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# Bibliometric Analysis of Problem-Based Learning Model with STEM Approach: Critical Thinking Skills of Elementary School Students

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**ABSTRACT**

Elementary schools must creatively develop critical thinking abilities to equip students with 21st-century competencies. Analyzing previous research on integrating learning models for this purpose is necessary. This study will bibliometrically analyze the research on integrating the Problem-Based Learning (PBL) model with the Science, Technology, Engineering, and Mathematics (STEM) approach to improve elementary school critical thinking. VOSviewer software was used to conduct a systematic literature review and bibliometric analysis of 52 Scopus-indexed articles from 2020–2024. Publish or Perish (PoP), linked to Scopus, collected publication data using "problem-based learning," "STEM," "critical thinking," and "elementary school." The literature review found that the STEM-integrated PBL model in elementary schools improves critical thinking and student learning by providing real-world problems to solve. Indonesia contributed 30 articles, followed by the US (5 articles) and Hong Kong (3 articles). The study's five-year collaboration network includes 69 researchers. Bibliometric analysis indicated a high association between "STEM" and "critical thinking" and "learning model," showing that STEM influences critical thinking skills. The association between "problem-based learning," "learning model," and "critical thinking" showed that PBL strongly impacts these skills. But network visualization revealed a research gap in the weak and narrow connections between "STEM," "Problem-Based Learning," and "Elementary School." The first co-occurrence analysis showed "critical thinking," followed by "problem-based learning" and "STEM." The rise of "bibliometric analysis" and "elementary school" suggests elementary education research is digitizing. In conclusion, STEM-integrated PBL has worked, but further research is needed to apply it to elementary school pupils.



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## 1. INTRODUCTION

The 21st century demands that students possess essential skills to face global challenges, summarized in the 6Cs concept: character, citizenship, critical thinking,

creativity, collaboration, and communication (Varas et al., 2023). These skills consist of character, citizenship, critical thinking, creativity, collaboration, and communication (Astuti, 2024). Critical thinking is one of the most important skills for students to learn because it helps them understand ideas, figure out how to solve problems, and make their own choices, especially in elementary school (Anggraeni et al., 2023; Larsson, 2017; Xu et al., 2023). Critical thinking skills include the ability to look at information, weigh the evidence, and make smart choices (Ariadila et al., 2023; Diani et al., 2020; Hitchcock, 2017; Jaelani et al., 2023; Plummer et al., 2022).

To develop these skills, an effective learning model is needed. Learning model as a structured framework or strategy that directs the interaction between educators and students to attain designated educational objectives (Diani et al., 2019; Joyce, 2008; Siregar, 2021). One widely used model is Problem-Based Learning (PBL), which emphasizes solving real-world problems through critical and exploratory thinking (Diani et al., 2018; Muzaini et al., 2022; van Der Vleuten & Schuwirth, 2019). PBL provides space for students to be active, analytical, and reflective in their learning (Hafizah et al., 2024; Hasbi & Fitri, 2023; Loyens et al., 2023). Additionally, Problem-Based Learning (PBL) is a way for students to learn by solving problems in steps based on scientific methods (Aprina et al., 2024; Arici & Yilmaz, 2023; Arthamena et al., 2025; Diani et al., 2018). Through this model, students not only gain a relevant understanding of the problems they face but also develop critical thinking, analytical skills, and independent problem-solving.

This PBL model can be combined with the Science, Technology, Engineering, and Mathematics (STEM) approach to make learning more relevant by giving students real-world problems to solve (Funa et al., 2024; Monika et al., 2023; Wiratman et al., 2023). The STEM approach was chosen because it can connect various disciplines in an integrated manner, allowing students to understand not only theory but also how these concepts are applied in real life (Dare et al., 2021; Diani et al., 2021; Juškevičienė et al., 2021; Le et al., 2023; Roehrig et al., 2021). The goal is to connect concepts to the real world and solve contextual problems through project-based, problem-based, or other learning (Diani et al., 2024). Thus, the integration of PBL and STEM creates exploration-based learning that can improve students' understanding of scientific concepts and critical thinking skills.

Previous studies have proven the effectiveness of these two approaches in enhancing students' critical thinking skills (Arisa & Sitinjak, 2022; Awaludin et al., 2025; Ikhsan et al., 2025; Khoirunnissa et al., 2024; Nurazmi & Bancong, 2021). Many studies have not thoroughly explored how PBL can be effectively integrated with STEM approaches and its impact on elementary school students' critical thinking skills. Most studies focus more on higher education levels, such as secondary or tertiary education, while paying less attention to implementation at the elementary school level. To fill this gap, the bibliometric method was chosen as the method in this study.

Bibliometrics is a quantitative method that systematically and structurally visualizes the results of analyzing large volumes of scientific literature (Donthu et al., 2021; Passas, 2024; Pessin et al., 2022). This method enables researchers to discern

publication patterns, emerging topic trends, collaborations among researchers, and prevailing concept maps within a specific field of study (Hassan & Duarte, 2024; Hidayatullah et al., 2024; Klarin, 2024; Öztürk et al., 2024). The use of bibliometric analysis in this study is important because this approach can provide a comprehensive and objective visualization of the development of scientific studies in the field of integrating Problem-Based Learning (PBL) and STEM approaches in elementary education.

This study utilizes the Scopus database from 2020 to 2024 to investigate the developmental trends and deficiencies in research concerning the integration of Problem-Based Learning (PBL) and STEM in fostering critical thinking skills among elementary school students. We expect the results of this analysis to contribute conceptually and practically to the development of innovative learning strategies at the elementary level. Moreover, this bibliometric study can provide a basis for future researchers investigating the amalgamation of learning models that address the requirements of 21st-century competencies, especially in enhancing critical thinking skills via problem-based and contextual methodologies.

