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Global Trends and Research Frontiers in Project-Based Learning: A Scopus-Based Bibliometric Review

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Abstract: The aim of this study is to analyse the development of publications of scientific articles focusing on the project-based learning model. The method used is a literature review with a bibliometric analysis approach. A keyword search in the Scopus journal database for "Project-Based Learning; Science Education" was used to start the research. An analysis was carried out using the Vosviewer application, which allows in-depth exploration of trends and key contributions in the field. The results showed that a total of 702 publications were recorded in Scopus-indexed journals over a fifteen-year period, from 2010 to 2024. The United States emerged as the country that contributed the most publications, followed by Indonesia in second place, reflecting its active role in promoting research related to the Project based learning model. Among researchers, Capraro, Robert M. was identified as the most prolific contributor during the period 2010-2024. In addition, the keyword 'project-based learning' appeared most frequently in the articles, confirming its centrality in discussions of innovative educational practices. These findings suggest a significant and growing interest in Project Based Learning in science education. However, this study highlights the need for a broader scope of research. Future research should not be limited to Scopus-indexed journals, but should also include various databases and resources.

Keywords: Bibliometric Review, Project-Based Learning, Science Education, Vosviewer Application

A. Introduction

Project-Based Learning (PjBL) has emerged as a transformative pedagogical approach in modern education, offering a student-centered framework that emphasizes active learning, collaboration, and the application of theoretical knowledge to real-world problems (Zhang et al., 2022; Cutri et al., 2022; Leles et al., 2024). Over the past two decades, PjBL has gained prominence across various educational disciplines, particularly in Science, Technology, Engineering, Arts, and Mathematics (STEAM) (Breda et al., 2023; Rahmawati et al., 2021). This approach not only equips learners with essential 21st-century skills such as critical thinking, creativity, and teamwork but also fosters deep engagement and meaningful understanding of subject matter

(Wang et al., 2019; Yoo & Kang, 2021; Hambali & Fadillah, n.d.). Recognizing its potential, educators and researchers have increasingly explored the theoretical underpinnings, practical implementations, and learning outcomes of PjBL, making it a focal point in contemporary educational research (Aránguiz et al., 2020; Ariyani et al., 2024).

Bibliometric analysis serves as a systematic method to map and evaluate research trends, key contributors, and thematic developments within a specific field (Bancong & Hambali, 2023; Okoro et al., 2024). In the context of PjBL, such an approach is essential for understanding its academic growth, geographic distribution, and intellectual evolution (Hariyadi & Darmuki, 2023). Despite the increasing number of PjBL-related publications, there is a notable absence of recent, comprehensive bibliometric studies that focus specifically on PjBL within science education. Existing reviews tend to focus on general pedagogy, STEM education broadly, or narrow subsections of PjBL, leaving a gap in capturing the holistic development of PjBL research over the last decade.

Moreover, the rapid expansion of digital learning tools, the rise of STEAM integration, and the pedagogical shifts accelerated by the COVID-19 pandemic have significantly reshaped the implementation of PjBL worldwide (Cranfield et al., 2021; Baraldi, 2024; Bennett et al., 2020). These developments underscore the urgency of conducting a bibliometric review that not only documents emerging trends but also identifies underexplored areas within the literature. A timely bibliometric mapping is therefore needed to synthesize recent scholarly discourse, reveal prevailing research clusters, and highlight gaps that can guide future investigations especially in science education settings where PjBL continues to evolve.

Project-Based Learning's core principle lies in integrating knowledge acquisition with hands-on, project-driven activities that bridge theoretical concepts with practical applications (Hambali, 2024). Recent studies underscore its effectiveness in promoting interdisciplinary learning, particularly in STEAM fields, where it fosters creativity, critical thinking, and problem-solving skills (Sonnenberg-Klein & Coyle, 2024; Rahmawati et al., 2021). For example, integrating robotics and low-cost toys in PjBL activities has been shown to improve STEM learning outcomes among primary students, demonstrating the adaptability of PjBL across diverse educational contexts (Lu et al., 2022; Escudeiro et al., 2024; Pandian, 2018).

Furthermore, PjBL has demonstrated remarkable resilience during global challenges such as the COVID-19 pandemic, where online and hybrid learning environments accelerated the adoption of digital, collaborative PjBL methodologies (Cranfield et al., 2021; Baraldi, 2024). These developments highlight the importance of understanding how PjBL has been integrated into educational practices worldwide, especially considering the diversity of socio-cultural and technological contexts (Mendieta-

Aragón et al., 2023; Dai et al., 2023).

