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Systematic literature review: analysis of problem-solving skill trends in physics education (2014-2024)

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Abstract

This study aims to gather information about efforts to improve students' problem-solving skills in physics education. This research uses a systematic literature review (SLR) review model based on the PRISMA model. This method was chosen to identify research articles using the keywords 'Problem-Solving Skill in Physics Education' with sources taken from Scopus from 2014-2024. Based on a review of 20 published articles, the application of the problem-based learning (PBL) learning model as much as 60% is the most frequently used learning model in improving cases related to problem-solving. The most frequently used research method in improving problem-solving skills in physics education is a quantitative method with a quasi-experiment design. The majority of articles were published in 2023. This research contributes to the field of education, especially the field of physics teaching evaluation, which aims to improve problem-solving skills. The findings of this study confirm that the PBL model can be used to overcome problems related to problem-solving skills in students. The weakness of this study is the limited data sources used, namely from Scopus, so for future research, it is recommended to be able to expand the data sources used, such as WoS, IEEE, etc.

Keywords: problem-based learning, problem-solving skill, systematic literature review

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I. Introduction

The development of an increasingly advanced era also requires students to have skills in the learning process, especially the skills to solve a problem in physics learning. Problem-solving is one aspect of high-level thinking skills that needs to be developed in every lesson. Problem-solving ability is one of the six important points in the field of learning and is needed in the 21st century, but problem-solving skills in students are still not optimal [1]. Problem-solving skills in classroom learning activities mean familiarising students with finding the right solution to a problem encountered in life [2]. This physics problem-solving skill is not only needed by students but also during college and when working later in completing their assignments or exams [3]. Therefore, problem-solving skills are required to support learning activities at all levels of education.

Problem-solving skills require a combination of basic knowledge and basic skills. Basic knowledge is stored in a person's long-term memory as a result of what is learned. The basic problem-solving skills include analyzing problems, linking relevant concepts, and planning the best alternative solution [4]. Sutriani [5], in his research, revealed that problem-solving learning is an innovation in learning; this is because the problem-

solving-based learning model can optimize students' thinking skills through a structured and systematic group or teamwork process so that students can empower, hone, test, and develop their thinking skills continuously.

In applying the problem-solving learning model, several activities include discussion, group work, and question and answer. Applying the problem-solving model has advantages, including being able to accustom students to face and solve problems skilfully and stimulate the development of students' thinking abilities creatively and thoroughly. This advantage can be a solution to the problems experienced by students related to their low problem-solving ability. Surya [6] states that during the learning process, it is still found that students have difficulty understanding a physics concept, analyzing a problem so that the right solution is found, it is still difficult to link relevant concepts, and critical thinking skills still have to be honed, so that if learning independently some students are still confused and wrong in determining concepts. Parno [1], in his research, stated that students' problem-solving skills are still low in physics subjects, such as temperature and heat, heat and energy, and modern physics.

This indicates that students' problem-solving level needs to be improved, and the problem-solving model can solve these problems. This aligns with research conducted by Ref [7] on the Effect of Creative Problem Solving Model Based on Information Technology on Physics Learning Outcomes of High School Students, which states that the problem-solving model significantly affects student learning outcomes. Safitri [2], problem-solving ability affects the learning process of students. Based on the above problems, an analysis is carried out using a systematic literature review (SLR) design, which contains research questions that will be the focus of the discussion. The research questions used to support this research are:

1. RQ1: What trends can be observed in the number of studies on problem-solving skills in the range of 2014 - 2025?
2. RQ2: What research methods are most often used to explore problem-solving skills in physics education?
3. RQ3: What learning models are most frequently used to improve problem-solving skills in physics education?

The novelty of this SLR study is that it is a more in-depth trend analysis. This study can expand the trend analysis related to how the effectiveness of PBL compared to other learning models. This study identifies supporting factors for the successful application of PBL in improving problem-solving skills. This study also analyzes the topics related to expanding research methods. Analyze how the use of a research method can improve problem-solving.

II. Methods

This study uses a Systematic Literature Review (SLR) analysis design with a PRISMA design focusing on problem-solving skills. This method aims to answer specific questions through identification, analysis, synthesis, evaluation, and comparison of all relevant literature in line with the formulation of the problems reviewed in the study [8]. Krath [9] states that the benefit of the systematic literature review method is that it can synthesize various findings of researchers in line or relevant, which makes the facts presented more complete and balanced. In this study, the Vos viewer application was also used to assist researchers in obtaining and processing information.