## 2. METHOD

The methods used in writing this scientific article are bibliometric analysis and bibliometric visualization. Bibliometric visualization methods function to display the structure and relationships within a particular field of study (Zakiyyah et al., 2022). In this study, the type of analysis used is descriptive bibliometrics, which focuses on describing the characteristics of the literature reviewed. The use of bibliometric analysis has several objectives, one of which is to identify current trends in the publication of scientific articles and journals (Azzahrawaani et al., 2023; Klarin, 2024). This method allows researchers to uncover data on trends, patterns, and relationships in a particular field by examining factors such as citations, collaborations between authors, and keywords. Relevant articles were downloaded in RIS format and then imported into Mendeley software, which stores reference information related to the articles.

The obtained data was processed and visualized using the VOSviewer application. Then, the publication frequency was obtained based on the keywords PBL, STEM, critical thinking, and elementary school students. VOSviewer is software for building and visualizing bibliometric analysis (Iriyani et al., 2023; Martins et al., 2024). This application provides an interactive interface that allows users to explore bibliometric maps in depth. Furthermore, VOSviewer can present maps in various visualizations according to the desired aspects, making it easier for users to conduct detailed analysis of the maps (Ananda et al., 2025).

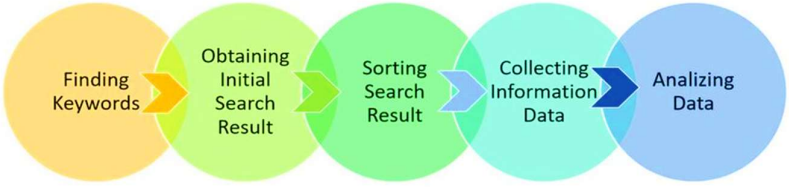



**Figure 1.** Bibliometric Analysis

**Stages in Bibliometric Analysis**

This analysis process employed five main stages, carried out in a structured manner to ensure the quality of the literature data synthesis and the depth of the analysis. These five stages are as follows:

1. Determining Selected Keywords

The crucial initial step in conducting bibliometric analysis is determining search keywords. Keyword selection must accurately represent the context and substance of the research topic. In this study, the research used primary keywords such as "problem-based learning," "STEM," "critical thinking," and "primary/elementary school." These keywords were chosen because they represent the three main pillars of the research: PBL, STEM, and critical thinking at the elementary education level. The selection of appropriate keywords significantly determines the relevance and quality of the collected scientific documents. These keywords are then entered into the Publish or Perish (PoP) software, which is connected to the Scopus database, the primary repository of scientific documents.

2. Initial Data Search

The second stage is conducting an initial search for scientific literature based on predetermined keywords. This search was conducted using PoP software to extract data from Scopus with publication dates spanning the last four years (2020-2024). This timeframe was chosen to capture current research trends and the topic's relevance in the context of modern education, which is increasingly based on technology integration and problem-based learning. The types of documents collected included scientific journal articles, conference proceedings, and other academically relevant, peer-reviewed works. This initial search aimed to broadly capture the literature as starting material before the screening and mapping process.

3. Narrowing the data results by only including inclusion criteria

After the documents were collected from the initial search, the next step was to filter or narrow the search results. Not all results collected from PoP were automatically used. This process eliminated irrelevant documents, duplicates, or those that did not meet the inclusion criteria. The narrowing was carried out systematically, considering several inclusion and exclusion criteria. The following are the inclusion and exclusion criteria applied by the researcher in the article selection process in Table 1.

**Table 1.** Inclusion and Exclusion Criteria

| Inclusion Criteria | Exclusion Criteria |
|---|---|
| The publication type is an article (Full Text) with open access, obtained from the Publish or Perish database in Scopus. | Publication Types other than articles obtained from the Publish or Perish database and Scopus |
| The title and content of the article are related to PBL, STEM, and Critical Thinking in Elementary Schools. | Unrelevant titles |
| Publication Year: 2020-2024. | Publication Year not within the 2020-2024 Period |

| Inclusion Criteria | Exclusion Criteria |
|---|---|
| All languages can be used in this study, depending on the needs and relevant research context. | Others |
| Publications with similar research topics will be selected based on the level of detail and the current relevance of the findings presented. | Others |
| The theme of the article is PBL, STEM, and Critical Thinking, with elementary school students as the research participants. | Themes other than PBL, STEM, and Critical Thinking, with elementary school students as participants. |

The Mendeley app was also used to group documents as a reference manager during this process. It sorted and stored the final selection results in RIS (Research Information Systems) format. This stage resulted in a more focused, high-quality, and relevant collection of literature for the bibliometric analysis objectives.

4. Analysis with VOSviewer

This crucial stage in bibliometric analysis is the visualization and analysis of the data network using VOSviewer software. This software is capable of constructing a visual map of the relationships between entities in the reviewed literature, such as:

• Relationships between keywords (co-occurrence)

• Collaboration between authors (co-authorship)

5. Reporting the final results

This stage is the final step in bibliometrics, where the articles from the search and selection are processed into a report and discussed in a literature review article. Through VOSviewer, researchers can identify dominant themes, discover research clusters, and detect trends in the development of studies related to the application of PBL with a STEM approach. Furthermore, this visual map enables researchers to identify research gaps that can be used as opportunities for further research. By integrating these three applications—PoP, Mendeley, and VOSviewer—this study not only presents descriptive bibliographic data but also provides a visual and interpretive understanding of the patterns of relationships between elements in the literature. This approach supports the achievement of the research objective, namely, to present a comprehensive and informative scientific mapping of the contribution of PBL and STEM to developing critical thinking in elementary school students.

Researchers used the POP database to collect metadata related to PBL, STEM, and critical thinking in elementary school students between 2020 and 2024. Relevant articles were downloaded in RIS format and then imported into Mendeley software, which stores reference information related to the articles. The collected data was processed and visualized using the VOSviewer application, and then publication frequency was obtained based on predetermined keywords.

