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Literature Study: Analysis of the Effect of the Problem-Based Learning Model on Critical Thinking pand Problem-Solving Skills

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ABSTRACT

Learning at school requires students to be able to develop their own learning skills, including critical thinking skills and problem-skills. Students will get various values that will bring changes to student actions. The research aims to re-analyze the effect of the PBL learning model on students' learning skills in biology learning. This research is a study that uses literature study techniques with a sample of 12 national journal articles and 4 international journal articles to be analysed. This journal article will show the effect size of each article that has been obtained will then be interpreted according to the effect size classification. The results of this study show that the effect size of students' learning skills on the average effect size of critical thinking skills is 1.56 and problem-solving skills is 1.22. In this study it can be concluded that the results of the meta-analysis show that there is an influence of the problem-based learning model on student learning skills.

INTRODUCTION

Education plays a very important role in developing students' potential and competencies needed to face the challenges of modern education. Along with global dynamics and societal changes, education is no longer understood merely as a process of knowledge transfer, but as a means of equipping learners with adaptive skills for lifelong learning. In this context, education encompasses all forms of learning that occur throughout life and in various learning environments, contributing positively to individual development (Taqiya et al., 2024). Consequently, current educational development emphasizes the mastery of 21st-century skills, which are essential for preparing students to actively participate in academic and professional contexts (Jumiah et al., 2024).

The term "21st-century skills" refers to the set of knowledge, work patterns, abilities, and character traits that a person needs to live life effectively, especially in the context of education and the professional world (Rahman, 2019). The first set of 21st-century skills focuses on critical learning and innovation skills: (1) critical thinking and problem solving, (2) communication and collaboration, and (3) creativity and innovation. Critical thinking and problem solving are

considered the foundation of 21st-century learning because these skills enable students to analyze information, evaluate evidence, and solve complex problems encountered in real-life situations (Trilling & Fadel, 2009; Tarigan, 2025).

In line with these demands, the current learning process emphasizes the role of students rather than teachers, making it *student-centered* (Auliana, 2019). Students are expected to develop learning skills, including critical thinking and problem-solving skills. The biology/science learning process emphasizes providing direct experience; therefore, students need to be assisted in developing a number of skills through various efforts on how to "know" and how to "do" so that students are able to understand the natural world in depth (Fitri, 2016). Through the process of learning biology/science, students will be able to develop critical thinking and problem-solving skills because biology/science has a comprehensive structure and study and is directly related to everyday life.

Critical thinking skills are high-level thinking abilities that help students make decisions, analyze assumptions, and solve problems. Critical thinking skills are also the ability to ask appropriate questions, gather relevant information, act efficiently and creatively based on information, and draw conclusions (Ariyani, 2020). Problem solving involving critical thinking in biology learning can be effectively addressed through direct experience, requiring students to construct their own thoughts (Putri, 2015). Students need strong critical thinking skills because critical thinking plays an important role in solving problems they encounter (Ayuningrum, 2015). Problem-solving skills provide students with direct experience, thereby enhancing their ability to construct, understand, and apply the concepts they have learned (Sumiantari, 2019).

Critical thinking and problem-solving skills are higher-order thinking skills that require students to be able to reason, analyze, and make decisions rationally. Critical thinking skills can be measured through several indicators, namely simple explanations, basic skills, conclusions, further explanations, as well as strategies and tactics. (Priani et al., 2025). Meanwhile, Polya's problem-solving indicator (Laia & Harefa, 2021) among others: a) understanding the problem; b) planning the solution; c) implementing the solution plan; d) reviewing the results of the solution, so that ultimately, with the problem-solving skills possessed by students, the techniques used in solving problems are more structured and logical. These indicators are important references in assessing the extent to which students are able to understand problems, process information, and determine the right solutions in biology learning.

To address the development of these higher-order thinking skills, an instructional approach that is theoretically grounded in cognitive learning principles is required. From a cognitive learning perspective, Problem-Based Learning (PBL) is based on constructivist theory, which emphasizes that knowledge is actively constructed through student engagement in meaningful problem solving. Problem-based learning encourages students to take an active role in the PBL learning context, which involves complex cognitive processes including analysis, evaluation, and reflection (Wijnia et al., 2024). Collaborative discussions and guided inquiry in PBL further facilitate the elaboration of ideas and enhance metacognitive awareness, which plays an important role in the development of critical thinking skills and problem-solving abilities (Fatimah et al., 2025).