Despite its widespread implementation, gaps remain in the existing literature. Many studies emphasize cognitive outcomes, while non-cognitive competencies such as collaboration, communication, and problem-solving are less frequently examined. Additionally, most research originates from developed countries, leading to an underrepresentation of PjBL practices and challenges in developing regions. Contextual variables such as institutional support, teacher readiness, and learning culture are often overlooked, even though these factors strongly influence the effectiveness of PjBL.

Given these gaps, a comprehensive and up-to-date bibliometric review is necessary. This study addresses the need by analyzing Scopus-indexed publications from 2010 to 2024 to map the evolution, influential contributors, and thematic patterns of PjBL research, with particular attention to science education. The research questions guiding this study are:

1. How has the research output on Project Based Learning evolved from 2010 to 2024?
2. Which source titles have contributed the most to publications on Project Based Learning during this period?
3. Who are the most prominent authors in the field?
4. Which countries have published the most research on Project-Based Learning?
5. What are the most relevant keywords associated with Project-Based Learning studies from 2010 to 2024?

B. Methods

To achieve the stated objectives, this study employs bibliometric analysis, leveraging data from Scopus a comprehensive and reputable academic database. The analysis focuses on identifying trends, thematic clusters, and collaboration networks among authors, institutions, and countries. This study employs a bibliometric approach with a descriptive quantitative method. The population in this study consists of scientific articles on the project-based learning model published in Scopus-indexed journals within the 2010–2024 period, amounting to 702 documents from article (21,7 %) and conference paper (78,3%).

The study was conducted by searching for articles through the Scopus database. It utilizes research data or scientific publications obtained from the Scopus database in the field of the PjBL model over a 15-year period (2010–2024). The stages of the research include collecting data based on publication years, starting from 2010 to 2024. Subsequently, the Scopus database was explored to examine the trends in publications or scientific works related to the Project Based Learning Model.

To map the development of scientific articles on the Project Based Learning Model, the VOSviewer software was used. The mapping process involved exporting the search results from the Scopus database into a CSV format, which was then imported into the VOSviewer software. The stages of the research process can be visualized in the following workflow:

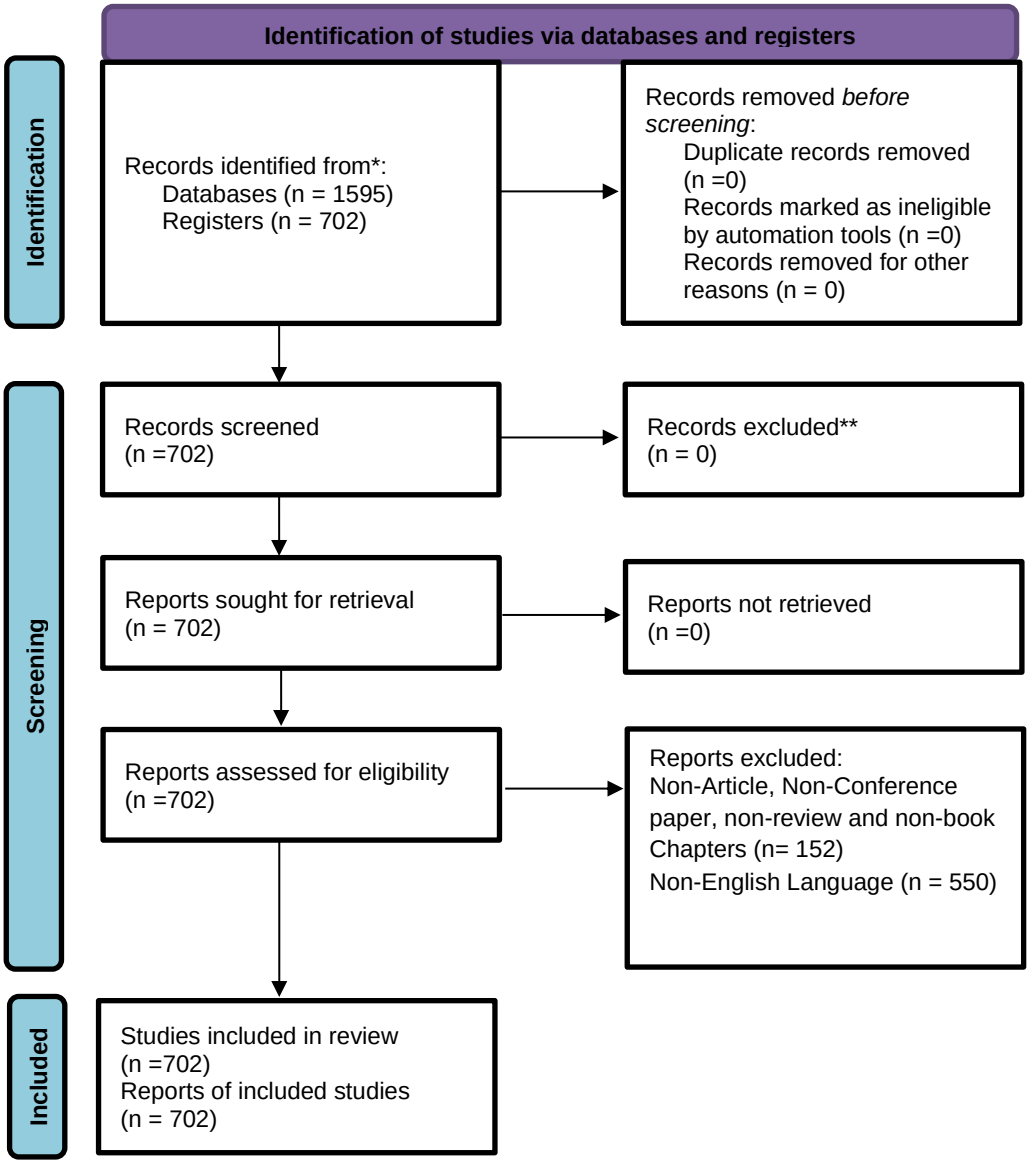

Figure 1. The PRISMA flow diagram detailing the screening and selection process of literature

The research data are then analysed using both quantitative descriptive and qualitative descriptive approaches (Clark & Creswell, 2008). Data processing is supported by the Scopus database through its "analyse" function. This function allows

the researcher to obtain statistical data from published scientific articles in the field of the Project-Based Learning model in CSV format. The data are then processed using one of the MS Office tools, namely MS Excel. In addition, the data is further processed in detail using the VosViewer application.

C. Results and Discussion

Trends in Project Based Learning Research Output

A search conducted in the Scopus database using the keywords "Project-Based Learning and Science Education" identified a total of 702 documents related to the PjBL model. After narrowing the publication period to 2010–2024, the same number of 702 documents was retrieved. The distribution of publications per year is as follows: in 2010, there were 33 publications (4.7%), 28 publications in 2011 (3.98%), 36 publications in 2012 (5.13%), 23 publications in 2013 (3.28%), 30 publications in 2014 (4.27%), 33 publications in 2015 (4.7%), 34 publications in 2016 (5.13%), 72 publications in 2017 (10.26%), 49 publications in 2018 (6.98%), 84 publications in 2019 (11.96%), 68 publications in 2020 (9.68%), 75 publications in 2021 (10.68%), 47 publications in 2022 (6.69%), 51 publications in 2023 (7.26%), and 39 publications in 2024 (5.55%). The data for 2024 include documents published up to December. Despite a slight decline in the number of publications in recent years, PjBL continues to be a trending topic in research. This trend is illustrated in the diagram below.