This review uses the PRISMA design. Haddaway [10] stated that systematic literature review research using the PRISMA design consists of several phases, which include the identification phase, screening, eligibility, and the number of final articles to be reviewed. In this study, researchers collected articles in the Scopus and Google Scholar databases by entering keywords related to the research topic to be studied. The range of articles published is from 2014 - 2024, while the exclusion criteria are articles that are not related to keywords that are by the research or in this study, related to problem-solving, abstract articles, articles that are not full text, and articles published before 2014.

Furthermore, articles that have met the desired criteria in the study will be collected and examined systematically. The process of finding articles obtained as many as 20 articles that met the requirements of the inclusion criteria, 49 articles that met the exclusion criteria, and as many as 20 articles to be analyzed articles that were relevant and in line with the research topic and keywords used, namely problem-solving learning on physics education. The technique used to analyze this study's data is descriptive statistical analysis. Descriptive statistical analysis is an analysis carried out by describing the data that has been determined without aiming to conclude something in general or general. Descriptive statistics in this study are used to describe the samples obtained.

Furthermore, the discussion and conclusion section presents a more specific article review and analysis of the research results. In the final part of the research, a comparison of findings is given, which is then presented and discussed in the article, which will be the conclusion of this research. The PRISMA stage scheme, which is a stage in extracting data, is shown in Figure 1.

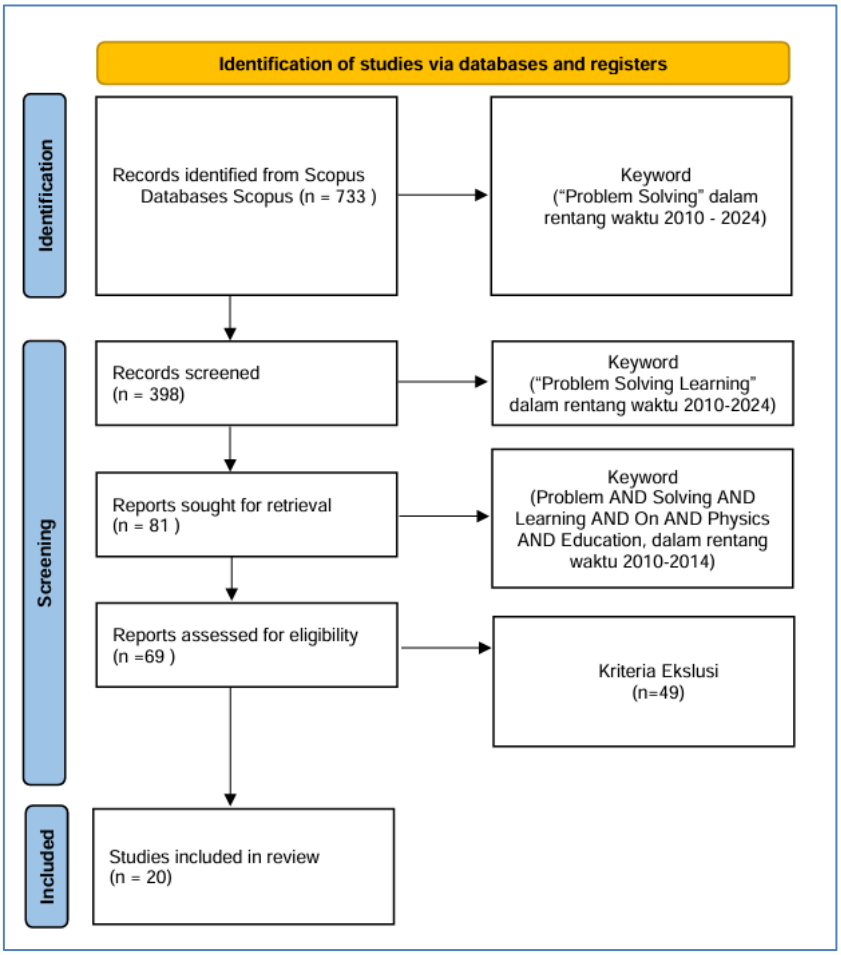

Figure 1. The PRISMA stage scheme

Based on the initial search in Scopus, 733 articles related to problem-solving learning were obtained. The articles are then filtered to determine which articles are suitable for use and which articles are not suitable for research. Based on the filter that focuses on the problems in the research, the purpose of the research, the design of the research, as well as the research findings, the final article obtained as many as 20 which really fit the research topic related to the problem-solving skills in students.

