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INCREASING CRITICAL THINKING SKILLS THROUGH STEM-PJBL LEARNING MODELS: RESEARCH TREND AND SYSTEMATIC LITERATURE REVIEW

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Abstract :
This study aims to analyze research trends on the effectiveness of STEM-PjBL learning models in improving students' critical thinking skills through a systematic literature review from 2013 to 2024. The research employs a bibliometric approach and follows the PRISMA framework to select and analyze 32 articles from the Scopus database. The results indicate that the implementation of STEM-PjBL significantly enhances students' critical thinking skills, particularly when integrated with technology and interactive learning tools. The analysis highlights trends in research focus, dominant contributing countries, and the most cited studies. Indonesia emerges as the leading contributor to STEM-PjBL research. Additionally, bibliometric visualizations using VOSviewer reveal key themes, including project-based learning models and their impact on 21st-century skills. The findings contribute to the advancement of science and technology education, offering valuable insights for educators and policymakers to develop more adaptive and effective curricula. Despite its contributions, this study is limited by potential publication bias and the absence of meta-analytical findings.

Keywords: Bibliometric Analysis, Critical Thinking, STEM-PjBL

INTRODUCTION

Rapid technological advances and globalization have created an increasingly competitive world. Individuals are required to have critical thinking skills in solving complex problems effectively (Iksal et al., 2024; Li, 2022; Ogedengbe et al., 2023). Critical thinking includes the ability to analyze information, make informed decisions, and apply knowledge in real situations (Sitopu et al., 2024; Thornhill-Miller et al., 2023; Yee & Huey Shyh, 2024). Education has an important role in developing these skills to support students' academic and professional success (García-Pérez et al., 2021; Sokhanvar et al., 2021; Wang et al., 2023). Therefore, innovative learning methods are needed to improve critical thinking skills.

The development of the concept of 21st century skills has changed the teaching method from traditional to more student-centered (Abdulsamee et al., 2021; Dada et al., 2022; Olugbenga, 2021). One approach used is Project-Based Learning (PjBL) which allows students to work on projects based on real problems (Chintya et al., 2023; Hussein, 2021; Sarwi et al., 2021). PjBL encourages students to think critically, work together, and develop investigation skills (Cortázar et al., 2021; Yanti et al., 2023;

Zulyusri et al., 2023). Through this approach, students learn how to solve problems with systematic strategies. The application of PjBL at various levels of education has shown positive results in improving students' thinking skills (Biazus & Mahtari, 2022; Fadhil et al., 2021; Issa & Khataibeh, 2021).

STEM-PjBL is a development of PjBL that integrates science, technology, engineering, and mathematics in project-based activities (Baran et al., 2021; Hasanah et al., 2024; Uden et al., 2023). This approach provides an interdisciplinary experience that allows students to explore real problems (Roslina et al., 2022; Shamuganathan, 2023; Winarni et al., 2022). Through hands-on experiments and data analysis, students can understand concepts more deeply. STEM-PjBL is effective in improving critical thinking because it requires students to design and implement solutions to the problems given (Bulu & Tanggur, 2021; Lestari et al., 2024; Rohmah et al., 2023). Thus, this method is relevant to be applied in the world of modern education.

Various studies have shown that PjBL and STEM-PjBL have a positive impact on improving students' cognitive abilities (Kurniahtunnisa et al., 2023; Maryani et al., 2021; Mulyani & Arif, 2021). Research shows that this model improves deep understanding of learning materials. In addition, students' problem-solving skills and creativity also develop through the application of this method. Project-based learning helps students to connect theory with practice, thus better understanding the concepts learned (AlAli, 2024; Karan, 2023; Yu, 2024). Therefore, the implementation of this method is becoming increasingly important in today's education system.

Although research on STEM-PjBL and PjBL has been widely conducted, there are still some gaps that need to be studied further. Most studies still focus on theoretical aspects without in-depth exploration of implementation at various levels of education. In addition, studies on the long-term impact of implementing this method on the development of students' critical thinking skills are still limited. Therefore, this study aims to fill this gap by analyzing the effectiveness of STEM-PjBL and PjBL in various educational contexts.

The novelty of this study lies in its approach that combines bibliometric analysis and systematic review to provide a comprehensive overview of STEM-PjBL and PjBL research trends. In addition, this study also examines the implementation aspects of this method more broadly, covering various levels of education and diverse learning materials. Thus, the results of this study can be the basis for further development in project-based learning.

The urgency of this study is based on the increasing demand for critical thinking skills in the world of education and the world of work. With the increasing development of technology and the complexity of global problems, students need to be equipped with analytical thinking skills and effective problem solving. Therefore, this study provides important insights into how STEM-PjBL and PjBL can be optimized to meet these needs. The results of this study are expected to contribute to the formulation of more adaptive and innovative education policies.

This study aims to analyze research trends related to the effectiveness of STEM-PjBL and PjBL in improving critical thinking skills. This study reviews articles published between 2013 and 2024 to understand the development of this learning model. The results of this study are expected to provide insight into the best implementation of the two learning methods. In addition, this study also provides recommendations for educators and policy makers in developing appropriate curricula. Thus, project-based learning can continue to develop and provide greater benefits to education.

