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Improving Critical Thinking Skills using Problem Based Learning: Systematic Literature Review

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Abstract: Enhancing critical thinking skills is a valuable learning asset in the twenty-first century, and utilizing an educational framework that promotes this development can aid students' growth. Research reveals problem-based learning as the sole form of instruction most effective at fostering critical thinking abilities among pupils. In light of these findings, this study examines articles from Sinta-indexed journals to evaluate research on PBL models regarding their impact on promoting critical thought processes. The purpose of this paper is to provide a comprehensive overview of reputable publications released within the last five years (2020-2024), highlighting how PBL strategies assist learners in cultivating crucial analytic capabilities. The primary focus of this study is data on critical thinking abilities and problem-based learning models in the fields of science, biology, chemistry, physics, and mathematics. This research used the PRISMA approach, a literature study methodology consisting of four parts (identification, screening, feasibility, and inclusion). It is found through identification, screening, and eligibility there are 12 articles collected from various journal publishers and hundreds of journal articles. The study's conclusions indicate that most research on PBL models and critical thinking abilities is carried out in Indonesia at different educational levels. Scientific research frequently makes use of experimental procedures. Furthermore, it was shown that PBL research encompasses more traits than only critical thinking abilities. The examination of current publications makes it clear that the PBL technique can promote critical thinking abilities.

Keywords: Critical thinking skills; Problem Based Learning; Systematic Literature Review.

Introduction

Learning for the twenty-first century should inspire students to learn effectively and develop their twenty-first century skills (Septikasari & Frasandy, 2018). Critical thinking is just as important as creativity, teamwork, and communication skills for students. Because critical thinking abilities are crucial in today's world, students need to develop them (Jamaluddin et al., 2020). For students to be ready to face the advancement of science and technology in the 21st century, critical thinking is a must. If students develop this skill during the learning process, they can become proficient in the skill. In the 21st century, learning should involve the development of critical thinking skills in addition to the mastery or understanding of the knowledge provided.

Problem-based learning model is one of the learning strategies that help students improve critical thinking skills. According to Fakhriyah, (2014) the problem-based learning model involves students in dealing with real-world problems to compile their own knowledge, develop critical thinking and inquiry skills, and build independence and confidence.

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There is now less effort made in secondary schools to support students in developing their critical thinking abilities. The continuous use of lecture-based learning models by teachers and the lack of student-centered teaching approaches are evident in the way they teach so students are not given the stimulus they need to develop critical thinking skills. In addition, to prevent students' engagement and boredom with the teacher's media, educational materials are given to students in the form of lectures.

Learning should occur naturally, i.e. students should be involved in activities and experience the material. Thus, learning involves more than just passing knowledge from teacher to student. A learning model is needed that assists teachers in explaining the subject matter taught and the circumstances faced by students through the use of inventive, progressive, and contextual learning models so that the desired learning outcomes are more meaningful (Al-Tabany, 2017).

The learning model is one of the tools used to assist the learning process because this learning model recognizes the needs of students and teachers should provide material in a way that makes students not bored (Dewi, 2018). The problem-based learning approach offers an excellent opportunity for students to improve their biological literacy and critical thinking skills. Good education is education in which there is teaching that develops students' critical thinking skills, which helps shape students' personalities and ultimately has a good impact on environmental reading culture activities (Handayani, 2020). The problem-based learning approach is one of the learning strategies that can help students improve their critical thinking skills.

A number of research studies have been carried out to assess how well PBL fosters critical thinking skills. The objective of this piece is to provide an overview of the research findings that have been examined and reported in credible daily articles over the course of the last five years (2020–2024), with an emphasis on the value of critical thinking skills for students and how the PBL model may be utilized to support their development. The majority of the data included in this study are associated with critical thinking in natural science and problem-based learning paradigms. Articles related to (1) Topic; (2) Subject; (3) Method; and (4) Result.

This research provides a thorough understanding of how problem-based learning (PBL) models have been used to improve critical thinking skills. PBL is recognized as an effective method that can help students deal with real problems and develop critical thinking skills. Therefore, the purpose of this literature review is to collect, evaluate, and synthesize previous research findings related to the application of PBL in improving critical thinking skills, especially in the field of education.

By conducting a systematic literature review, researchers can identify various approaches that have been done to develop critical thinking skills using PBL. This process also helps to discover existing research gaps and areas that have not been sufficiently explored, which in turn provides a foundation for further research. In addition, this literature review also aims to evaluate the effectiveness of PBL in the modern educational context, focusing on how PBL can be applied to meet the needs of students in facing the challenges of the 21st century. The results of this review will provide insights for educators and researchers in designing more innovative and effective learning strategies to improve students' critical thinking skills.