III. Results and discussion

Distribution of article data

After reviewing and analyzing the abstracts and keywords, and then filtering based on the eligibility criteria: articles must be written in English, material related to physics, articles published from 2014 to 2024, and related to problem-solving. With these criteria, 20 articles were obtained for further research or included in the inclusion category. The final results of the article selection are shown in Table 1.

Table 1 shows the distribution of articles used as discussion material. It is known that the distribution of the most published years of articles is in the range 2017 - 2021 with the type of article indexed Q1, which means that the article is at the highest level of all journals in the field, which is determined into four groups based on the SJR and Q3 values which are below Q1.

Table 1. Distribution of article data

Term	Frequency	Year (Q1)	Year (Medium)	Year (Q3)
Problem solving	27	2017	2017	2018
Education	14	2017	2017	2017
Teaching	13	2017	2017	2018
Surveys	6	2018	2018	2020
Computer aided instruction	5	2018	2018	2020
Problem solving skill	64	2019	2019	2021
Students	58	2019	2019	2021
Education computing	25	2019	2019	2021
Engineering Education	13	2020	2020	2020
Physics Education	13	2020	2020	2021
Curricula	9	2020	2020	2021
Problem Solving Abilities	7	2021	2021	2021
Senior high school students	6	2021	2021	2021

The most used keywords in articles related to the use of problem-solving skills in education

Based on the output of the Co-Occurance Network in Figure 2, the main node is 'Problem-Solving Skills,' indicating that this topic is the main focus of research in the analyzed dataset. The figure shows that the node is strongly connected with 'Education Computing,' 'Problem-solving,' and 'Physics Experiments,' which shows the link between the development of problem-solving skills and applications in the field of education and physics experiments. In the figure, there are several color clusters. These different colors represent interconnected clusters.

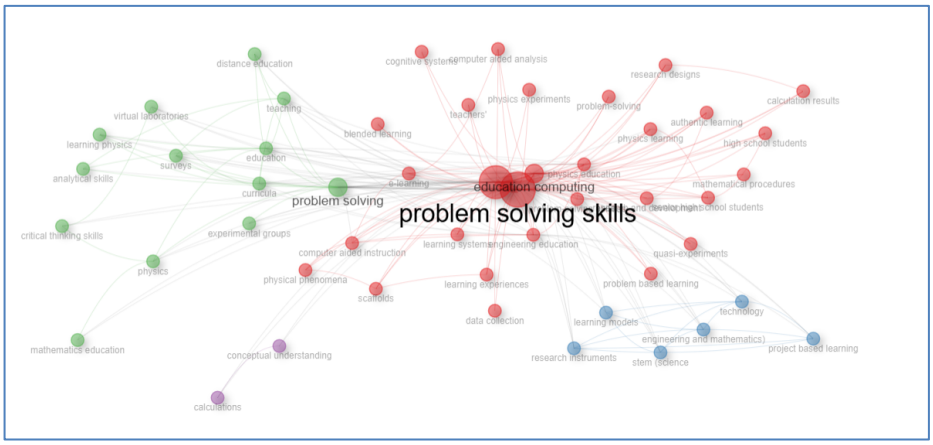

Figure 2. Co-occurance network

The green cluster that includes 'Critical thinking skills,' 'Mathematics education,' and 'Physics' focuses on developing analytical and critical skills in STEM-based education. The Red cluster contains the nodes 'Education computing,' 'Cognitive systems,' and 'Research design,' which show a focus on quantitative technology-based learning approaches. This cluster is linked to keywords such as 'Physics experiment' and 'Learning models' which highlight experimental-based learning methods. The blue cluster shows the nodes 'Project-based learning,' 'Engineering and mathematics,' and 'Technology,' which illustrate the relationship between project-based learning and engineering education technology. Finally, the purple cluster has the nodes 'Conceptual understanding' and 'Experimental groups,' which show the focus on conceptual understanding through experiments and learning groups.