RESEARCH METHOD

Research Design

This study uses a bibliometric approach and systematic literature review (SLR) based on PRISMA to analyze research trends related to STEM-PjBL in improving critical thinking skills (Krisnawati et al., 2023; Satiti et al., 2024). This approach allows a comprehensive analysis of research developments over a period of time, supported by bibliometric visualization.

Research Target/Subject

The research subjects are scientific articles published in reputable journals indexed by Scopus between 2013 and 2024. The focus of the research is a study that discusses the implementation of STEM-PjBL and PjBL in education and its impact on students' critical thinking skills.

Research Procedure

The research procedure followed the PRISMA framework which includes four main stages: identification, screening, eligibility, and inclusion (Rini et al., 2025; Suryonegoro et al., 2025). In the identification stage, articles were searched using relevant keywords through the Scopus database using the Publish or Perish application and obtained 100 articles. Articles found were recorded, and duplicates were removed. In the screening stage, articles were selected based on the title and abstract to ensure relevance to the research topic, obtained 32 articles. Articles that passed this stage were then checked for full text at the eligibility stage to ensure compliance with the inclusion criteria, obtained 5 articles. Articles that met all criteria were finally included in the inclusion stage for further analysis. The PRISMA diagram was used to visualize the flow of article selection, including the number of articles at each stage of the study until the final analysis stage. The procedure in this study can be seen in the following figure:

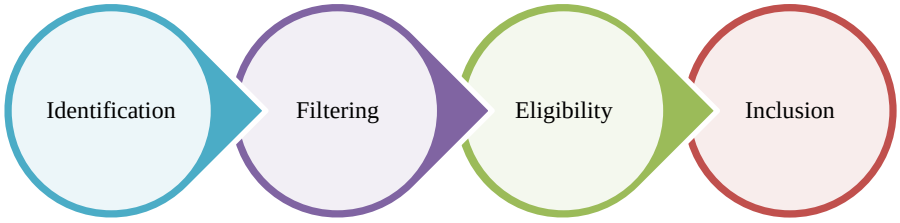

Figure 1. Research Procedure

Instruments, and Data Collection Techniques

The data in this study were collected through a search for relevant scientific articles using the Publish or Perish application and the Scopus database. The keywords used in the search were STEM-PjBL. The search was limited to articles published in reputable journals between 2013 and 2024. The articles found were then filtered using inclusion and exclusion criteria. Inclusion criteria include articles in English, published within a certain period, indexed by Scopus, and directly discussing the application of STEM-PjBL or PjBL in developing critical thinking skills as many as 5 articles. Meanwhile, exclusion criteria include articles that are not relevant to the research topic, duplicated, or not available in full text. Articles that pass the initial screening based on title and abstract are re-examined at the full text stage to ensure compliance with the selection criteria.

Data analysis technique

Data analysis was conducted bibliometrically and systematically. The collected data were analyzed using VOSviewer software to visualize relationships between studies, including collaborations between researchers and institutions, and to identify key trends in STEM-PjBL and PjBL research topics. In addition, a thematic analysis was conducted to explore the impact of STEM-PjBL and PjBL implementation on students' critical thinking skills. This process also aims to identify research gaps that require further study in the future. The findings from this analysis are compiled to provide a comprehensive overview of research developments in the topics studied.

RESULTS AND DISCUSSION

Based on the results of collecting articles using Publish or Perish with the Scopus database, 32 articles were obtained with the keyword STEM-PjBL from 2013-2024. The mapping of the number of articles per year can be seen in the following table:

Table 1. Mapping of Number of Articles Per Year

No.	Year	Number of Articles
1.	2024	2
2.	2023	9
3.	2022	2
4.	2021	8
5.	2020	9
6.	2019	1
7.	2018-2014	0
8.	2013	1

Table 1 presents a mapping of the number of articles obtained using the Publish or Perish (PoP) software with the Scopus database based on the STEM-PjBL keyword during the period 2013-2024. A total of 32 articles were successfully collected. The publication trend shows fluctuations, with the highest number of articles published in 2020 and 2023, with 9 articles each. 2021 also recorded a significant number, namely 8 articles. On the other hand, there were years without publications (2014-2018). The first publication was found in 2013, while the last year (2024) recorded 2 articles. This indicates that research with the STEM-PjBL theme has tended to increase in recent years.

Based on the search results, the countries that conduct the most research on STEM-PjBL were then mapped. The results of the mapping can be seen in the table below:

Table 2. Countries with the most research on STEM-PjBL

No.	Country	Number of Articles
1.	Indonesia	29
2.	Taiwan	2
3.	Turkey	1

Table 2 shows the results of mapping countries that conduct the most research related to STEM-PjBL based on data obtained from Publish or Perish using the Scopus database. Of the total 32 articles collected, Indonesia is the country with the most research, namely 29 articles. Taiwan is in second place with only 2 articles. While Turkey with 1 article. These data reflect that research on STEM-PjBL is more dominant in Indonesia compared to other countries. This shows that there is great attention to this topic in Indonesia, both in the context of implementation and development.