## 3. RESULTS AND DISCUSSION

There are 52 publications in the POP database that include the keywords PBL, STEM, and Critical Thinking in Elementary Schools during the 2020-2024 period, as shown in Table 2 and illustrated with a percentage graph in Figure 2.

**Table 2.** Number and percentage of STEM-integrated PBL publications on Critical Thinking of Elementary School Students (2020-2024)

| No | Publication Year | Number of Publications | Percentage |
|---|---|---|---|
| 1 | 2024 | 7 | 13,46 % |
| 2 | 2023 | 9 | 17,31 % |
| 3 | 2022 | 15 | 28,85 % |
| 4 | 2021 | 8 | 15,38 % |
| 5 | 2020 | 13 | 25,00 % |
| | Total | 52 | 100 % |

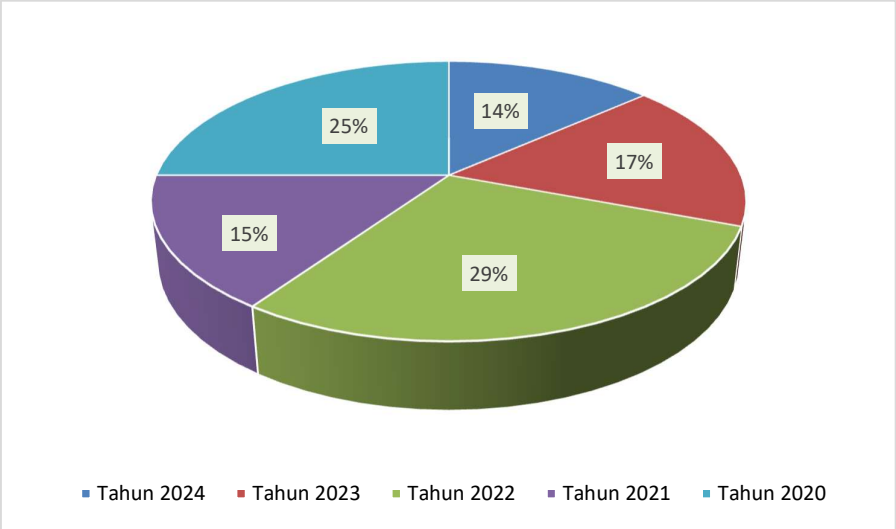



**Figure 2**. Graph of the Number and Percentage of STEM-Integrated PBL Publications on Critical Thinking of Elementary School Students (2020-2024)

The data indicated that the highest number of publications per year was in 2022, with 15 publications, with a research trend that has been declining for the past three years. Of these 52 publications, 52 were from journals or articles. The data analysis technique used in this study was descriptive. The analysis began with processing Publish Or Perish (POP) data using VOSviewer. There are 14 countries with published articles related to PBL, STEM, and critical thinking in elementary schools in the Scopus database.

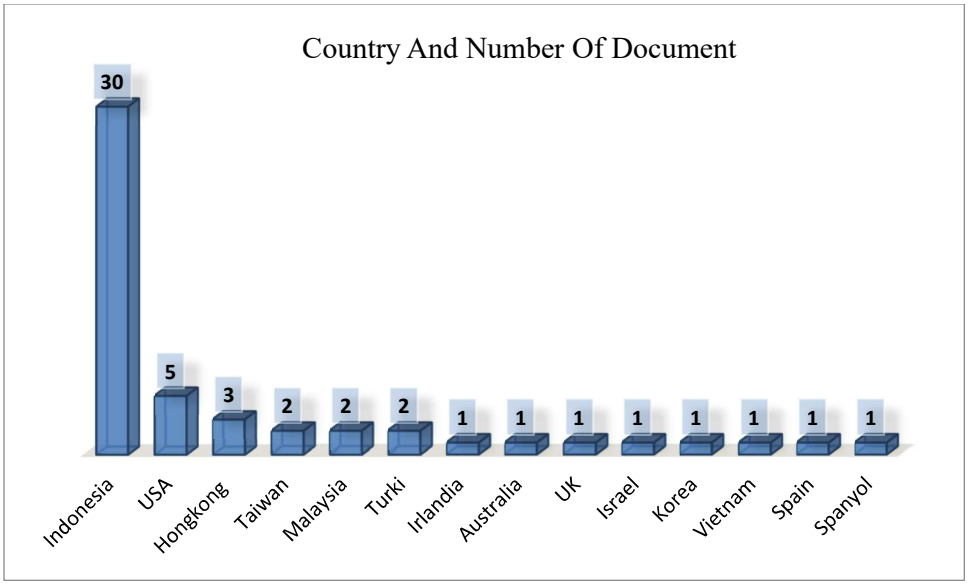



**Figure 3.** Graph of Distribution of Research in Various Countries

The graph above shows the distribution of published articles related to the application of PBL with a STEM approach to critical thinking in elementary education across various countries. According to the Scopus database, 14 countries have published this topic. Indonesia has made the most contributions to the field, with 30 publications. The USA comes in second with 5, followed by Hong Kong with 3, and Taiwan, Malaysia, and Turkey with 2 each. Meanwhile, Ireland, Australia, the UK, Israel, Korea, Vietnam, and Spain have only 1 publication.

Indonesia has demonstrated a significant role in research on the PBL model with a STEM approach to critical thinking in elementary school students. One example of a relevant publication is the study by Nurazmi & Bancong (2021), which examined the effect of implementing the PBL-STEM learning model on elementary school students' critical thinking skills in specific materials. This study was designed quantitatively with experimental and control groups. Experimental research has also been conducted to improve elementary school students' critical thinking skills using a systematic approach.