Method

Systematic Literature Review (SLR) is the method used in this study to allow the authors to more effectively report a systematic review to find, examine, assess and understand all the research that has been done on the subject of interest, focusing on relevant research questions. The authors followed the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) methodology when deciding which literature to study. Eligibility requirements, sources of information, search tactics, selection procedures, data collection procedures, and data items were all covered in the PRISMA guidelines applied (Ridho & Dasari, 2023). The overall literature search procedure was completed in April 2024. The author utilized the publish or perish application to conduct their search, which sourced databases from Google Scholar and Scopus websites. Additionally, they manually searched various journal websites. The search process on the publish or perish application used the keywords "problem based learning", "critical thinking" by providing a limitation of the publication period range. A total of 336 articles were found during the in-depth search procedure. To ensure that the data in these articles were appropriate and available, several criteria were applied. The results of the criteria for the articles analyzed can be seen in Table 1.

Tabel 1. Article Criteria

Type of Publication	Articles published in journals
Keywords	Problem based learning and critical thinking
Journal specifications	National journals indexed by Sinta 1-2
Year published	2020-2024
Research site	Indonesia
Field	Sains, Biology, physics, chemistry
Access	*Open Access*

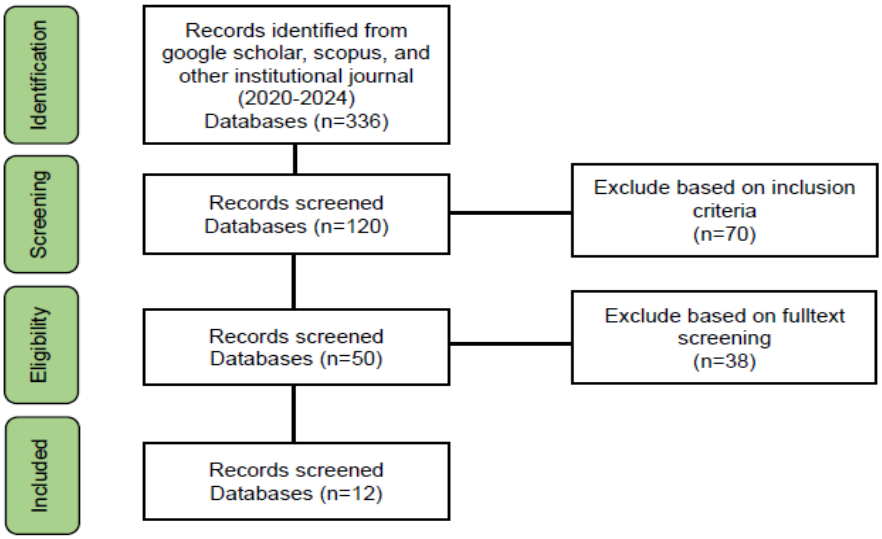

Figure 1. Flowchart of Prism Protocol-Based Literature Selection

After screening based on the inclusion criteria, about 30 articles remained. Furthermore, each article was thoroughly analyzed, and 12 articles were obtained that met the criteria and contained a complete discussion of problem-based learning and critical thinking. Based on the SLR technique that has been used, 12 articles were obtained, with details in Table 2.

Tabel 2. Detail of Articles

Indeks	Name	Keywords
Sinta 2	Jurnal mimbar ilmu	Learning Activities, Critical Thinking, Learning Outcomes, Problem-Based Learning
Sinta 2	Jurnal Penelitian Pendidikan IPA	Critical thinking skills; Electronics module; PBL; STEM.
Sinta 2	Jurnal Penelitian Pendidikan IPA	Critical thinking abilities; PBL; Video
Sinta 2	Jurnal Penelitian Pendidikan IPA	Worksheets; higher-order thinking skills; creative problem solving; biology content
Sinta 2	Jurnal Penelitian Pendidikan IPA	Problem-Based Learning Module; Critical Thinking; E-Module.
Sinta 2	Formatif: Jurnal Ilmiah Pendidikan MIPA	Elementary School, Mathematical Critical Thinking (MCT), Problem Based Learning (PBL)
Sinta 2	Formatif: Jurnal Ilmiah Pendidikan MIPA	Critical thinking, problem based learning, discovery learning
Sinta 2	Jurnal Pendidikan Sains Indonesia (Indonesian Journal of Science Education)	Problem-based learning; high order thinking skills; critical thinking; confidence
Sinta 1	Jurnal Pendidikan IPA Indonesia	Problem based instruction; blended learning; thermodynamic
Sinta 1	Jurnal Pendidikan IPA Indonesia	PBLA; critical thinking skills; junior high school
Sinta 1	Jurnal Pendidikan IPA Indonesia	Creative thinking; critical thinking; learning outcomes; PjBL; PBL
Sinta 1	Journal of Education and Learning (EduLearn)	Critical thinking skills, Inquiry method, iSpring application, Problem based learning, Trigonometry