Next, from the 32 articles, 5 articles were selected that were most cited. The mapping can be seen in the following table:

Table 3. 5 Most cited articles

No.	Author	Year	Journal	Citation	Country
1.	Tseng et al.,	2013	International Journal of Technology and Design Education	299	Taiwan
2.	Baran et al.,	2021	Journal of Turkish Science Education	31	Turkey
3.	Chen et al.,	2019	International Journal of Science and Mathematics Education	30	Taiwan
4.	Purwaningsih et al.,	2020	Jurnal Pendidikan IPA Indonesia	22	Indonesia
5.	Widarti et al.,	2020	Jurnal Pendidikan IPA Indonesia	15	Indonesia

Table 3 displays the 5 articles with the highest number of citations from a total of 32 articles obtained based on a search with Publish or Perish using the Scopus database. The article with the highest citations was written by Tseng et al. (2013) from Taiwan, which has been cited 299 times. The second and third articles came from Turkey (Baran et al., 2021) with 31 citations and Taiwan (Chen et al., 2019) with 30 citations. The next two articles came from Indonesia, namely Purwaningsih et al. (2020) with 22 citations and Widarti et al. (2020) with 15 citations. These data show significant contributions of

research from various countries in the topic of STEM-PjBL, with articles from Taiwan dominating in terms of citations.

Based on the 5 most cited articles, they were then analyzed using VOSviewer. The results of the analysis can be seen in the image below:

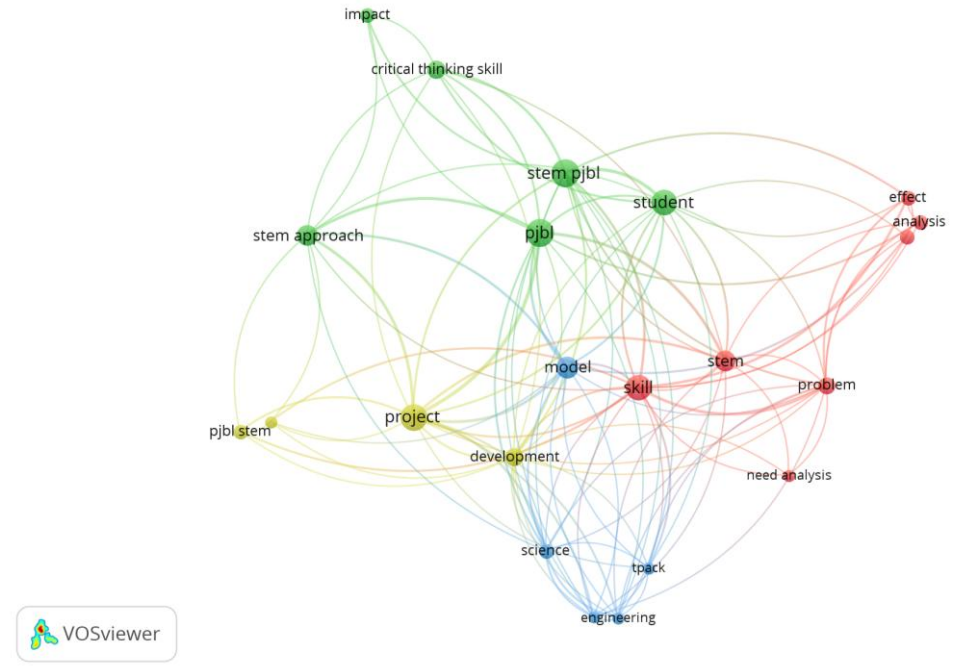

Figure 2. Network Visualization

This bibliometric visualization shows the relationships between terms that frequently appear in research on STEM-PjBL. The figure reflects five main groups (clusters) represented by different colors, each indicating a different focus of research on this topic.

The green cluster stands out as one of the largest groups, including terms such as STEM PjBL, student, and critical thinking skill. The strong relationship between these terms indicates a major focus on how STEM-PjBL is implemented to improve students' critical thinking skills. In addition, the terms stem approach and pjbl stem indicate that the research also highlights a project-based approach in a broad sense. The red cluster emphasizes the relationship between skill, STEM, effect, and analysis. This indicates that research in this group focuses heavily on analyzing the impact of STEM-PjBL implementation on students' skills, including specific aspects such as need analysis and problem solving.

The blue cluster highlights the relationship between science, engineering, development, and TPACK, indicating that the research also explores technology-based development in the context of STEM, with a focus on collaboration across disciplines such as science and engineering. The yellow cluster connecting project, model, and development shows that there is attention to the development of effective project-based learning models in the implementation of STEM-PjBL. This provides an indication that project-based learning methods are considered an important element in the STEM approach.

The overall visualization shows the complex relationship between the various terms, reflecting the various dimensions of research on STEM-PjBL, ranging from student skills, learning effectiveness, to the development of new technologies and learning approaches. However, there is an opportunity to further integrate elements such as creativity, technology, and cross-disciplinary applications in future research. This figure provides important insights to understand research trends and the potential for further development of this topic.