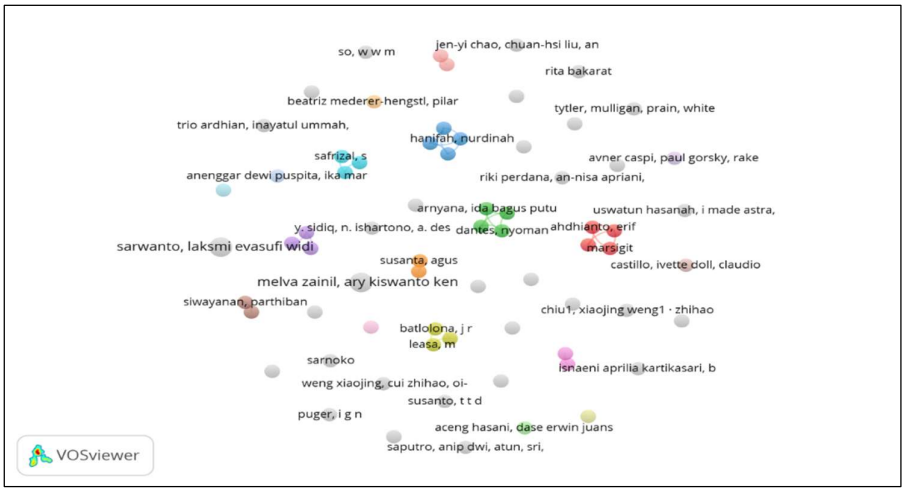



**Figure 4.** Visualization of Collaboration Between Authors

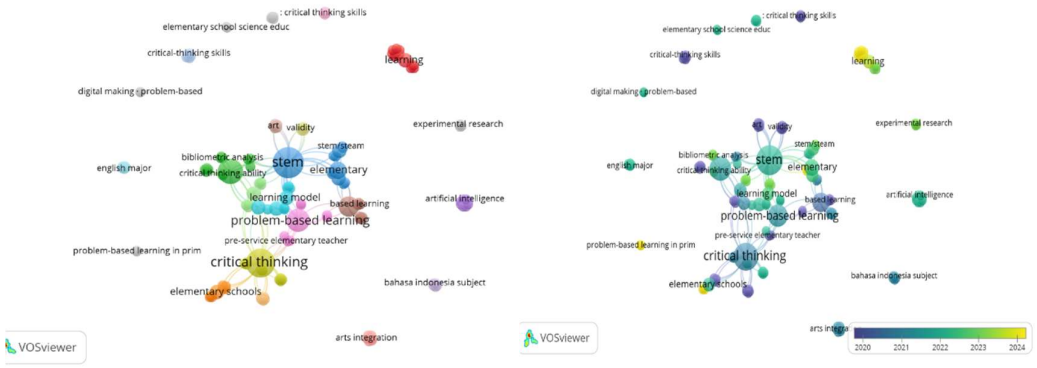
The figure above depicts a collaborative network between authors in research on PBL, STEM, and critical thinking over the past five years, generated using VOSviewer and involving 69 researchers. Nodes with similar color proximity represent groups of authors who frequently collaborate, forming clusters based on specific research topics. This collaboration reflects a common pattern in academic research, where researchers with similar interests collaborate, forming research groups focused on specific areas (Rahayu & Christiani, 2020).

From the analysis of 52 articles, 153 keywords were identified in research on PBL, STEM, and critical thinking in elementary schools. The researchers set a minimum threshold of one occurrence for each term to ensure statistical validity. The most dominant keyword was "STEM" with 9 occurrences, followed by "Critical Thinking" with 8 occurrences, "Elementary School" with 6 occurrences, "Problem-Based Learning" with 5 occurrences, "Learning Model" with 2 occurrences, "6C Skills" with 1 occurrence, and "Bibliometrics" with 1 occurrence. The findings of these frequently appearing keywords can be seen in Table 3 below.

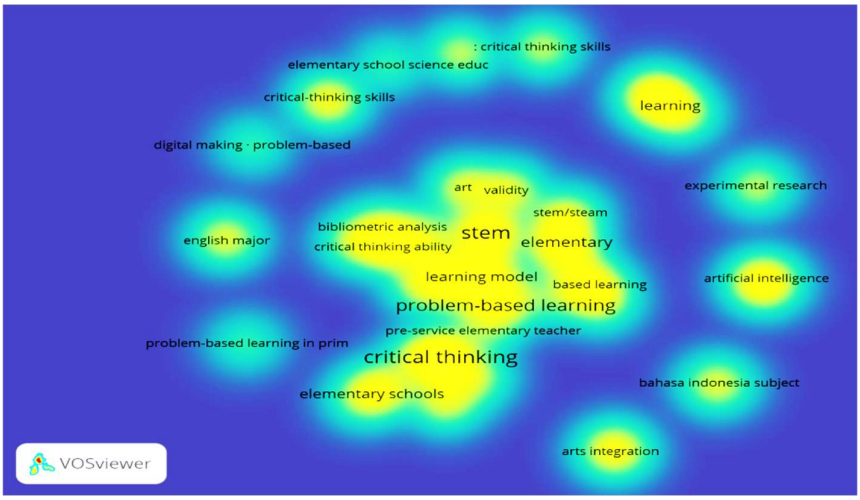
**Table 3.** Frequently Appearing Keywords

| Keyword | Occurences | Total Link Strenght |
|---|---|---|
| STEM | 9 | 34 |
| *Critical Thinking* | 8 | 30 |
| *Elementary School* | 6 | 20 |
| *Problem Based Learning* | 5 | 15 |
| *Learning Model* | 2 | 8 |
| *6C Skills* | 1 | 4 |
| *Bibliometrics* | 1 | 3 |

This study examines how the PBL learning model integrated with the STEM approach affects students' critical thinking skills in elementary schools. The primary aim of this study is to furnish a comprehensive and objective depiction of the evolution of scientific research in the integration of Problem-Based Learning (PBL) with the STEM approach at the elementary education level. The implementation of the Problem-Based Learning (PBL) model integrated with the Science, Technology, Engineering, and Mathematics (STEM) approach can significantly improve the 4C skills (Critical Thinking, Creativity, Collaboration, and Communication) of elementary school students (Angga, 2022). This PBL model can be integrated with the Science, Technology, Engineering, and Mathematics (STEM) approach to create a more contextual learning experience where they are faced with real problems that require solutions. Thus, the integration of PBL and STEM creates exploration-based learning that can improve students' understanding of scientific concepts and critical thinking skills (Funa et al., 2024; Nur & Ikhsan, 2024).