The reality on the ground is that students still find it difficult to develop the skills needed to identify and solve problems they encounter in biology learning. Biology learning is also related to

the process of finding out, so that biology learning is not just about mastering a collection of facts and concepts, but also a process of improving students' skills (Berutu & Tambunan, 2018). Currently, teachers still treat students as objects of learning rather than individuals whose potential should be developed (Nisa, 2020). Efforts to develop these skills have not yet been optimal. Based on a literature study of national and international journals, various problems have been identified, including: (1) students are not yet fully able to master the concepts, resulting in their inability to solve problems, (2) biology lessons are not yet accustomed to relating to the daily lives of students, (3) the minimum competency standards are quite high, (4) higher-order thinking exercises are not planned, resulting in low student ability to solve real-life problems and make decisions, (5) students' critical thinking skills are still low, (6) weak reasoning skills, students prefer to memorize what they learn from teachers rather than develop their critical thinking skills. Although many studies show that the Problem-Based Learning (PBL) model can improve students' critical thinking and problem-solving skills, the findings still show significant variations between studies. This variation raises the need to comprehensively evaluate the latest empirical evidence on the effectiveness of PBL in improving students' higher-order thinking skills. Thus, a literature-based re-analysis of previous studies is important to obtain a stronger picture and generalization of findings from various learning experiences.

Biology learning is closely related to finding out information and developing that information, so that students are expected to be able to overcome problems that arise (Kusumawati, 2019). Based on the issues discussed above, there is a need to improve the quality and innovation of learning, especially learning models that can guide students to solve problems and facilitate activities in an effort to improve students' critical thinking skills. One learning model that can be applied is the problem-based learning model. A learning model is a systematic procedure for organizing learning experiences to achieve learning objectives (Wulandari, 2019). Problem-Based Learning is an instructional model between teachers and students through problem solving based on student experiences. This learning model also addresses authentic problems with the aim of developing their own knowledge, fostering independence, and building self-confidence (Mukharomah, 2021).

The PBL model confronts students with problems as the basis for learning; in other words, students learn through problems or based on problems (Supiandi, 2016). The PBL model is a learning model based on the philosophy of constructivism. In implementing this learning model, students are required to be actively involved in the learning process through group discussions. PBL exposes students to problems as the basis for learning, thereby enabling students to explore information on problems that exist in everyday life (Ullynuha, 2015). According to Ibrahim and Nur in their research (Fitri, 2016), PBL has the following characteristics: (1) asking questions or posing problems, (2) focusing on interdisciplinary connections, (3) authentic inquiry, (4) producing and presenting products/works, and (5) collaboration. The learning steps in the problem-based learning model are: (1) orienting students to the problem, (2) organizing students to learn, (3) guiding individual/group experiences, (4) developing and presenting work, (5) analyzing and evaluating the problem-solving process. From a cognitive perspective, PBL is based on the principle that engagement in meaningful problem solving can encourage higher-order thinking processes such as analysis, evaluation, and reflection. This model allows learners to integrate prior knowledge with new information through active interaction, collaboration, and shared reflection,

thereby supporting the simultaneous development of critical thinking skills and problem-solving strategies (Fatimah et al., 2025).

PBL characteristics such as orientation towards real problems, information exploration, group collaboration, and solution reflection are directly related to critical thinking and problem-solving indicators measured in many 21st-century education studies, such as the ability to identify issues, formulate strategies, assess evidence, and make logic-based decisions. Although many studies show positive results, there is still no strong consensus on the extent to which PBL consistently improves students' critical thinking and problem-solving skills across different levels of education and subjects. In addition, some studies are still limited to specific local contexts, so they need to be examined more broadly to obtain more general conclusions. Thus, a re-analysis of these findings is needed to provide more comprehensive evidence that can be used as a guideline for evidence-based learning (Wiratama *et al*., 2025) Based on this explanation, the study aims to re-analyze the effect of the PBL learning model on students' learning skills in biology. This study is expected to provide benefits in the field of biology, especially for educators in the use of the problem-based learning learning model.