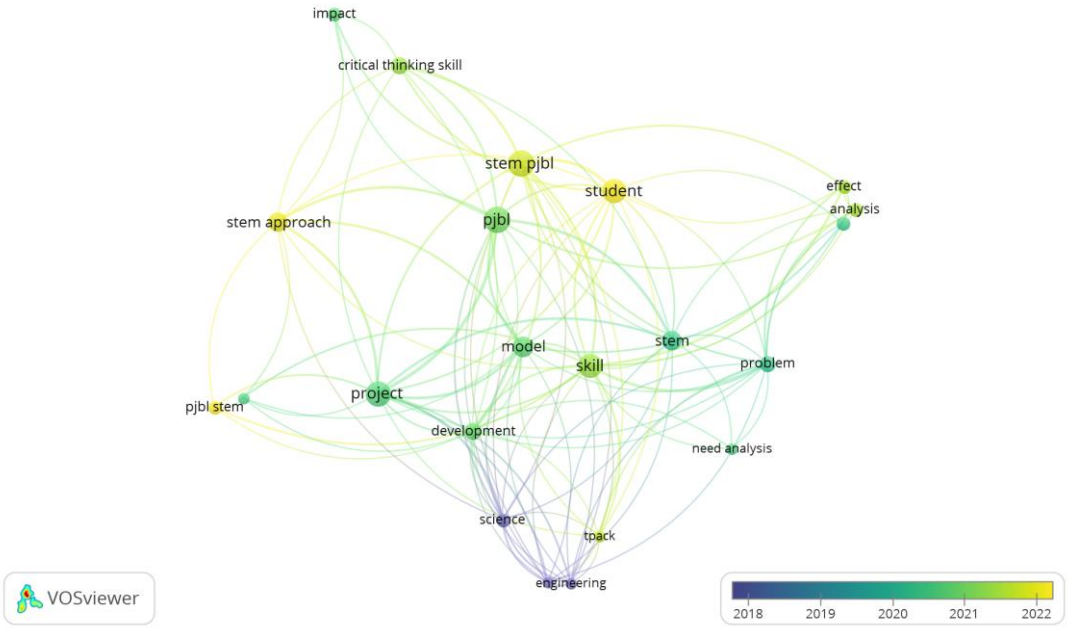

Figure 3. Overlay Visualization

This bibliometric map from VOSviewer shows the development of research on STEM-PjBL (Project-Based Learning) based on publications from 2018 to 2022. The main focus of research is seen in keywords such as STEM-PjBL, PjBL, Project, and Skill, indicating that many studies highlight the use of project-based learning models in STEM contexts to improve students' skills. The close relationship between PjBL, project, development, and STEM approach reflects that many studies focus on the development of project-based learning tools. In addition, the learning outcomes that are often studied are seen from the emergence of the keywords skill and critical thinking skill, which highlight the importance of developing students' critical thinking skills. Research on the effectiveness of this learning model is seen through the keywords effect, analysis, and impact which indicate a study of the influence of STEM-PjBL on student learning outcomes, especially critical thinking and problem-solving skills. In terms of time development, the color map shows a shift in research themes.

In 2018–2019 (marked in purple-blue), research focused more on the basics of STEM, educational technology approaches (TPACK), and science integration. Entering 2020–2021 (green), studies developed into project development, learning models, and skills evaluation. Meanwhile, in 2022 (yellow), research highlighted more aspects of impact and effectiveness analysis on critical thinking skills. However, several topics such as need analysis and TPACK appear to have fewer connections, indicating that studies on needs analysis and technology integration in STEM-PjBL learning have not been widely explored. This map reflects that research on STEM-PjBL continues to grow with a primary focus on project development and critical thinking skills enhancement, but opportunities for new studies remain open on aspects of needs analysis and educational technology integration.