**(a)** **(b)**




**(c)**

**Figure 5.** (a) Network Visualization, (b) Overlay Visualization Co-Occurences, (c) Destiny Visualization Co-Occurrence

Figure 5(a) shows the results of the analysis of 153 identified keywords. Ninety of the 153 identified keywords demonstrated a significant relationship, leading to their inclusion in the co-occurrence visualization. The visualization illustrates the relationship between the concept of "STEM" and various other concepts, such as "Critical Thinking" and "Learning Model," suggesting that the STEM approach as a learning method or model can positively impact students' critical thinking skills. The relationship between the keywords "Problem-Based Learning," "Learning Model," and "Critical Thinking" also indicates that PBL is a learning model that has a significant influence on critical thinking skills. However, the resulting bibliometric graphic visualization shows that the relationship between "STEM," "Problem-Based Learning," and "Elementary School" is narrow and less connected. This conclusion suggests a research gap and presents an opportunity for future research to integrate the problem-based learning model with the STEM approach in its application to elementary school students. STEM was chosen because it can connect various disciplines in an integrated manner so that students understand not only theory but also how these concepts are applied in real life (Ammar et al., 2024; Maričić & Lavicza, 2024). This approach

stresses the need to keep the teaching and learning process honest by improving teachers' skills through new and effective ways of learning (Abu Khurma et al., 2022; Talib et al., 2025).

Figure 5(b) displays a temporal dimension highlighting the dynamics of changes in the focus of keyword research between 2020 and 2024. The shift in color from blue to green in the visualization indicates that topics such as "Critical Thinking" were more dominant at the beginning of the period, followed by research developments in "Problem-Based Learning," then "STEM" in the middle of the period, and further growth at the end of the research period following digitalization, marked by the emergence of the keyword "bibliometric analysis" and its application in elementary schools, characterized by the keyword "Elementary School." This is certainly a positive trend, reflecting researchers' rapid response to the context of developing learning methods in elementary schools.

Figure 5(c) shows frequency patterns and identifies overall trends or dominant topics within a data collection. Areas with high density are typically represented by brighter colors, such as yellow, while areas with low density use cooler colors. Areas with higher light intensity are depicted by the keyword "STEM," followed by "Critical Thinking," "Elementary School," "Problem-Based Learning," and "Learning Model," indicating that these topics are frequently discussed in published literature. This visualization clearly illustrates the current research trends that dominate the related fields.

This article contributes to mapping and identifying trends, collaboration patterns (authors, institutions, countries), dominant keywords, and thematic developments of research linking PBL, STEM, and critical thinking skills at the elementary school level over a specific time. It provides a comprehensive overview of the implementation and effectiveness of the STEM-based PBL model as a framework for training critical thinking skills at the elementary school level, which is rarely synthesized bibliometrically. The results of this study can serve as a theoretical basis for curriculum development or teacher guidance in integrating STEM and PBL and strengthening critical thinking literacy in elementary schools. In addition, for teachers, it provides practical recommendations regarding the most effective keywords, instruments, and learning designs (based on the most influential articles) in implementing PBL-STEM to strengthen the critical thinking skills of elementary school students. Overall, the specific combination of the three main variables (PBL + STEM + Critical Thinking in Elementary School) analyzed using bibliometric methods is still relatively rare, especially with an exclusive focus on the elementary school level. Analysis is often broader in scope or only focuses on two of the three variables.

## 4. CONCLUSION

A literature review of 52 articles indexed by Scopus for the 2020–2024 period that met the inclusion criteria concluded that the implementation of the problem-based learning model integrated with STEM at the elementary school level has proven effective in improving critical thinking skills and student learning outcomes. This PBL model can be combined with the Science, Technology, Engineering, and Mathematics

(STEM) approach to make learning more relevant by giving students real-world problems to solve. The distribution of article publications related to the application of PBL with a STEM approach to critical thinking at the elementary school level varies across countries, with Indonesia contributing significantly by publishing 30 articles, followed by the USA with 5 articles and Hong Kong with 3 articles. Bibliometric analysis charted the collaborative network among authors, encompassing 69 researchers within the scope of this study over the preceding five years.

The results of the network visualization from the bibliometric analysis show the relationship between the concept of "STEM" and various other concepts, such as "critical thinking" and "learning model." This data indicates that the STEM approach, as a method or learning model, can impact students' critical thinking abilities. The relationship between the keywords "problem-based learning," "learning model," and "critical thinking" also indicates that PBL is a learning model that has a significant influence on critical thinking abilities. However, the visualization results indicate that the relationship between "STEM," "Problem-Based Learning," and "Elementary School" is narrow and less connected; this suggests a research gap that could be addressed in the future by integrating the Problem-Based Learning model with the STEM approach for application to elementary school students. The results of the bibliometric co-occurrence visualization overlay indicate that "critical thinking" was more dominant at the beginning of the period, followed by developments in "problem-based learning" and then "STEM" in the middle. Towards the end of the research period, digitalization emerged, marked by the introduction of the keyword "bibliometric analysis," which is applied in elementary schools, as indicated by the keyword "elementary school." Overall, this study confirms that the PBL learning model integrated with the STEM approach is an effective learning model for improving elementary school students' critical thinking skills. We anticipate that the analysis's results will contribute conceptually and practically to the development of innovative learning strategies at the elementary education level.