METHOD

This study employed a literature review design with a quantitative re-analysis approach (Astuti, 2019). A total of 16 journal articles (12 national and 4 international) were selected as research samples. The data were obtained through a systematic search using the Google Scholar database (Febrianti, 2021) with the following keywords: "problem-based learning", "critical thinking skills", "problem-solving skills", and "biology education". The inclusion criteria were: 1) articles published between 2015 and 2021, as the 2015-2021 publication period was chosen to capture previous empirical studies that reflect contemporary developments in 21st-century learning, critical thinking assessment, and the application of Problem-Based Learning (PBL) in the context of modern education. The time frame restriction ensures the inclusion of previous pedagogical practices and methodological approaches that are still relevant to current educational standards., 2) empirical studies using quasi-experimental designs, 3) studies reporting pre-test and post-test mean scores, 4) articles providing sufficient statistical data to calculate effect size, and 5) articles published in peer-reviewed national and international journals in English and Indonesian.

The article selection process followed the framework of PRISMA (Preferred Reporting items for Systematic Reviews and Meta-Analyses) to ensure transparency and systematic screening (Page et al., 2021). The flow of identification, screening, eligibility assessment, and final inclusion of studies. The data extracted from each article included: author (s), year of publication, research design, sample size, and mean scores of pre-test. Some of the articles used contain incomplete statistical data. The effect size (ES) was calculated using the following formula 1.

$$ES = (Mean\_post - Mean\_pre) / SD \ldots\ldots\ldots (1)$$

Where Mean_post represents the post-test mean score, Mean_pre test represents the pre-test mean score, and SD refers to the standard deviation of the pre-test scores. The results of the *effect size* calculation can be interpreted into the categories in Table 1.

Table 1. Classification of *Effect Size*

Effect size	Category Standard
0 Is 0.2	Low
0.2 < Es < 0.8	Medium
It is > 0.8	Height

[a](Santosa, 2021)

RESULTS AND DISCUSSION

This study reviewed 16 journal articles from national and international journals on the effect of the problem-based learning model on students' learning skills. The results show that the problem-based learning model has an effect on students' learning skills. The 16 journal article titles are listed in Table 2.

Tabel 2. Journal Article Title

No	Journal Article's Title
1	Problem-Based Learning and Student Critical Thinking to Improve Learning Achievement at Private Universities in Aceh
2	Learning Bryophyta: Improving Students' Scientific Literacy Through Problem-Based Learning
3	Problem-Based Learning: Generates Higher-Order Thinking Skills of Tenth Graders in Ecosystem Concept
4	Problem-Based Learning: Creative Thinking Skills, Problem-Solving Skills, and Learning Outcome of Seventh Grade Students
5	Pengaruh Penerapan Model Pembelajaran *Problem Based Learning* (PBL) terhadap Kemampuan Kognitif Mahasiswa pada Mata Kuliah Pengetahuan Lingkungan.
6	Efektifitas *Problem-Based Learning* dengan *Brainwriting* Berbasis Masalah Diversifikasi Pangan terhadap Kemampuan Berpikir Kritis dan Berkomunikasi Siswa
7	Komparasi Model *Problem Based Learning* dan *Discovery Learning* terhadap Keterampilan Berpikir Kritis Siswa SMP
8	Pengaruh Model Pembelajaran *Problem Based Learning* Berbantuan *Information and Communication Technologies* terhadap Keterampilan Berpikir Kritis Siswa.
9	Pengaruh Model Pembelajaran *Problem Based Learning* terhadap Keterampilan Berpikir Kritis Siswa SMP
10	Pengaruh Model Pembelajaran *Problem Based Learning* terhadap Keterampilan Berfikir Kritis Siswa
11	Pengaruh Model *Problem Based Learning* terhadap Kemampuan Pemecahan Masalah IPA Siswa Kelas VIII SMP
12	Penerapan Model Pembelajaran *Problem Based Learning* pada Pelajaran Biologi untuk Meningkatkan Kompetensi dan Kemampuan Berpikir Kritis Siswa Kelas X
13	Pengaruh Model *Problem Based Learning* (PBL) terhadap Kemampuan Memecahkan Masalah dan Hasil Belajar Kognitif Siswa Biologi SMA
14	Pegaruh Model *Problem Based Learning* terhadap Keterampilan Berpikir Kritis Siswa SMA pada Materi Protista
15	Pengaruh Pembelajaran *Problem Based Learning* (PBL) terhadap Kemampuan Berpikir Kritis Siswa Kelas X SMA Negeri 6 Surakarta
16	Penerapan Model *Problem Based Learning* (PBL) untuk Meningkatkan Kemampuan Berpikir Kritis Siswa Kelas X-4 SMA Negeri Kebakkramat Tahun Pelajaran 2014/2015.