The most research on problem-based learning on critical thinking skills was conducted in 2023, namely four studies, in 2020 there were three findings. In 2021 there were two journal articles and one journal article in 2022 and 2024. Based on the literature review with various limitations that have been made, only 12 journal articles were obtained on the topic of problem-based learning and critical thinking. This is because the majority of researchers use the terms problem-based learning and critical thinking skills.

Result and Discussion

Research Topic

In the last few lustrum, problem-based learning research has become a trend in learning, especially in natural sciences such as science, physics, chemistry, mathematics and biology. This is because natural sciences are very close to everyday life. For more details, the percentage of natural science fields of study that

have become problem-based learning research trends in the last one lustrum can be seen in Figure 2.

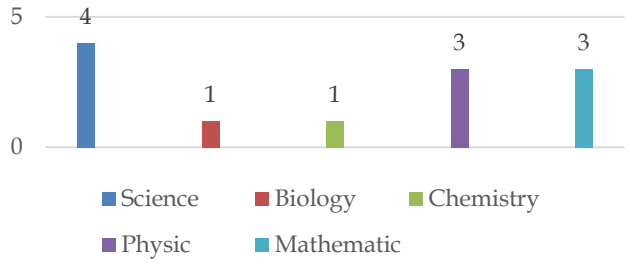

Figure 2. PBL Research Field Chart

Figure 2 displays data on research subjects employed in studies on critical thinking abilities and problem-based learning models for the last five years. Science is the scientific field with the most research, according to Fig. 2. We propose that scientific education ought to impart not just problem-related experiences but also the practical applications of the principles. Working with real-world examples and challenges will help students learn more effectively in both scenarios. The most effective method is to educate using the PBL approach. Using critical thinking and problem-solving techniques in a real-world setting is what PBL encourages students to do (Rahmadita et al., 2021).

Subject Research

The research results, which are based on the responses of the research subjects, have been achieved. The research area for elementary school, junior high school, senior high school and higher education was one of the four groups that the article focused on. There were 12 articles that included research topics divided into categories for elementary school students (N = 1) (Harianja et al., 2023). Junior high school level (N = 2) (Akhdinirwanto et al., 2020); (Prabasari, 2021). High school level (N = 6) (Adhelacahya et al., 2023); (Khoirulloh et al., 2024); (Fatmawati et al., 2021); (Palinussa et al., 2023); (Suradika et al., 2023); (Lestari et al., 2024). At the university level, the subjects involved were students (N = 3) (Rediani, 2022); (Rezkillah & Haryanto, 2020); (Marnita et al., 2020).

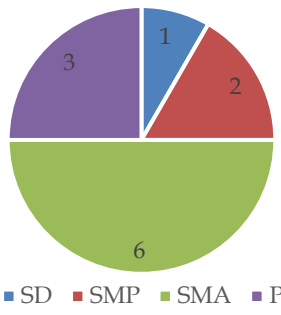

Figure 3. Graph of PBL Research Subjects

The association between students' growth in critical thinking abilities and their topic and course grades is also depicted in Fig. 3. Students should be taught how to critically assess material in the classroom starting in elementary school and continuing through college (Ramdani et al., 2019). For students to successfully navigate the challenges of the twenty-first century, critical thinking abilities are required (Franco et al., 2018; Purnami et al., 2021; Wulandari et al., 2021).

The 21st century requires four competencies, or 4Cs. Critical thinking, creativity, communication, and teamwork are among the 21 skills that the National Education Association (NEA) has recognized. One of the skills required for survival is critical thinking, which is useful in many facets of life. Students' critical thinking abilities ought to be encouraged. According to (Suryanti & Nurhuda, 2021), critical thinking is a method of thinking that tries to fully comprehend the issue at hand, avoids being receptive to the opinions and decisions of others, explains and assesses the information before coming to a decision, and can draw conclusions about cause and effect when assisting in the solution of problems that arise in both educational and real-world contexts.