Figure 3 visualizes the relationship between keywords often appearing in the Scopus database. Based on the image, the most dominant keywords are problem-solving skills and students, which are reflected in the largest size and position in the center. These problem-solving skills and student keywords have many relationships or links with other keywords, such as e-learning, physics experiments, and education. Edges or lines show the relationships between keywords, and different colors of clusters show the grouping of themes or topics based on similarities in the analyzed literature. The analysis shows that based on Figure 2, there is more focus on developing problem-solving in various contexts related to technology to physics experiments.

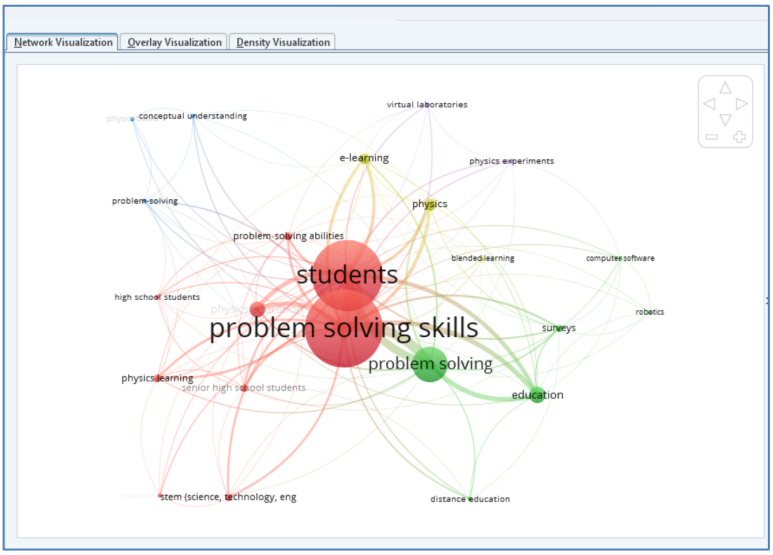

Figure 3. Network visualization on the database

Figure 4 shows the density visualization, which illustrates the intensity or density of specific keywords based on their occurrence in the dataset. The keywords problem solving and student are located in the bright yellow area, indicating that they appear frequently and are the main focus of the research. The darker colored areas indicate keywords with less frequent but still relevant occurrences, such as distance education and computer science.

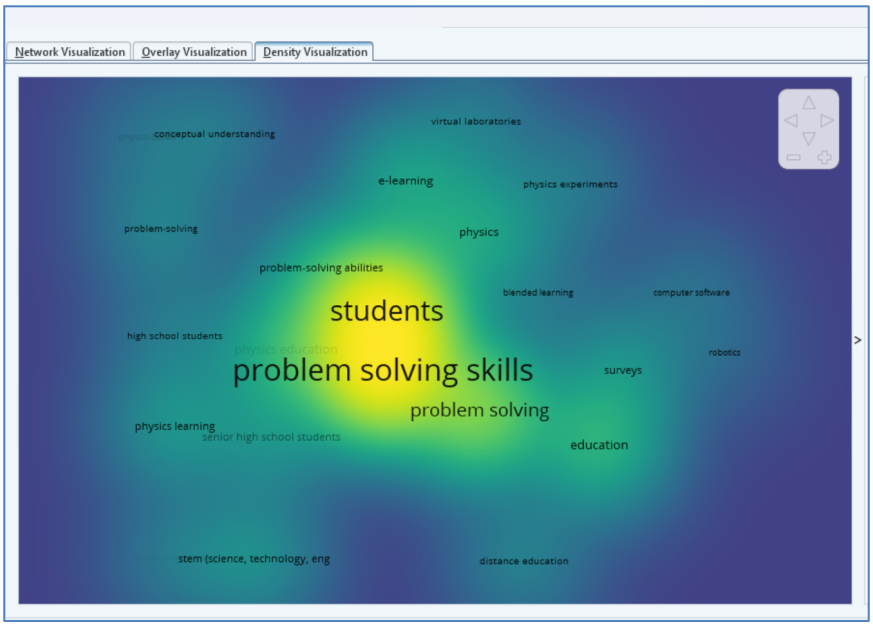

Figure 4. Visualization of density in database

Number of publications

The number of article publications indicates research activity on a particular topic. Figure 5 shows that research on problem-solving skills in physics has been carried out for a long time; from Figure 5, the research trend in 2017 - 2024 is reflected. A significant upward trend in this study occurred in 2023, with the number of publications peaking at five articles. This indicates an increased interest in research to explore problem-solving in the context of physics education. Figure 5 also reflects a decreasing trend in the following year.