As a suggestion, educational policymakers (such as the Ministry of Education and Culture) need to consider strengthening the implementation of STEM-based PBL in the elementary school curriculum as a key strategy for developing 21st-century skills. Future research should focus on developing and testing conceptual models that explicitly bridge PBL and each dimension of STEM (science, technology, engineering, and mathematics) in the cognitive context of elementary school students, particularly in measuring improvements in critical thinking. In addition, researchers are encouraged to use more rigorous quantitative experimental methods with control groups, as well as combine them with qualitative approaches to deeply understand students' critical thinking processes as they engage in PBL-STEM tasks.

## REFERENCES

Abu Khurma, O., Al Darayseh, A., & Alramamneh, Y. (2022). A framework for incorporating the “learning how to learn” approach in teaching STEM education. *Education Sciences*, *13*(1), 1. https://doi.org/10.3390/educsci13010001

Ammar, M., Al-Thani, N. J., & Ahmad, Z. (2024). Role of pedagogical approaches in fostering innovation among K-12 students in STEM education. *Social Sciences & Humanities Open*, *9*, 100839. https://doi.org/10.1016/j.ssaho.2024.100839

Ananda, Y., Rizal, E., & Rohman, A. S. (2025). Pemetaan pengetahuan terhadap perkembangan penelitian kebutuhan informasi pada database Scopus menggunakan VOSViewer. *Informatio: Journal of Library and Information Science*, *5*(1), 49–66. https://jurnal.unpad.ac.id/informatio/article/view/59622

Angga, A. (2022). Penerapan Problem Based Learning Terintegrasi STEAM untuk Meningkatkan Kemampuan 4C Siswa. *Jurnal Didaktika Pendidikan Dasar*, *6*(1), 281–294. https://doi.org/10.26811/didaktika.v6i1.541

Anggraeni, D. M., Prahani, B. K., Suprapto, N., Shofiyah, N., & Jatmiko, B. (2023). Systematic review of problem based learning research in fostering critical thinking skills. *Thinking Skills and Creativity*, *49*, 101334. https://doi.org/10.1016/j.tsc.2023.101334

Aprina, E. A., Fatmawati, E., & Suhardi, A. (2024). Penerapan model problem based learning untuk mengembangkan keterampilan berpikir kritis pada muatan IPA sekolah dasar. *Didaktika: Jurnal Kependidikan*, *13*(1), 981-990. https://doi.org/10.58230/27454312.496

Ariadila, S. N., Silalahi, Y. F. N., Fadiyah, F. H., Jamaludin, U., & Setiawan, S. (2023). Analisis pentingnya keterampilan berpikir kritis terhadap pembelajaran bagi siswa. *Jurnal Ilmiah Wahana Pendidikan*, *9*(20), 664-669. https://doi.org/10.5281/zenodo.8436970

Arici, F., & Yilmaz, M. (2023). An examination of the effectiveness of problem-based learning method supported by augmented reality in science education. *Journal of Computer Assisted Learning*, *39*(2), 446-476. https://doi.org/10.1111/jcal.12752

Arisa, S., & Sitinjak, D. S. (2022). Implementation of the STEM-PBL approach in online chemistry learning and its impact on students' critical thinking skills. *Jurnal Pendidikan Kimia Indonesia*, *6*(2), 88-96. https://doi.org/10.23887/jpki.v6i2.44317

Arthamena, V. D., Ayubi, M., Atun, S., & Putri, S. E. (2025). Effectiveness of a problem-based learning model integrated with socio-scientific issues to improve science process skills of high school students. *JKPK (Jurnal Kimia dan Pendidikan Kimia)*, *10*(1), 203-219. https://doi.org/10.20961/jkpk.v10i1.97608

Astuti, M. L. (2024). The Role of 6C Skills in 21st Century Learning of Elementary School Students. *DIDAKTIKA: Jurnal Pendidikan Sekolah Dasar*, *7*(2), 154-161.

Awaludin, R., Aripin, A., & Makiyah, Y. S. (2025). The Effect of the PBL-STEM on Students' Critical Thinking Skills. *Jurnal Pendidikan Fisika dan Teknologi*, *11*(1a), 110-116. https://doi.org/10.29303/jpft.v11i1a.6819

Azzahrawaani, Z., Riche Cynthia Johan, & Ardiansah. (2023). Analisis Bibliometrik Tren Penelitian Literasi Pada Lansia dengan Menggunakan VOSviewer. *BACA: Jurnal Dokumentasi Dan Informasi*, *44*(2), 125–140. https://doi.org/10.55981/baca.2023.1679

Dare, E. A., Keratithamkul, K., Hiwatig, B. M., & Li, F. (2021). Beyond content: The role of STEM disciplines, real-world problems, 21st century skills, and STEM careers within science teachers' conceptions of integrated STEM education. *Education Sciences*, *11*(11), 737. https://doi.org/10.3390/educsci11110737

Diani, R., Khotimah, H., Khasanah, U., & Syarlisjiswan, M. R. (2019). Scaffolding dalam pembelajaran fisika berbasis problem based instruction (PBL): efeknya terhadap pemahaman konsep dan self efficacy. *Indonesian Journal of Science and Mathematics Education*, *2*(3), 310-319. https://doi.org/10.24042/ijsme.v2i3.4356

Diani, R., Latifah, S., Jamaluddin, W., Pramesti, A., Susilowati, N. E., & Diansah, I. (2020). Improving students' science process skills and critical thinking skills in physics learning through fera learning model with savir approach. In *Journal of Physics: Conference Series* (Vol. 1467, No. 1, p. 012045). IOP Publishing. https://doi.org/10.1088/1742-6596/1467/1/012045

Diani, R., Saregar, A., & Ifana, A. (2016). Perbandingan model pembelajaran problem based learning dan inkuiri terbimbing terhadap kemampuan berpikir kritis peserta didik. *Jurnal Penelitian Pembelajaran Fisika*, *7*(2). https://doi.org/10.26877/jp2f.v7i2.1310