Type of Research

Figure 4's data demonstrates how researchers included problem-based learning models and critical thinking strategies into their studies. Experimental research was one of the three types of research used by (Rediani, 2022); (Adhelacahya et al., 2023); (Harianja et al., 2023); (Palinussa et al., 2023); (Rezkillah & Haryanto, 2020); (Marnita et al., 2020); (Lestari et al., 2024); (Suradika et al., 2023); Development (Fatmawati et al., 2021); (Prabasari, 2021); (Akhdinirwanto et al., 2020); PTK (Classroom Action Research) (Khoirulloh et al., 2024). Figure 3 below shows a summary of the numbers for each research method used.

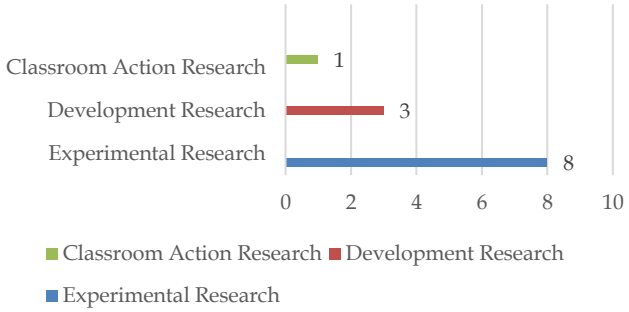

Figure 4. Type of Research PBL

It is evident from Fig. 3 that problem-based learning models and critical thinking abilities make the greatest use of experimental research among the several types of study that have been carried out. To gather data for their

experimental investigation, the researchers employed a range of research designs. The factorial design, the pre-test-post-test control group design, and the post-test only design are the two quasi-experimental study designs that served as the foundation for the identification outcomes. The effect that is observed following treatment is examined through experimental research.

Result Study

The results shown in Table 3 indicate that the PBL approach is successful in enhancing students' critical thinking abilities.

Table 3. Data related to the research results.

Author	Year	Sampel penelitian	Result
Rediani	2022	N = 58 Experiment class = 23 Control class = 25	The findings demonstrated that the activity-based PBL paradigm had a simultaneous and partial effect on learning outcomes and critical thinking abilities.
Adhelacahya et al.	2023	N = 34 Experiment class = 34 Control class = 0	A STEM-integrated approach to problem-based learning improves students' capacity for critical thought.
Khoirulloh et al.	2024	N= 36	The class action research's findings demonstrate that students' critical thinking abilities differed before and after PBL was implemented.
Fatmawati et al.	2021	N=12	This study found that constructivist-based LKS, particularly creative problem solving, should be extensively used to develop students in higher order thinking skills.
Prabasari et al	2021	N=88	Students' critical thinking abilities can be enhanced by the use of problem-based science modules in science materials, particularly those that deal with additives and addictive chemicals. Based on the average validation results of 92%, which include the very feasible category, the produced e-module is highly viable to utilize to support teaching and learning activities.
Harianja et al	2023	N=25	The study's findings demonstrate how PBL might help sixth-grade pupils' critical thinking abilities.
Palinussa et al	2023	Seluruh siswa kelas XI yang terdiri dari 4 kelas	In order to boost student confidence, the PBL model gives students the chance to experience talking and working together to solve challenges pertaining to the subject and helps them discover concepts on their own.
Rezkillah & Haryanto	2020	N=200 kelas eksperimen = 100 kelas control = 100	HOTS-integrated PBL learning model influences critical thinking skills and self-confidence in basic education Ahmad Dahlan University.
Marnita et al	2020	Mahasiswa semester tiga program studi fisika Universitas Almuslim.	Based on the researcher's observations, the situation occurred because students were less likely to become bored and felt uncomfortable or insecure around the lecturer or other students. Students also found it easier to find the fundamental concepts of thermodynamics through direct investigation and with the help of learning videos that aided in their comprehension of each topic covered in the thermodynamics course.
Akhdinirwanto et al	2020	N=26	Learning theories like constructivism, scaffolding, and behavioral learning theory all support the use of the PBLA paradigm to enhance critical thinking abilities.
Suradika et al	2023	2 kelas (XI Farmasi 1 dan XI Farmasi 2)	PBL solves the problem that ice cream is a colloidal liquid emulsion and liquid foam because in making ice cream, agar-agar (colloidal ice crystals by mixing dragon fruit juice as a natural color and flavor) CMC is used in making homemade ice cream. In the syntax of the PBL model, namely guiding individual and group investigations, students critically take action and consider ideas based on the consequences that will be received and think of alternatives in making a project.
Lestari et al	2024	N=20	The use of the iSpring program in conjunction with the problem-based learning model and inquiry technique has a positive impact on students' critical thinking abilities.