Research results are generally sourced from common problems that often arise around researchers [11]. One of the significant challenges today is the low problem-solving ability; besides that 21st, 21st-century learning requires human resources with competencies and achievements directed at learning and innovation skills, including problem-solving skills, which are trending and must be developed [12].

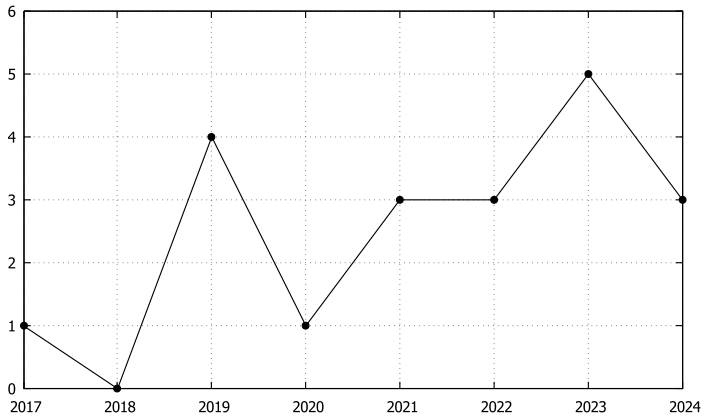

Figure 5. Distribution of publication article

Method tren

Figure 6 is a pie chart showing the distribution of the use of various research methods, namely mixed methods that combine quantitative and qualitative approaches to provide in-depth analysis by 15%, quantitative methods that involve the collection and analysis of numerical data by 35%, qualitative methods that focus on non-numerical data such as interviews, observations, or texts to understand a phenomenon by 10%, R&D methods that focus on creating or improving new products, processes, or technologies by 30%. More used in problem-solving problems in physics education, Educated design research by 5%, and ASSURE approach by 5%.

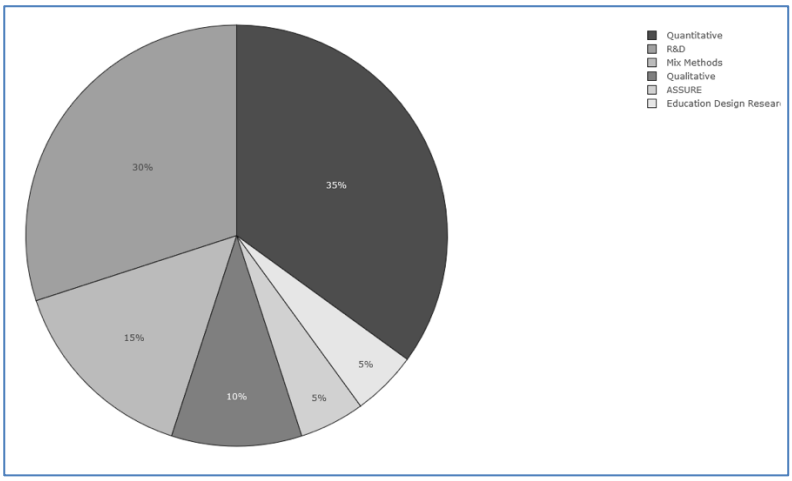

Figure 6. Frequency of use research method

In addition to identifying the types of research, this study also describes the distribution of research designs contained in Table 2, which is based on the options determined and chosen by the researchers. Table 2 shows that quasi-experimental research designs were used more than other designs. Quasi-experiments are used in research to compare which intervention is most effective for improving problem-solving skills in learners [13]. Previous research shows that the quasi-experiment design effectively improves learners' problem-solving skills [14]. This suggests that this approach has an impact on learners' learning outcomes.

Learning Model

The use of learning models implemented to improve problem-solving skills is shown in Figure 6, which is related to the distribution graph of learning models in related articles. Figure 7 shows that the most widely used learning model to improve students' problem-solving skills is the problem-based learning (PBL) model by 60%. One of the many learning models that can support the improvement of students' abilities and learning outcomes in physics learning is the PBL learning model [15]. This PBL model can potentially improve students' problem-solving skills and is effectively used to improve student learning outcomes in physics [16].