Diani, R., Susanti, A., Widiawati, N., & Velina, Y. (2024). Enhancing Computational Thinking in Physics Labs: Synergizing STEM Multimedia with Islamic Literacy Integration. *Kasuari: Physics Education Journal (KPEJ)*, *7*(2), 371-383. https://doi.org/10.37891/kpej.v7i2.728

Diani, R., Yanti, Y., Hartati, N. S., Fujiani, D., & Hasanah, I. F. (2021). Islamic literacy-based physics e-module with STEM (science, technology, engineering, and mathematics) approach. In *Journal of Physics: Conference Series* (Vol. 1796, No. 1, p. 012098). IOP Publishing. https://doi.org/10.1088/1742-6596/1796/1/012098

Diani, R., Yuberti, Y., & Syarlisjiswan, M. R. (2018). Web-enhanced course based on problem-based learning (PBL): Development of interactive learning media for basic physics II. *Jurnal Ilmiah Pendidikan Fisika Al-Biruni*, *7*(1), 105-116. https://doi.org/10.24042/jipfalbiruni.v7i1.2849

Donthu, N., Kumar, S., Mukherjee, D., Pandey, N., & Lim, W. M. (2021). How to conduct a bibliometric analysis: An overview and guidelines. *Journal of business research*, *133*, 285-296. https://doi.org/10.1016/j.jbusres.2021.04.070

Funa, A. A., Roleda, L. S., & Prudente, M. S. (2024). Integrated science, technology, engineering, and mathematics—problem-based learning—education for sustainable development (I-STEM-PBL-ESD) framework. In *A diversity of pathways through science education* (pp. 151-172). Singapore: Springer Nature Singapore. https://doi.org/10.1007/978-981-97-2607-3_9

Hafizah, M., Solin, S., Purba, C. T., Sihotang, M. M., Rahmad, R., & Wirda, M. A. (2024). Meta-analysis: The impact of problem-based learning (PBL) models on students' critical thinking skills. *Journal of Digital Learning and Education*, *4*(3), 167-179. https://doi.org/10.52562/jdle.v4i3.1393

Hasbi, M., & Fitri, F. (2023). Pre-Service Teachers with Courses in Problem-Based Learning in Mathematics. *ETDC: Indonesian Journal of Research and Educational Review*, *2*(2), 51-60. https://doi.org/10.51574/ijrer.v2i2.588

Hassan, W., & Duarte, A. E. (2024). Bibliometric analysis: a few suggestions. *Current problems in cardiology*, *49*(8), 102640. https://doi.org/10.1016/j.cpcardiol.2024.102640

Hidayatullah, N. M., Bani, B., Angelia, C., Nurhidayati, H., & Ningrum, S. A. R. (2024). Analisis bibliometrik: Penelitian technology acceptance model tahun 2014-2023 menggunakan Bibliometrik dan Vosviewer. *Comdent: Communication Student Journal*, *2*(1), 138–158. https://doi.org/10.24198/comdent.v2i1.58290

Hitchcock, D. (2017). Critical thinking as an educational ideal. In *On reasoning and argument: Essays in informal logic and on critical thinking* (pp. 477-497). Cham: Springer International Publishing. https://doi.org/10.1007/978-3-319-53562-3_30

Ikhsan, M., Buhera, R., Abiabdillah, L. H., Nurohman, S., & Natadiwijaya, I. F. (2025). STEM-PBL Based Learning: Digital Student Worksheet Simulation aided by PhET to Improve Students' Critical Thinking Skills in Science Learning. *Journal of Education and Teaching (JET)*, *6*(1), 196-214. https://doi.org/10.51454/jet.v6i1.469

Iriyani, S. A., Patty, E. N. ., Rahim, A., Awaliyah, M., & Ria, R. R. P. (2023). Tren Manajemen Pendidikan: Analisis Bibliometrik Menggunakan Aplikasi Vosviewer. *Edu Cendikia: Jurnal Ilmiah Kependidikan*, *3*(01), 93–100. https://doi.org/10.47709/educendikia.v3i01.2281

Jaelani, A. K., Hasbi, M., & Baharullah, B. (2023). A critical thinking profile of mathematics education students in solving ill-structured problem based on mathematical ability. *JTAM (Jurnal Teori dan Aplikasi Matematika)*, *7*(2), 545-559.

Joyce, B., Calhoun, E., & Hopkins, D. (2008). *Models of learning, tools for teaching*. McGraw-Hill Education (UK).

Juškevičienė, A., Dagienė, V., & Dolgopolovas, V. (2021). Integrated activities in STEM environment: Methodology and implementation practice. *Computer Applications in Engineering Education*, *29*(1), 209-228. https://doi.org/10.1002/cae.22324

Khoirunnissa, R., Suwarma, I. R., & Muslim, M. (2024). The Implementation of STEM-PBL Learning to Enhance Students' Critical Thinking Skills. *Jurnal Pendidikan Fisika dan Teknologi*, *10*(1), 175-185. https://doi.org/10.29303/jpft.v10i1.6879

Klarin, A. (2024). How to conduct a bibliometric content analysis: Guidelines and contributions of content co-occurrence or co-word literature reviews. *International Journal of Consumer Studies*, *48*(2), e13031. https://doi.org/10.1111/ijcs.13031

Larsson, K. (2017). Understanding and teaching critical thinking—A new approach. *International Journal of Educational Research*, *84*, 32-42. https://doi.org/10.1016/j.ijer.2017.05.004

Le, H. C., Nguyen, V. H., & Nguyen, T. L. (2023). Integrated STEM approaches and associated outcomes of K-12 student learning: A systematic review. *Education Sciences*, *13*(3), 297. https://doi.org/10.3390/educsci13030297