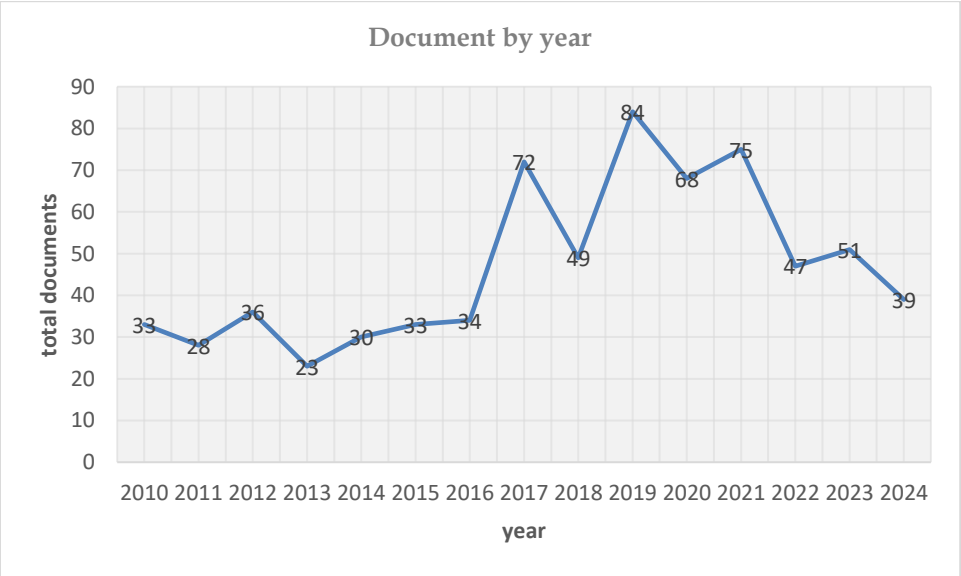

Figure 2. Number of published articles per year

Most Relevant Source

Scopus indexed publications related to Project Based Learning originate from various journals and proceedings. The results of the Scopus database search can be seen in the following table:

Table 1. Sources Contributing to the Project Based Learning Model

No	Publisher	Records	Quartile
1	ASEE Annual Conference and Exposition Conference Proceedings	74	-
2	Journal Of Physics Conference Series	53	-
3	Proceeding's frontiers In Education Conference (FIE)	39	-
4	IEEE Global Engineering Education Conference (Educon)	26	-
5	ACM International Conference Proceeding Series	23	-
6	International Journal of Engineering Education	17	Q2
7	Advances In Intelligent Systems and Computing	15	Q4
8	IEEE Transactions on Education	12	Q1
9	Lecture Notes in Computer Science	11	Q2
10	Proceedings Of the International Astronautical Congress	10	-
11	Communications In Computer and Information Science	9	Q4
12	Annual Conference on Innovation and Technology in Computer Science Education (ITICSE)	6	-
13	Lecture Notes in Networks and Systems	5	Q4
14	Proceedings Of International Conference of The Learning Sciences	5	-
15	Ceur Workshop Proceedings	4	-

Based on the table above, the 10 journals that have contributed the most to the Project Based Learning model in science education are as follows: ASEE Annual Conference and Exposition Conference Proceedings published 74 documents, Journal of Physics Conference Series published 53 documents, Proceedings Frontiers in Education Conference (FIE) published 39 documents, IEEE Global Engineering Education Conference (EDUCON) published 26 documents, ACM International Conference Proceeding Series published 23 documents, International Journal of Engineering Education published 17 documents, Advances in Intelligent Systems and Computing published 15 documents, IEEE Transactions on Education published 12 documents, Lecture Notes in Computer Science published 11 documents, and Proceedings of the International Astronautical Congress (IAC) published 10 documents.

Most Relevant Authors

Several authors have emerged as key contributors to PjBL research during the study period. Notably, Capraro, Robert M, has been identified as one of the most prolific researchers, with numerous impactful publications on the design and implementation

of PjBL frameworks. Their work has significantly influenced the adoption of PjBL in higher education, particularly in STEM fields(Cutri et al., 2022)(Chen & Lin, 2019)Moreover, journals such as *ASEE Annual Conference and Exposition Conference Proceedings* have been identified as major platforms for disseminating PjBL-related studies, further establishing their role in shaping the field (Admawati & Jumadi, 2021).

Table 2. Authors Contributing to the PjBL Model in Science Education

No	Authors	Document	Citation
1	Capraro, R.M.	5	75
2	Chang, C.C.	5	25
3	Woll, R.	5	304
4	Castro, M.	4	54
5	Chase, L.	4	54
6	Frye, M.	4	62
7	Lou, S.J.	4	323
8	Plaza, P.	4	4
9	Sabitzer, B.	4	4
10	Sancristobal, E.	4	5

In research related to the Project-Based Learning (PjBL) model in science education, several authors have made significant contributions both through the number of ublished documents and the impact of their citations. Among the most prominent is R.M. Capraro, with 5 documents and a total of 75 citations. Furthermore, C.C. Chang and R. Woll have also published 5 documents each, with citation counts of 25 and 304, respectively, reflecting varying levels of influence. Other authors such as M. Castro, L. Chase, and M. Frye have each published 4 documents with citation counts of 54, 54, and 62, respectively. A significant contribution is also evident from S.J. Lou, with 4 documents and 323 citations, positioning them as one of the most influential researchers in the field.

