

A Decade of Project-Based Learning (PjBL) and Mathematical Problem-solving: Past, Present, and Future Direction

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Abstract

Over the last decade, research related to the impact of implementing the Project-Based Learning (PjBL) model on students' mathematical problem-solving ability has been widely published in a number of reputable journals. However, there is still a lack of research related to mapping the results of this research which can later provide insight to the researchers and educators, especially teachers, in mathematics learning activities. Therefore, it is necessary to study various research findings that implement the PjBL model which impact students' problem-solving abilities. The aim of this research is to obtain information from various research results regarding the impact of implementing the PjBL model on mathematical problem-solving ability. Meanwhile, the method used is a Systematic Literature Review (SLR) with reference to journal articles published from 2013 to 2023. Furthermore, the keywords used in obtaining this research article are by combining the PjBL model and mathematical problem-solving ability with inclusion and exclusion criteria, resulting in 20 journal articles. The research results show that the PjBL model can be applied in mathematics learning and has a positive impact on students' mathematical problem-solving abilities. Finally, this study contributes as a promising resource to potential research opportunities and significant implications for future research regarding the PjBL model and mathematical problem-solving ability

Keywords: mathematical problem-solving ability, project-based learning model, promising resources, reputable journals, systematic literature review

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INTRODUCTION

Considering how fast science and technology develop, it is important to prepare human resources to face these changes. Thus, ensuring that students have a strong understanding of mathematical concepts and ideas that can be implemented in solving problems through connecting, communicating, and reasoning, is one of the goals of mathematics education in Indonesia (Safithri et al., 2021). Several studies suggest that strong mathematical understanding significantly enhances mathematical problem-solving abilities and learning outcomes (Kholid, M. et al., 2021; Sinaga, B., et al. (2023); Nahdi, D. S., et al., 2023). Kholid, M. et al., (2021) stated that high mathematical ability helps solve mathematical problems correctly, while moderate mathematical ability requires more effort and understanding, and low mathematical ability is less precise. Meanwhile, Sinaga, B. et al., (2023) stated that students' problem-solving understanding has a significant influence on mathematics learning results, with a p-value of 0.000. Nahdi, D. S., et al., (2023) state that Reading comprehension and mathematics interest have a noteworthy positive correlation with mathematical problem-solving abilities, surpassing the correlation with mathematics interest. According to Isnaini, S., et al., (2023), Mathematical problem-solving ability involves

understanding the problem, choosing the right strategy, and being systematic in solving the problem.

Indicators of mathematical problem-solving ability, namely: (1) Able to understand problems as evidenced by the ability to recognize known and required elements; (2) Able to develop mathematical models; (3) Able to determine and hone problem-solving techniques; (4) Can describe and verify the accuracy of the results obtained (Mawaddah & Anisah, 2015). Meanwhile, mathematical problem-solving ability, basically, students who study mathematics must be proficient in the ability to solve mathematical problems because this is a very important mathematical skill. This shows that the ability to solve mathematics problems can not only help students learn mathematics easily, but also provide benefits in other fields and in everyday life. (Novianti et al., 2020). Thus, one of the abilities that students must master is mathematical problem-solving ability. With these abilities, students can confidently overcome mathematical problems and utilize their understanding in various situations (Hardiningsih et al., 2023).

Current research continues to show that students' mathematical problem-solving ability have not yet reached their maximum potential, especially in understanding real-world problems. When given questions related to contextual problems, students still have difficulty recognizing the elements that are known and asked about in the questions. When given questions that are different from the previous examples, they also have difficulty understanding the problem and finding a solution. This shows that students still lack mathematical problem-solving abilities (Mardhiyah et al., 2022). As a result, teachers must be able to design original and creative learning models to improve mathematical problem-solving abilities and shape students' way of thinking.

One learning model that can be used to overcome problems with students' mathematical problem-solving abilities is the Project-Based Learning (PjBL) model. This PjBL model involves learning with projects that take quite a long time and asks students to design, create, and present solutions to real-world problems. (Muslim, 2017). In PjBL, students must be able to produce products related to the concept and have a comprehensive understanding to complete the project. (Susanto et al., 2020). Thus, it is necessary to obtain information about the appropriateness of using PjBL in various problems related to students' mathematical problem-solving abilities

To obtain the information in question, the researcher aims to investigate in more depth the answers to the following questions: (1) How does the PjBL model influence improving mathematical problem-solving abilities? (2) How are learning tools implemented in the PjBL model to improve mathematical problem-solving abilities? These two questions were driven by the researcher's motivation to contribute to an in-depth understanding of the PjBL model which might be a reference and help teachers in their efforts to support an effective mathematics learning process to improve mathematical problem-solving abilities.