Ref. [17]–[19], in their research, also confirmed that the PBL model is effectively used to improve skills related to problem-solving. Therefore, this model can improve students' problem-solving skills.

Table 2. Distribution of problem-solving articles in physics based on research methods

Research methods			Total (n)
Quantitatif	Eksperimental	Quasi-Eksperimen	5
		Pra-Eksperimen	1
	Non-Eksperimen	Descriptif Quantitatif	1
Qualitatif		Descriptif Qualitatif	2
Development and Research		R&D ADDIE	2
		R&D 4D	3
		R&D Dick dan Carey	1
Mix-Methode		Embedded design	3
Education Design Research			1
ASSURE			1

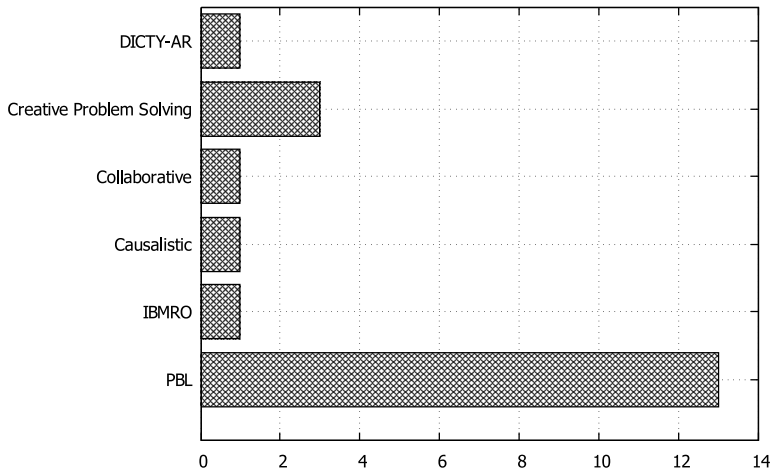

Figure 7. Distribution of problem-solving articles in physics by research method

Figure 8 is a distribution of the countries of origin of researchers who have researched problem-solving in various countries. The country of origin of researchers in the figure above shows varied diversity. Based on the 20 articles reviewed, the articles come from various countries that vary.

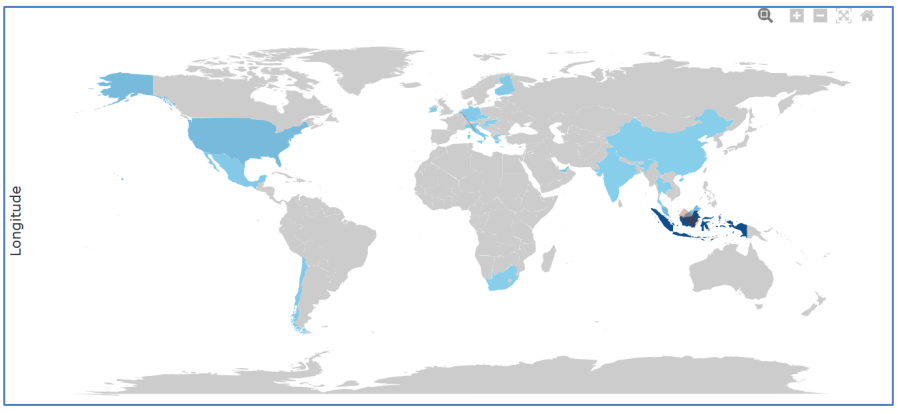

Figure 8. Countries' collaboration world map

IV. Conclusions

Analysis of research publications on problem-solving skills in physics education in the span of 2014-2024 shows a significant upward trend in research interest in this field. The peak of research activity occurred in

2023, with the number of articles published being five out of 20 articles sorted by researchers. The majority of the research used quantitative research methods, and the research design that was widely used was a quasi-experimental design. In an effort to improve students' problem-solving skills, the most frequently used learning models are PBL (Problem-Based Learning) and Creative Problem Solving. The PBL learning model has also proven effective in improving problem-solving skills in students; this is in line with research conducted by [20]. The findings of this systematic literature review involving 20 articles can be a reference for further research, especially in developing problem-solving skills in physics education.

This study is limited to the database used in the discussion and the inclusion and exclusion criteria used for article selection, which can also affect the results of the analysis. Therefore, future research or systematic literature review studies on the same topic are expected to use more varied database sources, including regional databases or open repositories, that can increase the coverage of the analyzed literature.

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