning physics?

Selection Criteria

The selection criteria used in this study are shown in table 1 as follows:

Table 1. Inclusion and Exclusion Criteria

Aspect	Criteria
Inclusion criteria (acceptance)	Articles according to research topics regarding problem-based learning (PMB) models or problem-based learning (PBL) in physics subjects. Publications (2015-2021). Full text.
Exclusion criteria (rejection)	Research journals or scientific papers outside the research topic. Publication before 2015. Unfull text.

Developing the Search Strategy

The search was done using Google Chrome software with the site address <http://sinta.kemendikbud.ac.id>. Search strings are needed for more specific searches and to avoid filtering too large a number. Search string in this research: (a.) Search Journals: IPA, Science dan physics, (b.) "Model problem-based learning.", (c.) "Model PBM" or "Model PBL", (d.) ("Physics")

The Study Selection Process

In the study selection process, namely, the process where the title and abstract of the article are examined first to determine whether the research is relevant or not (Zawacki-Ricter et al., 2019).

Appraising the Quality of Studies

Research using the Systematic Literature Review model will evaluate the data that has been found from the research questions and has met the criteria used in this research: Each journal article will give an answer value for each question above with Y (Yes) or T (No).

- QA1. Does the article write down research problems that are relevant to this research?
- QA2. Does the article use appropriate research methods to develop problem-based learning models?
- QA3. Does the article increase students' skills that are relevant to this research?

Result and Discussion

Developing the Search Strategy

The findings from the search strategy on the site <http://sinta.kemendikbud.ac.id/> with the search string that was determined at the research's beginning found 330 articles. This research utilizes secondary data, namely data that already exists or data that previous

researchers have carried out by using the method of documenting these data, not data obtained in direct observation. Secondary sources in this study are scientific articles in reputable journals accessed in the database in Table 2.

Table 2. Overview of the Number of Articles from Each Journal

Publisher	Index	Frequency
Jurnal Pendidikan IPA Indonesia	Sinta 1	42
Cakrawala Pendidikan	Sinta 1	22
Jurnal Inovasi Pendidikan IPA	Sinta 2	20
Jurnal Penelitian dan Pembelajaran IPA	Sinta 2	5
Jurnal Penelitian Pendidikan IPA	Sinta 2	56
Jurnal Pengajaran MIPA	Sinta 2	21
Jurnal Pendidikan Science Indonesia	Sinta 2	158
Momentum Physics Education Journal	Sinta 2	4
Indonesian Review of Physics	Sinta 2	2
Total		330

Selection Criteria

The findings from the selection criteria for acceptance (inclusion) and rejection (exclusion) of 330 articles, articles that met the acceptance criteria, namely 18 articles with acceptance criteria: (1) The topic of problem-based learning (PBL) models or problem-based learning models (PBM) in physics subjects, (2) Publications (2015-2021), and (3) Full text.

Three hundred twelve articles were selected or rejected, while the exclusion criteria were: (1) Outside the topic of problem-based learning (PBL) models or problem-based learning models (PBM) in elementary mathematics subjects, (2) Prior publications (2015 -2021) and (3) Unfull tex.

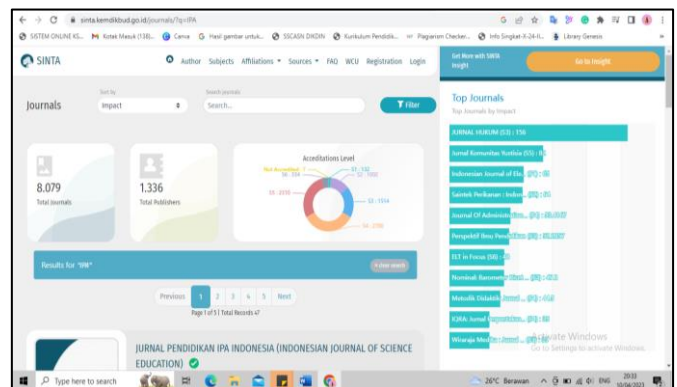


Figure 2. Article Search

The Study Process

After selecting the criteria for acceptance and rejection of scientific articles that will be examined, at this stage, the researcher reads the title and abstract of

each article to find out whether the article is relevant to the topic raised in this research. At this stage, 16 articles were found, and two were not relevant to this study. Articles that are considered irrelevant because the authors need to include the subjects in their research and their research methods are not appropriate.

The Quality of Studies

The results of the study quality are that ten journal articles meet the study quality criteria, as evidenced by the yes answers to all questions (QA1, QA2, QA3). This means that the journal articles in the table have been indexed in Sinta 1 and Sinta 2, written down research problems related to the PBL model in physics learning, and the author wrote down the research method.

Synthesis Result

The final stage is to perform data synthesis. This stage was carried out to obtain and integrate information from selected research to respond to research questions. RQ1. How is the achievement of student learning outcomes in learning physics based on the results of a review of research articles regarding the PBL model?