METHODS

The Systematic Literature Review (SLR) approach was used in this research. A systematic and objective research method is known as the SLR method to collect, assess, and synthesize related data from various previously published literature sources (Yanti & Novaliyosi, 2023). With this method, researcher review and identify journal articles systematically by following established procedures in each process. The research procedure in this article is divided into 3 stages, namely searching, evaluating, and synthesizing. During the review process, researchers used the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) method and checklists.

To find as much relevant literature as possible, between October 2023 and November 2023 researchers carried out a search process on three databases, namely Crossref, Open Alex, and Google Scholar. Researchers limited the search to research published between 2013 and 2023 and researchers selected articles that matched the title and abstract. Article searches were carried out by entering keywords and titles by combining relevant terms, such as "PjBL model, improving mathematical problem-solving abilities" or "PjBL, mathematical problem-solving abilities". We searched for terms in keywords and titles so we got 540 articles. After that, the researcher selected based on the title and abstract. Then, researchers determined inclusion and exclusion criteria. The exclusion criteria can be seen in **Table 1.** below.

Table 1. Exclusion Criteria

Criterion	Description	Example
1. Didn't fit with the topic	This article discusses another issue	Sri Rezaki (2019), A Wahyuni, LM Angraini (2021), F Ramadanti, H Pujiastuti (2020), YR Hasibuan, N Khairani, E Surya (2022), A Fitriani, I Budiman (2022)
2. Not empirical	The article is not an empirical study or field research	L Lutfiyana, E Pujiastuti, I Kharisudin (2023), RR Jannah, SB Waluya, M Asikin, Zaenuri (2021), Rohmatulloh, H Pujiastuti, M Fathurrohman (2022), RA Yanti, N Novaliyosi (2023)
3. Another language	The article was not published in Indonesian or English	-
4. Does not discuss the PjBL model	Articles that discuss other than the PjBL model	A Solong, M Nasir, F Ferawati (2022), RSB Depari, RD Suyanti (2022),
5. The file cannot be opened	The article file cannot be opened	E Rachmawati (2015), RP Juniawan (2019), A Amam (2021), D Fitriana Anisatul Mustafidah (2014), DD Harahap (2018)
6. Don't have a URL	The article cannot be downloaded because there is no URL	SS Hikmawan (2022)

After searching for articles using the exclusion criteria as in **Table 1.**, the researcher then selected based on the inclusion criteria. The inclusion criteria are: (1) according to the topic, where the topic is related to the PjBL model and mathematical problem-solving ability; (2) empirical studies; (3) not published in other languages, namely Indonesian and English. Of the 540 articles selected based on the exclusion criteria, 12 articles were obtained. Next, search for additional articles manually via Google which were selected based on inclusion and exclusion criteria to obtain 20 articles. More concisely, it can be seen in the following PRISMA diagram.