Analysis of the effect of the Problem Based Learning model on students' learning skills based on the type of research can be seen in Table 3. The table shows that of the 16 journal articles

have been analysed, there were 4 journal articles that belonged to the Classroom Action Research (CAR) type and 12 journal articles that belonged to the quasi-experimental research type.

Table 3. Literature Study Based on Research Type

No	Research Type	Frequency
1	Classroom Action Research	4
2	Quasi-experiment	12

The types of journals taken from several journal articles and international journal articles are listed in Table 4.

Tabel 4. Literature Study Based on Journals and Year of Publication

No	Researcher	Journal	Published
1	Ibrahim, et al.	International	2021
2	Vitri, et al.	International	2021
3	Ramdiah, et al.	International	2018
4	Khoiriyah, et al.	International	2018
5	Mukharomah, et al.	National	2021
6	Arsanti, et al.	National	2020
7	Ariyani, et al.	National	2020
8	Wulandari, et al.	National	2019
9	Auliana, et al.	National	2019
10	Kusumawati, et al.	National	2019
11	Sumiantari, et al.	National	2019
12	Fitri.	National	2016
13	Supiandi, et al.	National	2016
14	Ayuningrum, et al.	National	2015
15	Ullynuha, et al.	National	2015
16	Putri, et al.	National	2015

Table 4 shows that the results of the journal article literature study found 4 international journal articles published in 2018 and 2021. Meanwhile, there were also 12 national journal articles published in 2015, 2016, 2019, 2020, and 2021. In addition to the above literature study, we can also see the results of a literature study on the effect of the *problem-based learning* model on the learning abilities of students, as shown in Table 5.

Based on Table 5, the data from the analysis of the Problem Based Learning model and its effect on critical thinking skills shows that in point 1, the critical thinking score before using the Problem Based Learning model was 56.93, while the critical thinking score after using the Problem Based Learning model was 82.02. The critical thinking score of students before using the Problem Based Learning model was 56.93, while the critical thinking score after using the Problem Based Learning model was 82.02. a1>was 56.93, while the critical thinking results after using the Problem Based Learning model were 82.02. The critical thinking results of the students in this case showed a positive effect with a percentage of 25.09%.

Tabel 5. Results of Analysis of the Effect of PBL Learning Model on Critical Thinking and Problem-Solving Skills

No	Critical Thinking		Influence (%)	*Effect Size*	Problem Solving		Influence (%)	*Effect Size*
	Before	After			Before	After		
1	56,93	82,02	25,09	**1,50**	71,10	76,80	5,7	**0,35**
2	43,12	83,62	40,5	**2,42**	48,33	80,66	32,33	**2,02**
3	11,67	36,23	24,56	**1,47**	65,20	79,00	13,8	**0,86**
4	79,23	86,78	7,55	**0,45**	71,29	99,75	28,46	**1,78**
5	50,40	78,50	28,1	**1,68**	N/A	N/A	N/A	**N/A**
6	46,21	79,55	33,34	**1,99**	64,40	70,00	5,6	**0,35**
7	75,35	78,40	3,05	**0,18**	72,00	73,50	1,5	**0.09**
8	26,77	77,33	50,56	**3,02**	N/A	N/A	N/A	**N/A**
9	28,60	37,30	8,7	**0,52**	N/A	N/A	N/A	**N/A**
10	41,56	64,17	22,61	**1,35**	N/A	N/A	N/A	**N/A**
11	N/A	N/A	N/A	**N/A**	31,61	74,45	42,84	**2,68**
12	75,82	92,51	16,69	**0,99**	75,78	90,19	14,41	**0,91**
13	49,54	74,19	24,65	**1,47**	46,36	64,09	17,73	**1.10**
14	28,19	73,16	44,97	**2,69**	N/A	N/A	N/A	**N/A**
15	89,00	97,00	8	**0,47**	86,00	92,00	6	**0,37**
16	42,36	95,14	52,78	**3,16**	46,53	93,75	47,22	**2,95**
	Number		391,15	23,43			215,59	13,49
	Average		26,07	1,56			19,59	**1,22**
	Standard Deviation		16,69				15,97	

Based on Table 5, 11 effect sizes were obtained for critical thinking skills in the "high" category, including: 1.50; 2.42; 1.47; 1.68; 1.99; 3.02: 1.35; 0.99; 1.47; 2.69; 3.16. This study also obtained 5 effect size values in the "moderate" category, including: 0.45; 0.52; 0.47 and 1 effect size value in the "low" category, namely 0.18. Meanwhile, the effect of the problem-based learning model on problem-solving skills showed seven effect size values in the "high" category, including: 2.02; 0.86; 1.78; 2.68; 0.90; 1.10; 2.95. This study also obtained *effect size* values in the "medium" category, including: 0.35; 0.35; 0.37 and there was 1 *effect size* value in the "low" category, namely 0.09.