It is proven to work based on a review of 10 journal articles regarding the problem-based learning model. Article 1 was written by Aulia et al. (2019). This research gives good results, proving that using the The PBL model can increase student study results. In this research, it was shown that there was an increase in student independence, which indicates that there is an increase in student learning outcomes. This research displays the average value between the control and experimental classes. Namely, the average value in the control class is 58.51. In the class that has been given treatment, it is 58.51. 71.67. Where student learning independence after being given treatment is better than before, using the PBL model in this study can increase student learning independence.

Article 2, written by Yarid & Ariswan (2016). As for the results of this study, the accumulated indicators showed that the mastery of students' learning outcomes in the experimental class was higher, with a value of 62.93% compared to the control class of 57.20%. Then in the cognitive aspect, the average value in the experimental class was 62.93, and the average value in the control class was 57.20. Furthermore, the experimental class's results on students' learning interests had an average value of 67.50, and the control class had an average of 65.65. Moreover, in the experimental class, the learning outcomes of students' creative thinking had an average of 74.91 and an average control class of 65.56.

Article 3, written by Ulva (2017). This study showed that the pretest and posttest results of the students' physics learning outcomes increased by around 17.10 points from the average pretest score of 58.20 and the posttest average score of 75.30. It can be concluded PBL-based Physics learning tools through the use of blogs are a learning process that allows students to participate during the learning process actively and can develop their scientific process skills and problem-solving.

Article 4 written by Kurniawati & Suryadarma (2015). The results of this study obtained an average pretest score of 4.93 and an average posttest score of 7.32. In addition, it is also proven that learning media can improve students' critical thinking skills, as indicated by a significance value of 0.00. So PBL-based computer-assisted learning media is feasible and effective for improving students' critical thinking skills.

Article 5 was written by Aristawati et al. (2021). The results show that the final average of students' creative thinking abilities is 73.80 in learning with the PBL model and 65.97 in the final average of students' creative thinking abilities with the expository learning model. Besides that, the increase in student learning outcomes in the knowledge aspect was 17.14%. In addition, students' learning outcomes in the skills aspect also increased. Using problem-based learning models can improve students' learning outcomes and skills, especially creative thinking skills.

Article 6, written by Suwandi et al. (2021). The results of this study indicate an increase in problem-solving abilities in students. The strategy implementation is the indicator with the highest increase, with a value of 0.59, which is categorized as medium. This indicates an increase in students' problem-solving abilities after using the PBL learning model, although the increase is not very significant.

Article 7 written by Rahmadita et al. (2021). This research shows that there are differences in critical thinking skills between male students and female students. The difference is significant, with the average value of male students' critical thinking ability being 59.1 and 52.8 for female students. The difference in average scores is because students have different mindsets. Male students can identify existing problems with the facts faced by the problem and think logically, concisely, effectively, and efficiently. In addition, students can identify existing problems based on elements that are only related to the problem. However, female students only identify using the facts in the questions logically, detailed, and in completely. So that there are differences between male and female students, namely being able to identify problems and understand the questions in these problems. This can be seen from the ability to write down the elements that are known from these elements

Article 8, written by Putri et al. (2021). This research produces the average value of the indicators of argumentative, counter-argument, refutable evidence, argument justification, counter-argument justification, and rebuttal justification. The six results show all high categories, with average values sequentially, namely 1.5, 1.5, 1.4, 2.1, 2.1, and 2.1. The conclusion of this research shows that student learning outcomes are measured by students' argumentation skills for each indicator in the high category.

Article 9, author Aufa et al. (2021). Research from this study resulted in differences in critical thinking skills and environmental care attitudes among participants who used the wetland environment-based PBL model e-module and used standard textbooks, which was shown through the MANOVA test with the results of the value of $F = 3798.463$ and $p = 0.00 < 0.05$. From the results of this study, the average value of students' critical thinking skills can be seen from the average value of the normalized gain score, which is obtained 0.84 in the experimental group that used the problem-based learning model based on the basalt environment, which is higher than the control class that uses ordinary textbooks that is equal to 0.66. Furthermore, this study found the average acquisition for environmental care attitude scores. The experimental group was still superior at 0.86 and the control class at 0.61. The difference in the average gain score indicates that the PBL model based on the wetland environment has a positive effect on the results of students' critical thinking skills. Based on the research and discussion results, using the Problem-Based Learning e-module model based on the wetland environment can improve the ability to think critically and care for the surrounding environment from the control class, which only uses ordinary textbooks.