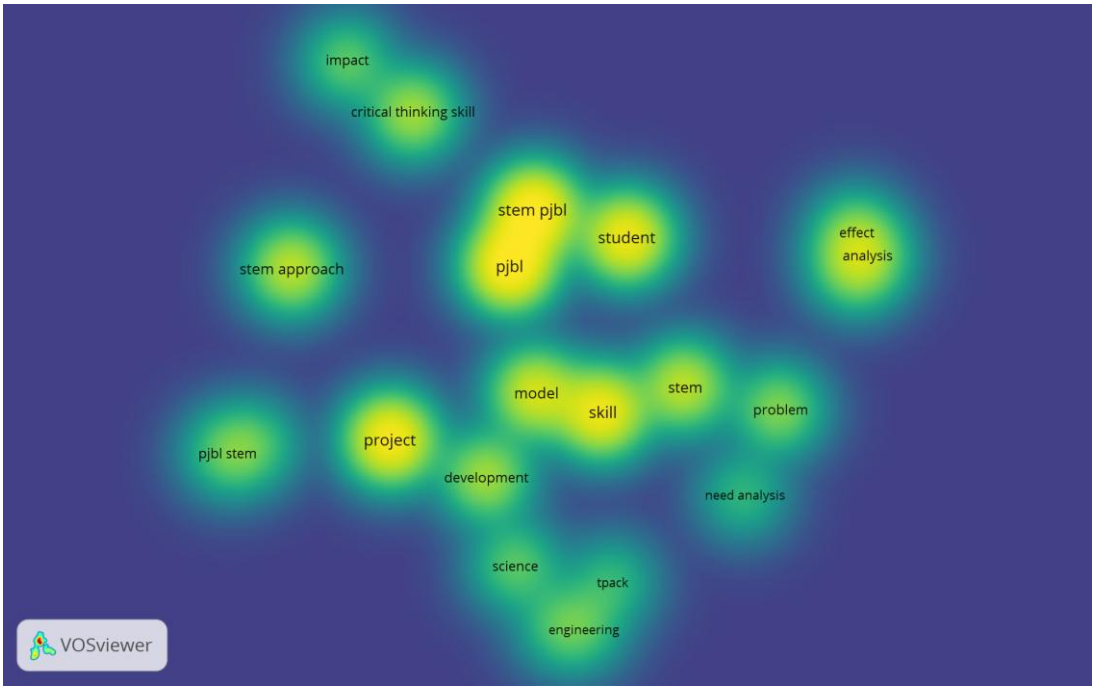

Figure 4. Density Visualization

This bibliometric map in the form of density visualization shows the density of research related to STEM-PjBL based on frequently occurring keywords. Yellow indicates areas with high density, indicating topics frequently discussed in research, while green to blue indicate topics with lower frequency. The main focus of the research is seen in the keywords STEM-PjBL, PjBL, project, model, and skill, which reflect the great attention to the use of project-based learning models in the STEM context to improve students' skills. In addition, the keywords critical thinking skill, impact, and effect analysis indicate that many studies explore the impact of the STEM-PjBL learning model on students' critical thinking skills.

Low density is seen in keywords such as need analysis, TPACK, and engineering, indicating that these topics have not been widely explored. This indicates new research opportunities, such as analyzing the needs for developing learning tools or exploring technology integration (TPACK) in STEM-PjBL. In addition, the problem keyword that appears in the medium density area indicates that there is research that discusses problem-solving skills as a result of implementing this model. This map illustrates that STEM-PjBL research has developed rapidly in improving critical thinking skills and problem-solving skills, but there are still opportunities for exploration in the technology and needs analysis aspects.

Implementation of the STEM-PjBL Learning Model in Improving Critical Thinking Skills

Based on the literature study that has been conducted, 32 articles have been selected from the Scopus database which shows that 5 articles discuss the implementation of the STEM-PjBL learning model in improving students' critical thinking skills. The results of the literature study are presented in Table 4 below.

Table 4. Matrix of the application of the STEM-PjBL learning model in improving students' critical thinking skills

No.	Author	Year	Research methods	Research result
1.	Astra et al.,	2023	(R&D) with the ADDIE model	The results of this study are based on the average proportion of the material validation test of 96.25%, the media validation test of 73.62%, the learning validation test of 80%, and the product assessment by the teacher's perspective of

				89.23%, and the product assessment by students of 88.4%. With an overall average of 85.5%, based on the validation and product trials, a proportion of 85.5% was obtained, the Sway e-learning media was in the very feasible category, and an n-gain value of 0.58 was also obtained in the moderate category. From the results of the n-gain value, it is concluded that e-learning based on PjBL integrated with STEM products using Microsoft Sway on parabolic motion material can improve students' critical thinking skills.
2.	Nafi'ah	2020	(R&D) with the ADDIE model	The main design results developed include the home page, login, and main menu which have nine options to facilitate the mathematics learning process. Based on expert assessments, the average value of 4.78 indicates a good assessment category. Therefore, the interactive multimedia design based on STEM-PjBL for mathematics learning activities in stimulating students' MCTS quality can be continued to the development, implementation, and evaluation stages.
3.	Prastiyan et al.,	2023	Quasi-Experiment	This study showed that there was no significant difference between students' critical thinking skills in both groups (U=25.00, p>0.05). This may be because students did not work together during the project and had low dependence on learning. These results imply that improving students' critical thinking skills is not easy to do. Furthermore, more attention and effort are needed when implementing TPACK-integrated STEM-PjBL during online learning environments.
4.	Parno et al.,	2022	Quasi-Experiment	The results showed that the CTS in the Experimental class with an average of 65.19 and an increase of 0.52 (moderate) was significantly higher than the comparison class with an average of 52.36 and an increase of 0.35 (moderate). Experimental class students had different levels of improvement in the probability and uncertainty analysis indicators. However, both classes experienced almost the same increase in the problem solving and decision making indicators, as well as an increase in the low category in the hypothesis testing indicator. The effect size value of 1.13 (Very Large category) indicates that PjBL-STEM-AF learning should be carried out more often in the field. Experimental class students gave a more positive learning response than the Comparison class. It is recommended in further research to add the "Art" aspect to the STEM approach to further develop students' CTS.
5.	Pramasdyahsari et al.,	2023	Experiment	The research findings show that the STEM PjBL digital book is valid and significant in fostering students' critical thinking skills and has a positive impact on other 21st century learning skills.