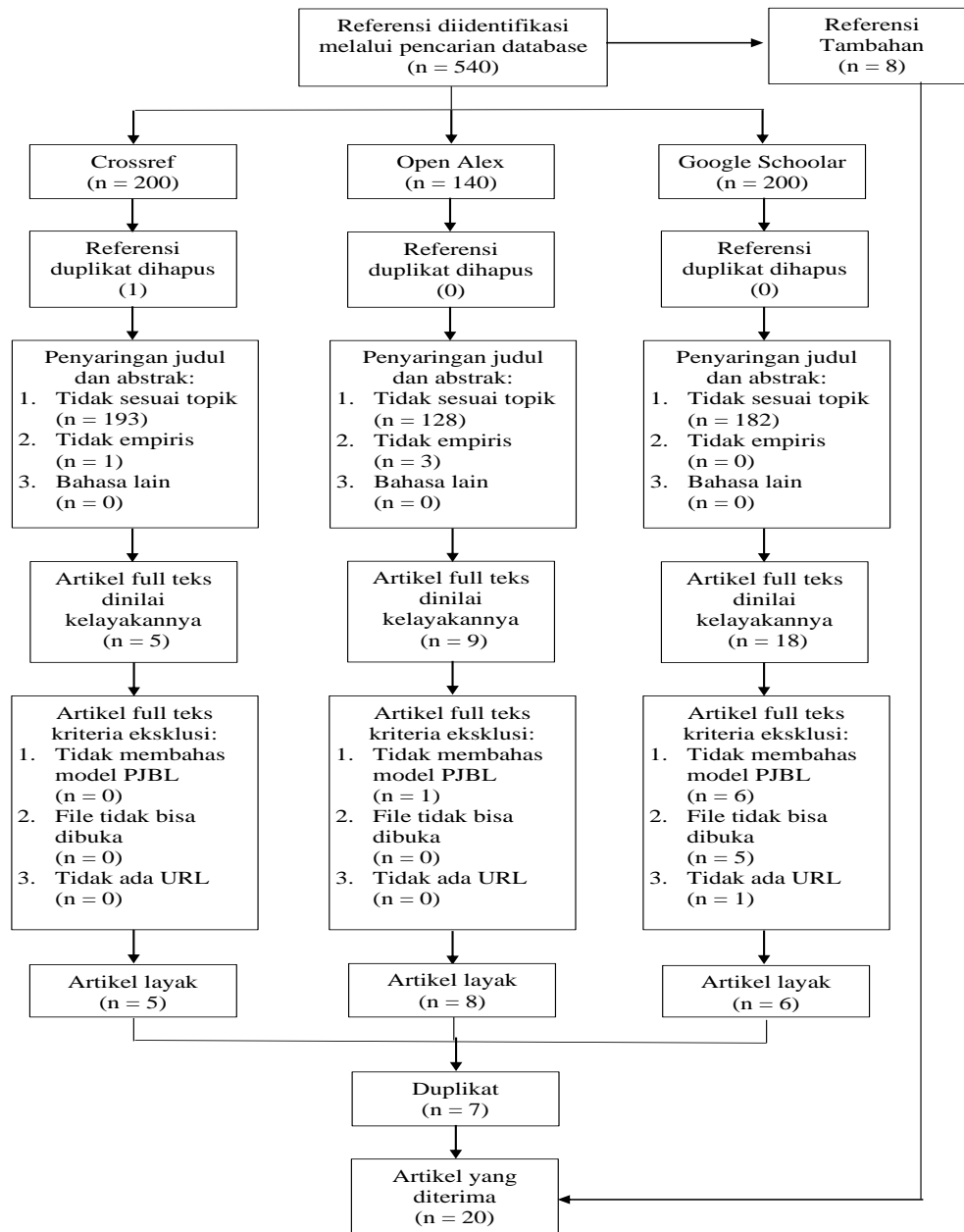


Figure 1. PRISMA Diagram

RESULTS AND DISCUSSION

Based on a literature search using keywords according to the topic and inclusion and exclusion criteria, 20 articles were obtained. Next, the researcher will examine articles related to the PjBL model on mathematical problem-solving abilities. Data from research contained in these articles will be documented as in the table below.

Table 2. PjBL Model Research Results on Mathematical Problem-solving Ability.

Researcher and Year	Research Results	Answer the question	
		No.1	No.2
(Rahmazatullaili, Morina, 2017)	Cut, The implementation of project-based learning has a high influence on students' problem-solving abilities compared to conversional learning.	✓	
(Safithri, et al., 2021)	Through project-based learning, students are able to get new concepts to answer mathematical problems posed by the teacher.	✓	
(Sofyan et al., 2021)	One effort to encourage student activity is by implementing the PjBL model with the help of Student Project Worksheets. Thus, there is an increase in students' mathematical problem-solving ability.	✓	✓
(Mardhiyah et al., 2022)	The application of the ethnomathematics-based PjBL model with the help of e-modules that can be opened anytime and anywhere can be used to improve students' mathematical problem-solving ability.	✓	✓
(Sakinah et al., 2022)	Students' mathematical problem-solving ability increases after using a project learning approach that utilizes assistance from Macromedia Flash.	✓	✓
(Hasriyani et al., 2022)	The project-based learning model using a scientific approach is one way to increase students' mathematical problem-solving ability.	✓	
(Suciawati et al., 2022)	With project-based learning, students are free to be creative, thus influencing their mathematical problem-solving ability more than traditional learning.	✓	
(Setyaningsih & Rahman, 2023)	Students' mathematical problem-solving ability increases after using a project-based learning approach that uses the help of Dynamic Mathematics Software.	✓	✓
(Hasyim & Eldiana, 2020)	Schoology-assisted project-based learning has no impact on mathematical problem-solving ability when viewed from students' self-efficacy.	✓	✓
(Mardin & Zainil, 2019)	Learning using the PjBL model has more impact on mathematical problem-solving abilities compared to traditional learning.	✓	
(Mardhiyah et al., 2022)	Students who are involved in project-based PjBL model learning using the Lubuk Etnomathematics e-module show better abilities in solving mathematical problems compared to students who take part in conventional learning.	✓	✓
(Fatimah et al., 2022)	The application of the PjBL model can improve mathematical problem-solving ability, both assessed individually and as a whole in the first and second cycles in graph material in discrete mathematics courses.	✓	
(Nurfitriyanti, 2016)	The application of the PjBL model has a positive impact on students' mathematical problem-solving ability. This is because students are actively involved in the entire series of learning activities, students feel they are working together to solve problems, share knowledge, and support each other, so that they can improve learning outcomes better.	✓	
(Hardiningsih et al., 2023)	When teaching mathematical statistics to students, the PjBL model can be an alternative to improve their mathematical problem-solving ability.	✓	
(Sasmita et al., 2021)	By implementing the PjBL model effectively, an interesting learning experience for students can be realized, which ultimately increases students' mathematical problem-solving ability.	✓	
(Christina et al., 2023)	The use of the PjBL model using flashcard media can make students interested in learning while playing. Thus, there is a positive impact from Project Based Learning which is supported by flashcard media on increasing students' mathematical problem-solving ability related to plane material.	✓	✓
(Sucipta et al., 2018)	Students who use the PjBL model with the help of GeoGebra have superior mathematical problem-solving ability compared to those who use the 5M learning model.	✓	✓
(Amam & Lismayanti, 2020)	Optimal mathematical problem-solving can be done through the PjBL model with the help of ICT.	✓	
(Hikmiyah, 2021)	The PjBL model with the help of Minitab in presenting data in statistics material can improve students' mathematical problem-solving ability.	✓	✓
(Wulansari et al., 2023)	The increase in students' mathematical problem-solving abilities occurred after learning through the PjBL model which was combined with the Lubuk Etnomathematics e-module Lawang Sewu Semarang,	✓	✓