The data from the analysis of the Problem Based Learning model related to its effect on problem-solving skills shows that at point / a1>1, the problem-solving results before using the Problem Based Learning model were 71.10, while the problem-solving skills results after using the Problem Based Learning model were 76.80. The results of the problem-solving analysis in this case show that the effect is not very high, at 5.7%.

The average score of the analysis of the effect of the Problem Based Learning model on students' learning skills in critical thinking was 26.07%, while in problem-solving skills it was 19.59%, as shown in Figure 1.

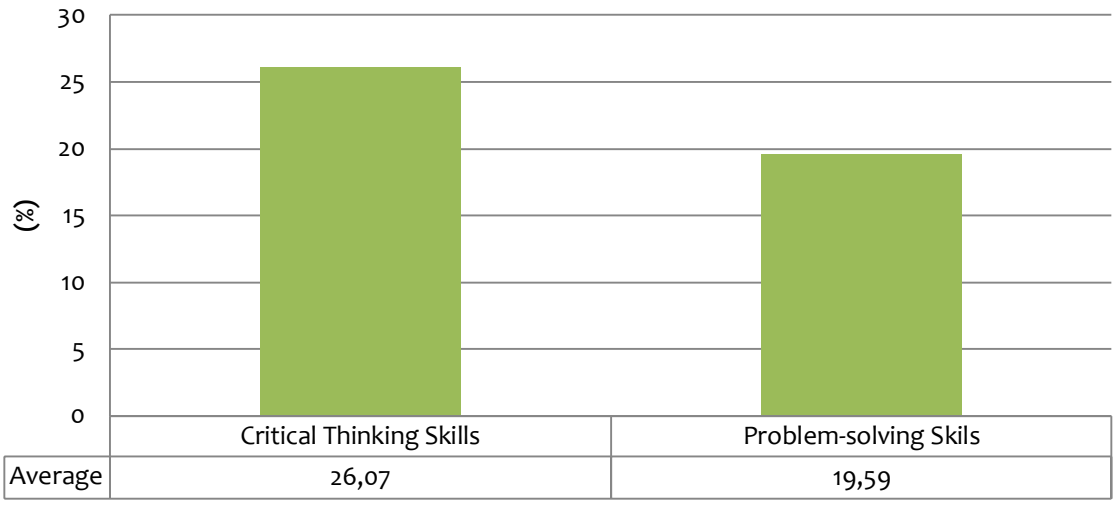

Figure 1. Average Effect of PBL on Critical Thinking and Problem-Solving Skills

The explanation shows that the analysis results indicate the effect of the problem-based learning model on critical thinking skills and problem-solving skills through the average effect size, as shown in Figure 2.