	Furthermore, the data shows that students feel satisfied and interested in learning through active teaching and learning methods that combine ICT tools and STEM-PjBL aspects.

The results of the literature review indicate that the application of the STEM-PjBL learning model has the potential to improve students' critical thinking skills with various approaches. The use of STEM-PjBL-based e-learning has proven effective with an increase in critical thinking skills in the moderate category. The development of interactive multimedia based on STEM-PjBL in mathematics learning has received good reviews from experts and has the potential to improve students' critical thinking skills. However, the application in online learning shows less than optimal results due to minimal cooperation between students, so more attention is needed in technology integration. The PjBL-STEM-AF model shows high effectiveness with a significant increase in critical thinking skills and positive student learning responses, while recommending enrichment of the approach with aspects of art (STEAM). In addition, the use of STEM-PjBL-based digital books has proven effective in fostering critical thinking skills and 21st century skills, with positive responses from students to active and innovative learning methods. Overall, the STEM-PjBL approach is effective in improving critical thinking skills, especially when supported by relevant learning tools, appropriate technology integration, and a collaborative learning environment.

This research has a significant positive impact on the development of science and technology education. This study can provide in-depth insights into the trends, effectiveness, and implementation patterns of the STEM-PjBL learning model in improving critical thinking skills. In addition, the results of this study can be a primary reference for educators and policy makers in designing a more relevant and contextual curriculum. By mapping research results for more than a decade, this study also helps identify the best strategies, challenges faced, and opportunities for the development of more innovative and effective learning models.

However, this study also has several limitations. First, as a systematic literature review, the results of the study are highly dependent on the quality and availability of the reviewed articles, so publication bias can affect the findings. Second, the time span of 2013–2024, although quite long, may not cover the latest developments in real time, especially research that has not been widely published. In addition, limitations in the analysis method, such as the lack of quantitative meta-analysis, can limit the generalizability of the results. Even so, this study still makes an important contribution in providing direction for future research and the development of evidence-based learning practices.

CONCLUSION

This study provides a comprehensive overview of research trends on the implementation of STEM-PjBL learning models to enhance students' critical thinking skills. The findings confirm that STEM-PjBL effectively fosters critical thinking, especially when supported by technology integration, collaborative projects, and interactive learning tools. The study also highlights Indonesia’s leading role in STEM-PjBL research. However, the results reveal gaps in technology integration and needs analysis within the existing literature, indicating opportunities for future exploration. Despite potential publication bias and limited meta-analytical synthesis, this study contributes valuable insights to educational practice and policy. Future research should focus on quantitative meta-analyses and explore underrepresented aspects such as technology integration and cross-disciplinary approaches in STEM-PjBL implementation.

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REFERENCES

Abdulsamee, N., Elkhadem, A., & Nagi, P. (2021). EC DENTAL SCIENCE Review Article Newer Dental Teaching Methods: Paradigm Shift from Teacher-Centered to Student-Centered Learning. Review. *Nagy Abdulsamee, Ahmed Elkhadem, and Passant Nagi*, *6*, 1–13.

AlAli, R. (2024). Enhancing 21St Century Skills Through Integrated Stem Education Using Project-Oriented Problem-Based Learning. *Geojournal of Tourism and Geosites* , *53*(2), 421–430. https://doi.org/10.30892/gtg.53205-1217

Baran, M., Baran, M., Karakoyun, F., & Maskan, A. (2021). The Influence of Project-Based STEM (PjbL-STEM) Applications on the Development of 21st-Century Skills. *Journal of Turkish Science Education*, *18*(4), 798–815. https://doi.org/10.36681/tused.2021.104

Biazus, M. de O., & Mahtari, S. (2022). The Impact of Project-Based Learning (PjBL) Model on Secondary Students' Creative Thinking Skills. *International Journal of Essential Competencies in Education*, *1*(1), 38–48. https://doi.org/10.36312/ijece.v1i1.752

Bulu, V. R., & Tanggur, F. (2021). The Effectiveness of STEM-Based PjBL on Student's Critical Thinking Skills and Collaborative Attitude. *Al-Jabar : Jurnal Pendidikan Matematika*, *12*(1), 219–228. https://doi.org/10.24042/ajpm.v12i1.8831

Chintya, J., Haryani, S., Linuwih, S., & Marwoto, P. (2023). Analysis of the Application of the Project Based Learning (PjBL) Learning Model on Increasing Student Creativity in Science Learning in Elementary Schools. *Jurnal Penelitian Pendidikan IPA*, *9*(6), 4558–4565. https://doi.org/10.29303/jppipa.v9i6.2726

Cortázar, C., Nussbaum, M., Harcha, J., Alvares, D., López, F., Goñi, J., & Cabezas, V. (2021). Promoting critical thinking in an online, project-based course. *Computers in Human Behavior*, *119*(October 2020), 1–18. https://doi.org/10.1016/j.chb.2021.106705