Several research findings in [Table 2.](#), are presented to answer several previously existing problem formulations.

1. The Influence of the PjBL Model to Improve Mathematical Problem-solving Ability

The models implemented in teaching certainly have their respective influences. In this case, the PjBL model has a significant influence in efforts to improve students' mathematical problem-solving abilities. Research by Rahmazatullaili, Cut Morina, and Said (2017) provides an explanation of the differences between learning that uses the PjBL model and learning that does not. Where, learning using the PjBL model can improve students' mathematical problem-solving abilities. In line with research conducted by Lenny, Thamrin, Lisnasari, Andi, and Mardhiah (2021) that solving abilities increased after implementing the PjBL model in the learning process. Apart from that, Emilyawati, Masjudin, Zainal, Muksin, and Istin (2023) in their research also said that when teaching mathematical statistics to students, the PjBL model can be an alternative to improve their mathematical problem-solving abilities. From several research results above, the application of the PjBL model in the learning process, especially in mathematics learning, has an influence on students' mathematical solving abilities compared to learning without using the PjBL model.

2. Application of Learning Tools in the PjBL Model to Improve Mathematical Problem-solving Ability

Developing learning tools is one way to improve a person's ability to solve mathematical problems (Ahmad & Asmaidah, 2018). Learning tool development involves designing and implementing tools or methods that support the teaching and learning process. This can include the use of technology, innovative teaching strategies, and the preparation of effective learning materials. Eka, Candiasa, and Sukajaya (2018) implemented learning tools based on the PjBL model with the help of GeoGebra. The research findings show that compared to the 5M learning model, the PjBL learning model using GeoGebra can help students become more proficient in solving mathematical problems. Meanwhile, the learning tool perfected by Nurwadita, Bornok, and Mariani (2022), is a learning tool based on the PjBL model with the help of Macromedia Flash. Based on research findings, the application of the PjBL model has helped students' ability to solve mathematical puzzles with the help of Macromedia Flash. From the research results above, the enhanced learning tools are considered credible and efficient, making it possible to apply them in the classroom and increase students' mathematical problem-solving abilities.

In an effort to show the novelty of this research, it is the first research to use the SLR method which discusses the PjBL model to improve mathematical problem-solving abilities. Apart from that, the lack of articles discussing the PjBL model to improve mathematical problem-solving abilities makes this something new or even an advantage.

CONCLUSION

The results of the Systematic Literature Review for each study can be found in journals published between 2013 and 2023. The studies obtained are in the form of articles using quantitative, experimental, RnD, and PTK methods. From all the research found, it confirms that the application of the PjBL model has an effect on mathematical problem-solving abilities. One effort to support the PjBL teaching and learning process is by developing learning tools, such as the use of technology, teaching strategies, and the preparation of effective and innovative PjBL learning materials. By implementing various learning tools in the PjBL model, students' mathematical problem-solving abilities can be improved.

Articles on the PjBL model discuss developments and changes in the approach over time. Older articles may focus more on basic concepts and their application at the time, while newer articles cover recent developments and innovative approaches to applying the PjBL model in case studies. Suggestions for further research, it is hoped to carry out research related to the PjBL model by applying learning tools

using Artificial Intelligence (AI), because there is still minimal research on this matter and AI is currently becoming a trend in the world of education.

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