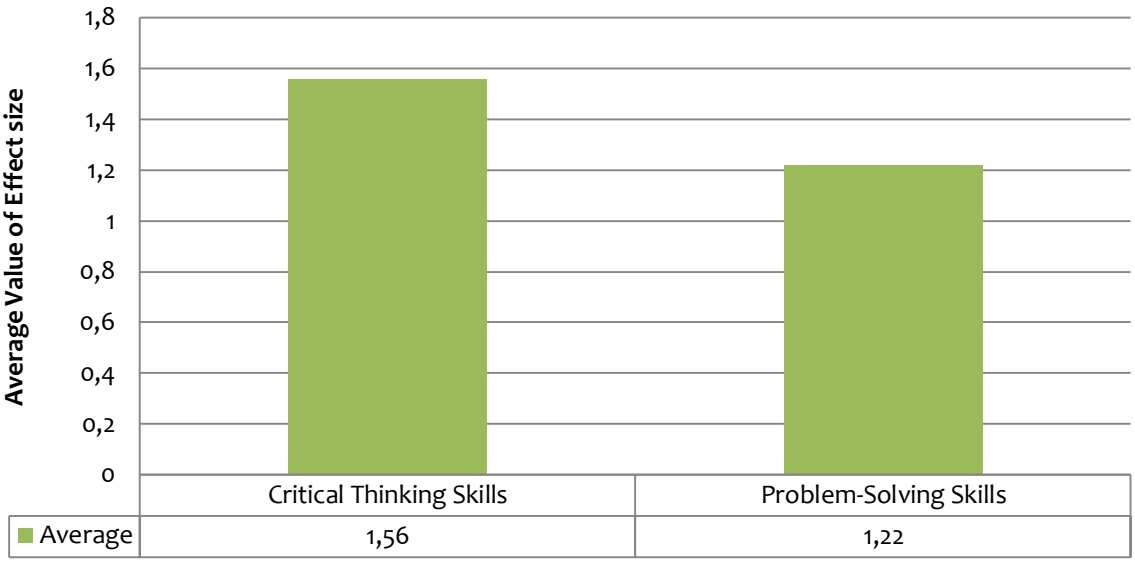

Figure 2. The Average of *Effect Size*

Based on Figure 2, the results obtained were an effect size of 1.56 for critical thinking skills and 1.22 for problem-solving skills. The findings show that the average effect size for critical thinking skills (1.56) is higher than that for problem-solving skills (1.22). This difference may be influenced by several factors. First, most of the studies analysed applied PBL to biology topics that require conceptual reasoning and analytical interpretation, such as ecosystems and protists, which are closely related to critical thinking indicators. Second, critical thinking skill assessment tools are often more structured and aligned with cognitive indicators, making the impact of PBL easier to measure than problem-solving skills, which involve more complex procedural and contextual dimensions. In addition, differences in education levels may contribute to differences in effect sizes. Studies conducted at the high school level tend to report higher effect sizes than studies at the junior high school level, possibly due to the more developed cognitive readiness and abstract

reasoning abilities of high school students. These analysis results show that the problem-based learning model has an effect on students' critical thinking and problem-solving skills.

This is in line with the statement that the implementation of problem-based learning is a model for developing active and creative learning in solving problems faced by students in every learning process (Ibrahim, 2021). Learning activities must be designed to ensure that students are at the forefront of learning activities or are student-centred in order to be more creative in creating a conducive classroom and subsequently to produce meaningful learning, in this case developing creative thinking skills and problem-solving skills (Khoiriyah, 2018).

Students need strong critical thinking skills because critical thinking plays an important role in solving problems they encounter (Ayuningrum, 2015). Problem-solving skills provide students with direct experience, thereby enhancing their ability to construct, understand, and apply the concepts they have learned (Sumiantari, 2019). Therefore, with this learning model, in addition to learning to solve contextual problems, students' critical thinking skills can also develop (Arsanti, 2020). Furthermore, it is explained that PBL also develops students' skills to be more innovative and creative in completing tasks (Ramdani et al., 2021). The construction of knowledge through PBL is a reason to engage students' skills (Nainggolan, 2021).

This study has several limitations. First, most of the studies included in this analysis used quasi-experimental designs (12 studies) rather than classroom action research (4 studies), which may affect the generalizability of the findings. Second, variations in sample size, assessment tools, and biological topics across studies may contribute to the heterogeneity of effect size values. Third, the analysis relied on reported statistical data, and some studies did not provide complete information, limiting a comprehensive quantitative synthesis. Further research is recommended to conduct a full meta-analysis with heterogeneity testing and moderator analysis to explore factors influencing effect size differences.

CONCLUSION

Based on the findings, it can be concluded that the results of this analysis show that the problem-based learning model has an effect on students' critical thinking and problem-solving skills. This is evidenced by the results of the *effect size* of critical thinking skills, which is 1.56, and problem-solving skills, which is 1.22. These findings imply that the Problem-Based Learning (PBL) model can be effectively applied by teachers as a learning approach to develop higher-order thinking skills, particularly in a learning context that emphasizes real-world problems and active student engagement. Teachers are advised to design learning activities that integrate authentic problems, collaborative discussions, and reflective thinking in order to maximize the benefits of applying PBL in classroom learning practices. Furthermore, future research is recommended to explore the application of the PBL model at various levels of education, fields of study, and learning environments. Empirical studies with experimental or quasi-experimental designs are also needed to examine the long-term impact of PBL on students' cognitive and metacognitive abilities and its effectiveness when integrated with digital or blended learning approaches.

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