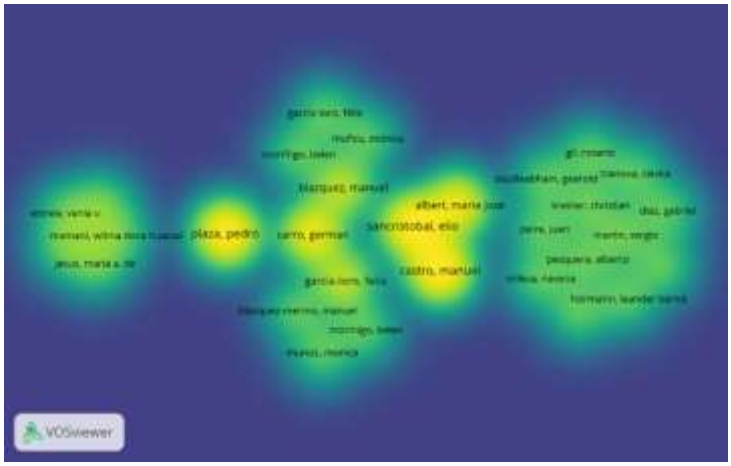

Figure 3. Density of authors

Most Relevant Countries

From 2010 to 2024, there has been a steady increase in the number of publications on PjBL in Scopus-indexed journals, reflecting growing academic interest in this pedagogical model. Preliminary bibliometric analysis reveals that the United States is the leading contributor to Project Based Learning research, followed by countries such as Indonesia, Finland and Taiwan, which have demonstrated significant advancements in integrating Project Based Learning into their educational systems (Markula & Aksela, 2022; Escudeiro et al., 2024). Additionally, the keyword "Project-Based Learning" consistently ranks as one of the most frequently used terms in related publications, emphasizing its centrality in the discourse.

Table 3. Top 15 Publisher Countries

No	Countries	Document	Citation
1	United States	248	2075
2	Indonesia	55	228
3	Spain	45	474
4	Germany	30	164
5	China	28	91
6	United Kingdom	28	63
7	Taiwan	24	436
8	Japan	21	63
9	Portugal	17	47
10	Malaysia	16	145
11	Canada	15	174
12	Finland	14	199
13	Israel	13	93
14	Italy	13	235
15	Brazil	11	63

Based on the table above, the number of articles published in each country can be identified. The country with the highest number of PjBL model journal publications is the United States, with 248 documents. Following the United States, Indonesia has published 55 documents, Spain 45 documents, Germany 30 documents, the United Kingdom 28 documents, China 28 documents, Taiwan 24 documents, Japan 21 documents, Portugal 17 documents, and Malaysia 16 documents. Below is the overlay visualization for countries using VOSviewer.

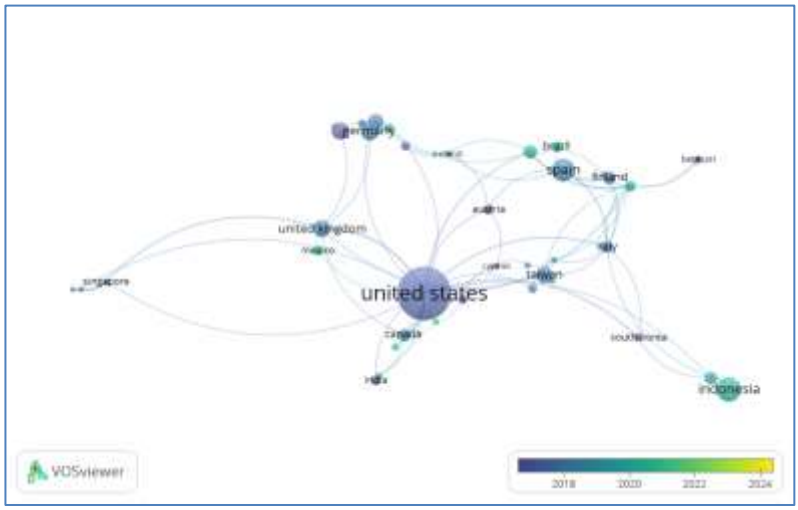

Figure 4. Overlay visualization for countries

Most Relevant Keywords

An analysis based on keywords with a minimum occurrence of 4 out of 4420 keywords reveals that 398 keywords meet the threshold. These 398 keywords are divided into 11 clusters, represented by red, green, dark blue, yellow, purple, light blue, orange, brown, light purple, pink, light green. To visualize these clusters, the bibliometric mapping results can be observed in three different visualizations: network visualization, overlay visualization, and density visualization. In the keyword visualization, each keyword is labeled with a colored circle. The size of the circle indicates its connection to the keyword's occurrence in titles and reflects the high frequency of its appearance. Below are the network visualization, overlay visualization, and density visualization.