Loyens, S. M., Van Meerten, J. E., Schaap, L., & Wijnia, L. (2023). Situating higher-order, critical, and critical-analytic thinking in problem-and project-based learning environments: A systematic review. *Educational Psychology Review*, *35*(2), 39. https://doi.org/10.1007/s10648-023-09757-x

Maričić, M., & Lavicza, Z. (2024). Enhancing student engagement through emerging technology integration in STEAM learning environments. *Education and Information Technologies*, *29*(17), 23361-23389. https://doi.org/10.1007/s10639-024-12710-2

Martins, J., Gonçalves, R., & Branco, F. (2024). A bibliometric analysis and visualization of e-learning adoption using VOSviewer. *Universal Access in the Information Society*, *23*(3), 1177-1191. https://doi.org/10.1007/s10209-022-00953-0

Monika, P. S., Suharno, S., & Rahmasari, L. (2023). Effectiveness of science technology engineering mathematics problem based learning (STEM PBL) and science technology engineering mathematics project based learning (STEM PjBL) to improve critical thinking ability. *Jurnal Penelitian Pendidikan IPA*, *9*(11), 9593-9599. https://jppipa.unram.ac.id/index.php/jppipa/article/view/4910

Muzaini, M., Hasbi, M., Ernawati, E., & Kristiawati, K. (2022). The empowerment of problem-based learning models to improve students' quantitative reasoning. *Formatif: Jurnal Ilmiah Pendidikan MIPA*, *12*(1), 11-24. http://dx.doi.org/10.30998/formatif.v12i1.8502

Nurazmi, & Bancong, H. (2021). Model Problem Based Learning Terintegrasi STEM: Pengaruhnya Terhadap Keterampilan Berpikir Kritis Peserta Didik. *Kasuari: Physics Education Journal (KPEJ)*, *4*(2), 70–77. https://doi.org/10.47709/educendikia.v4i03.

Nur, S., & Ikhsan, J. (2024). Implementation of STEM Integrated Problem Based Learning Model to Improve Problem Solving Skills and Learning Motivation of Grade X Vocational High School Students on the Material of Substances and Their

Changes. *Jurnal Penelitian Pendidikan IPA*, *10*(11), 8882-8891. https://doi.org/10.29303/jppipa.v10i11.9121

Öztürk, O., Kocaman, R., & Kanbach, D. K. (2024). How to design bibliometric research: an overview and a framework proposal. *Review of managerial science*, *18*(11), 3333-3361. https://doi.org/10.1007/s11846-024-00738-0

Passas, I. (2024). Bibliometric analysis: the main steps. *Encyclopedia*, *4*(2). https://doi.org/10.3390/encyclopedia4020065

Pessin, V. Z., Yamane, L. H., & Siman, R. R. (2022). Smart bibliometrics: an integrated method of science mapping and bibliometric analysis. *Scientometrics*, *127*(6), 3695-3718. https://doi.org/10.1007/s11192-022-04406-6

Plummer, K. J., Kebritchi, M., Leary, H. M., & Halverson, D. M. (2022). Enhancing critical thinking skills through decision-based learning. *Innovative Higher Education*, *47*(4), 711-734. https://doi.org/10.1007/s10755-022-09595-9

Rahayu, S. P., & Christiani, L. (2020). Kolaborasi dan Produktivitas Penulis Artikel Imiah Pada Jurnal Lentera Pustaka. *Jurnal Ilmu Perpustakaan*, *9*(1), 83–91. https://ejournal3.undip.ac.id/index.php/jip/article/view/29973

Roehrig, G. H., Dare, E. A., Ellis, J. A., & Ring-Whalen, E. (2021). Beyond the basics: A detailed conceptual framework of integrated STEM. *Disciplinary and Interdisciplinary Science Education Research*, *3*(1), 11. https://doi.org/10.1186/s43031-021-00041-y

Siregar, R. L. (2021). Memahami tentang model, strategi, metode, pendekatan, teknik, dan taktik. *Hikmah: Jurnal Pendidikan Islam*, *10*(1), 63-75. https://ojs.staituankutambusai.ac.id/index.php/hikmah/article/view/251

Talib, S., Alias, B. S., Matore, M. E. E. M., & Abdullah, A. H. (2025). Empowering STEM education through the role of principals: a systematic literature review. *Journal of Education and Learning (EduLearn)*, *19*(1), 570-578. https://doi.org/10.11591/edulearn.v19i1.21889

van Der Vleuten, C. P., & Schuwirth, L. W. (2019). Assessment in the context of problem-based learning. *Advances in Health Sciences Education*, *24*(5), 903-914. https://doi.org/10.1007/s10459-019-09909-1

Varas, D., Santana, M., Nussbaum, M., Claro, S., & Imbarack, P. (2023). Teachers' strategies and challenges in teaching 21st century skills: Little common understanding. *Thinking Skills and Creativity*, *48*, 101289. https://doi.org/10.1016/j.tsc.2023.101289

Wiratman, A., Bungawati, B., & Rahmadani, E. (2023). Project-based learning integrated with science, technology, engineering, and mathematics (STEM) to the critical thinking skills of students in elementary school. *SITTAH: Journal of Primary Education*, *4*(2), 167-180. https://doi.org/10.30762/sittah.v4i2.1828

Xu, E., Wang, W., & Wang, Q. (2023). The effectiveness of collaborative problem solving in promoting students' critical thinking: A meta-analysis based on empirical literature. *Humanities and Social Sciences Communications*, *10*(1), 1-11. https://doi.org/10.1057/s41599-023-01508-1

Zakiyyah, F. N., Winoto, Y., & Rohanda, R. (2022). Pemetaan bibliometrik terhadap perkembangan penelitian arsitektur informasi pada Google Scholar menggunakan VOSviewer. *Informatio: Journal of Library and Information Science*, *2*(1), 43. https://doi.org/10.24198/inf.v2i1.37766