Dada, D., Laseinde, O. T., & Tartibu, L. (2022). Student-Centered Learning Tool for Cognitive Enhancement in the Learning Environment. *Procedia Computer Science*, *217*, 507–512. https://doi.org/10.1016/j.procs.2022.12.246

Fadhil, M., Kasli, E., Halim, A., Evendi, Mursal, & Yusrizal. (2021). Impact of Project Based Learning on Creative Thinking Skills and Student Learning Outcomes. *Journal of Physics: Conference Series*, *1940*(1), 1–8. https://doi.org/10.1088/1742-6596/1940/1/012114

García-Pérez, L., García-Garnica, M., & Olmedo-Moreno, E. M. (2021). Skills for a working future: How to bring about professional success from the educational setting. *Education Sciences*, *11*(1), 1–25. https://doi.org/10.3390/educsci11010027

Hasanah, N., Hasruddin, D., & Yus, A. (2024). The Effect of Problem Based Learning Model on Students Science Process Skills. *Journal of Science and Science Education*, *5*(2), 163–167. https://doi.org/10.2991/aisteel-18.2018.80

Hussein, B. (2021). Addressing collaboration challenges in project-based learning: The student's perspective. *Education Sciences*, *11*(8), 1–20. https://doi.org/10.3390/educsci11080434

Iksal, I., Hayani, R. A., & Aslan, A. (2024). Strengthening character education as a response to the challenges of the times. *Indonesian Journal of Education (INJOE)*, *4*(3), 761–774.

Issa, H. B., & Khataibeh, A. (2021). The Effect of Using Project Based Learning on Improving the Critical Thinking among Upper Basic Students from Teachers' Perspectives. *Pegem Egitim ve Ogretim Dergisi*, *11*(2), 52–57. https://doi.org/10.14527/pegegog.2021.00

Karan, E. (2023). Discovery-based approach combined with active learning to improve student learning experiences for STEM students. *International Journal of Education and Humanities*, *3*(4), 288–299.

Krisnawati, F., Ekawati, A. D., & Abdurachman, E. (2023). Fuzzy SERVQUAL to Measure the Service Quality of Tutoring Institutions: A Systematic Literature Review Using PRISMA. *E3S Web of*

Conferences, *426*, 1–7. https://doi.org/10.1051/e3sconf/202342601064

Kurniahtunnisa, K., Anggraito, Y. U., Ridlo, S., & Harahap, F. (2023). STEM-PjBL Learning: The Impacts on Students' Critical Thinking, Creative Thinking, Communication, and Collaboration Skills. *Jurnal Penelitian Pendidikan IPA*, *9*(7), 5007–5015. https://doi.org/10.29303/jppipa.v9i7.2985

Lestari, H. D., Rahmawati, Y., & Usman, H. (2024). STEM-PjBL Learning Model To Enhance Critical Thinking Skills of Students on Magnets, Electricity, and Technology. *Jurnal Penelitian Pendidikan IPA*, *10*(8), 6027–6037. https://doi.org/10.29303/jppipa.v10i8.8153

Li, L. (2022). Reskilling and Upskilling the Future-ready Workforce for Industry 4.0 and Beyond. *Information Systems Frontiers*, *26*(5), 1697–1712. https://doi.org/10.1007/s10796-022-10308-y

Maryani, I., Astrianti, C., & Erviana, V. Y. (2021). The Effect of The STEM-PjBL Model on The Higher-Order Thinking Skills of Elementary School Students. *Sekolah Dasar: Kajian Teori Dan Praktik Pendidikan*, *30*(2), 110. https://doi.org/10.17977/um009v30i22021p110

Mulyani, D. F., & Arif, S. (2021). Implementation of Project Based Learning (Pjbl) Based on Science, Technology, Engineering and Mathematics (Stem) To Improve Metacognitive Thinking Ability. *INSECTA: Integrative Science Education and Teaching Activity Journal*, *2*(1), 117–129. https://doi.org/10.21154/insecta.v2i1.2931

Ogedengbe, D. E., James, O. O., Afolabi, J. O. A., Olatoye, F. O., & Eboigbe, E. O. (2023). Human Resources in the Era of the Fourth Industrial Revolution (4Ir): Strategies and Innovations in the Global South. *Engineering Science & Technology Journal*, *4*(5), 308–322. https://doi.org/10.51594/estj.v4i5.617

Olugbenga, M. (2021). The Learner Centered Method and Their Needs in Teaching. *International Journal of Multidisciplinary Research and Explorer (IJMRE)*, *1*(9), 64–69. https://doie.org/10.1016/IJMRE.2021831851

Rini, E. F. S., Raharjo, S. B., & Bramastia, B. (2025). Bibliometric Analysis From 2014-2024 : Integration of Ethnoscience in Science Learning. *Journal Evaluation in Education (JEE)*, *6*(1), 185–199. https://doi.org/10.37251/jee.v6i1.1262

Rohmah, N. S., Suryaningtyas, W., & Holisin, I. (2023). Implementation of the STEM-GeoGebra Integrated PjBL Model to Improve Student's Critical Thinking Skills. *Jurnal Pendidikan Matematika ISSN-P*, *14*(2), 123–134.