Article 10, written by Lestari & Projosantoso (2016). The results of this research show the average value of students' analytical thinking, which is an average of 0.51 for the experimental class of researchers in the moderate category and 0.39 for the control class in the moderate category. Furthermore, the average value of students' scientific attitude acquisition was also obtained, which was 0.43 in the experimental class in the moderate category, and the control class was 0.36 and in the moderate category. The increase in gain shows that comic media effectively increases students' analytical thinking skills and scientific attitudes. The multivariate analysis in Table 10 shows that at a significance level of 0.05, the Sig value of Wilks' Lambda is 0.041. This value is < 0.05 . In conclusion, there is a difference in the average analytical thinking ability and scientific attitude due to the use of comic media in the experimental class. Comics with the PBL model effectively increase analytical thinking skills and scientific attitudes. There is

a significant effect due to the treatment of comic media using the PBL model in the experimental class.

The ten articles reviewed in this study show that there is an increase in learning outcomes after using the PBL model in learning activities, especially learning physics. The increase can be seen from the research results of each researcher. Researchers in articles A1, A2, A5, A9, and A10 compared the experimental class and the control class, namely the experimental class using a problem-based learning model and the control class using another learning model. Moreover, research on articles A3, A4, A6, A7, and A8 was carried out by comparing the students' pretest and posttest results.

RQ2. Does the PBL model affect the achievement of students' 21st-century learning outcomes in learning physics?

To see whether there is an influence or not from the PBL model on physics learning, we can see the achievement of student learning outcomes from several studies. Based on the results of a review of problem-based learning articles, an outline is explained in table 3.

Table 3. Improvement of Student Skills

21st-Century Learning Outcomes	Frequency (%)
Creative Thinking Skills	20
Critical Thinking Skills	20
Argumentation Skills	10
Science Process Skills	10
Problem Solving Skills	20
Analytical Thinking Skills	10
Learning independence	10

As seen in table 3, student learning outcomes in 21st-century learning can be achieved using the PBL model. The 21st-century learning outcomes achieved from this study's ten articles are creative thinking and problem solving, critical thinking, argumentation, science process, and analytical thinking skills. These data prove that there is an influence of the PBL model in learning physics on the achievement of 21st-century learning outcomes of students.

The effect of applying the PBL model was measured based on the difference in the pretest and post-test scores of each treatment group and control group. The statistical analysis results show that the learning model significantly affects problem-solving abilities and students' cognitive learning outcomes. Students who learn using the PBL model have higher problem-solving skills and cognitive learning outcomes than those who get conventional learning.

The results obtained are closely related to the learning activities applied. Learning with the PBL model involves students actively in understanding the

concepts and principles of a material because the characteristics of this learning pose problems to students. The problems given can train students to carry out problem-solving habits that will affect students' high-level abilities. The ability in question, for example, accustoms students to think creatively by exploring and expressing ideas and identifying solutions that can be applied to solve a given problem. The problem-based learning model can make it easier for students to develop thinking and problem-solving skills, become independent learners and trains them to develop and explore problems by increasing their awareness of different ways of thinking for solving a problem. The problem-based learning model is found to develop students' problem-solving abilities and cognitive learning outcomes because it is considered to have the principle that students not only gain knowledge in learning but also understand how to implement it in everyday situations, including learning how to learn. In Problem Based Learning (PBL), students discuss and analyze problems in groups. This causes several issues or topics that require exploration. Students then use unresolved issues or topics as a guide to direct their learning activities. PBL can also increase student activity in-class learning and the amount of information students can remember. When student participation increases, thinking activity also increases, improving students' cognitive abilities; it affects the increase in cognitive learning outcomes.

PBL involves active students in learning so that student learning becomes more meaningful. Besides, the Problem Based Learning (PBL) evaluation phase can be used as a reflection activity. Students can rewrite new experiences and knowledge so that this activity cause positive things for students memory of the material being taught. This also affects students' cognitive learning outcomes. In line with the view of constructivism, the discovery of knowledge compiled and built by students will stick to students' memories for a long time.

Learning with the PBL model also allows students to interact with fellow students and between teachers and students. This impacts the sense of belonging that learning in the classroom belongs not only to the teacher but also to students so that students will be trained to be responsible in their learning. Students who are given autonomy will show internal motivation, less learning tension, and learn concepts better.

Conclusion

Based on the research results of systematic literature reviews of journal articles prove that there is an effect of implementing problem-based learning

models on learning physics, which can be seen from the increased achievement of learning outcomes after implementing the model, namely: (1) increasing the independence of student learning, (2) increasing creative thinking skills, (3) critical thinking skills, (4) argumentation skills improvement, (5) science process skills, (6) problem-solving skills and (7) analytical thinking skills.

Acknowledgements

The author expresses his gratitude to the supervisor who has helped carry out this research.

Author Contribution

Utari Nurmahasih, the principal author, contributed to the planning, execution, and writing of the research studies. Jumadi Jumadi, the second author, assisted in directing the research and drafting of the articles.

Funding

There was no outside support for this study.

Conflicts of Interest

The authors say they have no competing interests.

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