One way to improve critical thinking skills is by implementing the problem-based learning approach as an instructional method. Students have the opportunity to increase their knowledge through cognitive processes by using the model. Students still need to be asked to focus on the problem, do all the research themselves, and work hard to practice their ideas in order to learn effectively and be able to apply knowledge. The problem-based learning approach allows students to take an active role in honing their critical thinking abilities. In real life, where numerous issues arise in both personal and external domains, students' critical thinking, open-mindedness, active learning, problem-solving, communication, teamwork, and interpersonal skills make their thinking talents useful.

PBL facilitates group discussions among students, allowing them to exchange ideas and knowledge both individually and in groups. This helps students solve problems more quickly (Fauziah & Fitria, 2022). PBL uses a variety of simulated or real-world scenarios to teach adult tasks while fostering students' independence and autonomy as learners. Because some students appear passive (less passionate) when learning using the PBL approach, and because less than 50% of students actively explain difficult topics to their classmates, it still takes time to transform students' habits from passive to active (Suryanti & Nurhuda, 2021). Students cannot solve problems that are not supported by the PBL model and when they can solve their problems because the PBL model gives them the opportunity to collaborate with others (Suryanti & Nurhuda, 2021).

The PBL paradigm has the potential to enhance students' critical thinking abilities, contingent upon the particular findings of the literature study. According to Adhelacahya et al., (2023), Khoirulloh et al., (2024), Fatmawati et al., (2021), Palinussa et al., (2023), Suradika et al., (2023), and (Lestari et al., 2024), the PBL model is most frequently utilized in high schools to help students develop their critical thinking abilities. This is to ensure students can learn critical thinking, which is a skill expected of them in school. PBL models and critical thinking abilities have drawn a lot of attention in recent research trends concerning science content (Akhdinirwanto et al., 2020); (Prabasari, 2021); (Rediani, 2022); (Rezkillah & Haryanto, 2020). Science-related research materials are essential because science involves both theoretical underpinnings and real-world applications of these theories. Presenting real-world problems is the teaching method of the PBL model. In PBL methodology, solving problems that are important to daily life is the first phase. Students can learn the problem from the information they get by solving the problem (Prahani et al., 2022).

In addition to providing students with restricted time for learning, the PBL concept has drawbacks. The usage of the iSpring application-assisted inquiry method is one way to get around this (Lestari et al., 2024); E-module (Prabasari, 2021); Worksheets (Fatmawati et al., 2021). Video which is the main type of media used (Khoirulloh et al., 2024). A number of indicators of critical thinking skills can be developed with the help of learning videos, explanations in each submaterial, conversations, and practical investigations (Marnita et al., 2020). This research also shows that experimental research using a quasi-experimental research design is the most popular method for studying PBL models and critical thinking skills (test-post-test control group design). Studies often use critical thinking assessments and descriptions to measure patients' critical thinking ability. Appropriate conclusions should be based on actions that result in reasonable or logical conclusions.

It is crucial to choose a method that gives students the freedom to decide how they want to approach the task. Using a mind mapping strategy is one approach that can be used. Compared to traditional teaching approaches, the use of PBL with digital mind maps greatly improves students' critical thinking skills (Kernan et al., 2018). Students' critical thinking skills can be improved by mind mapping (Hidayati et al., 2022). Mind mapping can help organize and explain ideas, plan, communicate, be more creative, solve problems, focus, remember things clearly, learn faster, and practice how and when to communicate concepts. Mind maps are used to help students generalize, connect ideas, derive meaning from different ideas, and show relationships between concepts. In addition, there is also a definition of mind mapping as a learning strategy for idea exchange, narration, intellectual organization, problem solving, and cognitive performance (Kernan et al., 2018). Students will learn more efficiently with mind maps because it helps students organize knowledge, store as much as they need, categorize it appropriately, and make it easily accessible (Arini & Tristiantari, 2017). A very helpful and easy-to-use tool for structured thinking.

There are similarities and differences among the articles studied. Critical thinking skills and the PBL model were presented consistently through the article studies. Although not the only ones, the subjects, research techniques, topics, and sample sizes can be considered as variations from the original articles.

Conclusion

These studies and discussions illustrate the fact that PBL models can improve critical thinking skills. Based on a review of academic articles teaching problem-based learning methods and critical thinking in science, biology, chemistry, physics, and math over the next five years (2019-2024). Science was the subject that received

the most attention. In addition, PBL research also considers other variables besides critical thinking skills.

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Author Contributions
Article writing was done by E.M Data collection and data analysis were done by N.K.L.B, G.D.L, and Z.Z. Direction, guidance, review of ideas, concepts, methodology, analysis were done by S.S.

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Conflicts of Interest
The authors declare no conflict of interest.

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