Roslina, R., Samsudin, A., & Liliawati, W. (2022). Effectiveness of Project Based Learning Integrated STEM in Physics Education (STEM-PJBL): Systematic Literature Review (SLR). *Phenomenon : Jurnal Pendidikan MIPA*, *12*(1), 120–139. https://doi.org/10.21580/phen.2022.12.1.11722

Sarwi, S., Baihaqi, M. A., & Ellianawati, E. (2021). Implementation of Project Based Learning Based on STEM Approach to Improve Students' Problems Solving Abilities. *Journal of Physics: Conference Series*, *1918*(5), 1–5. https://doi.org/10.1088/1742-6596/1918/5/052049

Satiti, N. R., Yin, T. S., & Pitchay, A. A. (2024). Financial and Technological Literacies: An Integrated Systematic Review Using PRISMA Workflow, Bibliometric Analysis and TCCM Framework for Future Research Agenda. *International Journal of Academic Research in Economics and Management Sciences*, *13*(2), 538–565. https://doi.org/10.6007/ijarems/v13-i2/21797

Shamuganathan, S. (2023). STEM Project-Based Learning Activities for Sustainability : Enhancing Scientific and 21st Century Skills Among Pre-University Students. *Learning Science and Mathematics*, *18*, 62–83.

Sitopu, J. W., Khairani, M., Roza, M., Judijanto, L., & Aslan, A. (2024). the Importance of Integrating Mathematical Literacy in the Primary Education Curriculum : a Literature Review. *International Journal of Teaching and Learning (INJOTEL)*, *2*(1), 121–134.

Sokhanvar, Z., Salehi, K., & Sokhanvar, F. (2021). Advantages of authentic assessment for improving

the learning experience and employability skills of higher education students: A systematic literature review. *Studies in Educational Evaluation*, *70*(February 2020), 101030. https://doi.org/10.1016/j.stueduc.2021.101030

Suryonegoro, B. M., Sri, T., Asih, N., Mariani, S., & Rosyida, I. (2025). Meta Analysis : Analysis of Students ' Mathematical Critical Thinking Ability Through the Inquiry Learning Model. *Journal Evaluation in Education (JEE)*, *6*(1), 89–101. https://doi.org/10.37251/jee.v6i1.1305

Thornhill-Miller, B., Camarda, A., Mercier, M., Burkhardt, J. M., Morisseau, T., Bourgeois-Bougrine, S., Vinchon, F., El Hayek, S., Augereau-Landais, M., Mourey, F., Feybesse, C., Sundquist, D., & Lubart, T. (2023). Creativity, Critical Thinking, Communication, and Collaboration: Assessment, Certification, and Promotion of 21st Century Skills for the Future of Work and Education. *Journal of Intelligence*, *11*(3). https://doi.org/10.3390/jintelligence11030054

Uden, L., Sulaiman, F., Ching, G. S., & Rosales, J. J. (2023). Integrated science, technology, engineering, and mathematics project-based learning for physics learning from neuroscience perspectives. *Frontiers in Psychology*, *14*(June), 1–15. https://doi.org/10.3389/fpsyg.2023.1136246

Wang, T., Lund, B. D., Marengo, A., Pagano, A., Mannuru, N. R., Teel, Z. A., & Pange, J. (2023). Exploring the Potential Impact of Artificial Intelligence (AI) on International Students in Higher Education: Generative AI, Chatbots, Analytics, and International Student Success. *Applied Sciences (Switzerland)*, *13*(11). https://doi.org/10.3390/app13116716

Winarni, E. W., Karpudewan, M., Karyadi, B., & Gumono, G. (2022). Integrated PjBL-STEM in Scientific Literacy and Environment Attitude for Elementary School. *Asian Journal of Education and Training*, *8*(2), 43–50. https://doi.org/10.20448/edu.v8i2.3873

Yanti, N., Rahmad, M., & Azhar. (2023). Application of PjBL (Project Based Learning) Based Physics Learning Model to Improve Collaboration Skills and Creative Thinking Ability of Students. *Jurnal Penelitian Pendidikan IPA*, *9*(11), 9973–9978. https://doi.org/10.29303/jppipa.v9i11.5275

Yee, K. K., & Huey Shyh, T. (2024). Problem-Based Learning: Media and Information Literacy Project to Combat Misinformation for Future Communicators. *Journalism and Mass Communication Educator*, *79*(3), 340–364. https://doi.org/10.1177/10776958241256404

Yu, H. (2024). Enhancing creative cognition through project-based learning: An in-depth scholarly exploration. *Heliyon*, *10*(6), e27706. https://doi.org/10.1016/j.heliyon.2024.e27706

Zulyusri, Z., Elfira, I., Lufri, L., & Santosa, T. A. (2023). Literature Study: Utilization of the PjBL Model in Science Education to Improve Creativity and Critical Thinking Skills. *Jurnal Penelitian Pendidikan IPA*, *9*(1), 133–143. https://doi.org/10.29303/jppipa.v9i1.2555