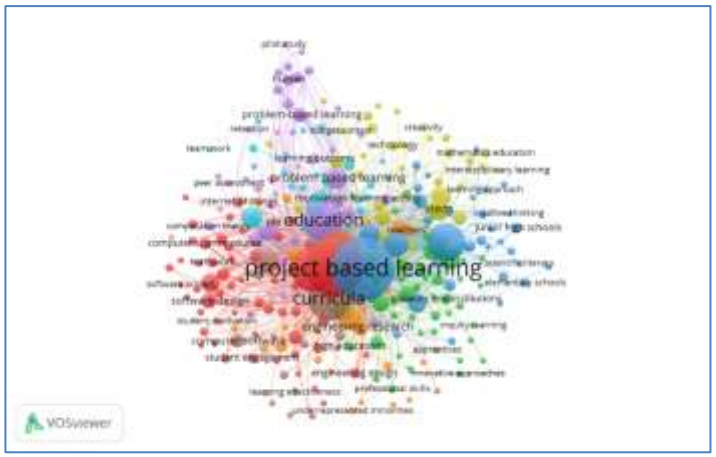

Figure 5. Keywords network visualization

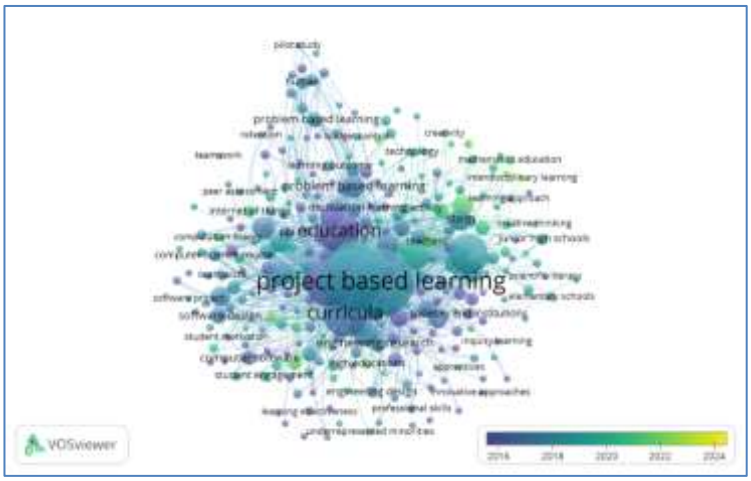

Figure 6. Keywords overlay visualization

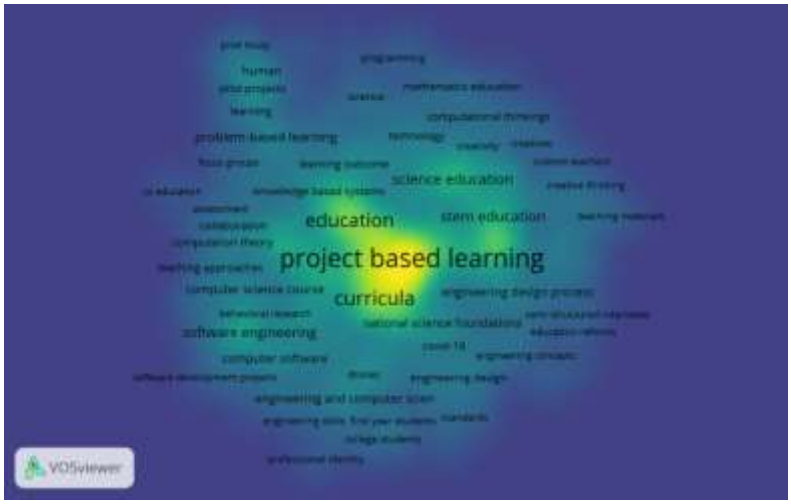

Figure 7. Keywords density visualization

Discussion

Project-Based Learning model in science education has been an area of considerable interest to researchers. Over a 15-year period (2010-2024), 702 documents on project-based learning in science education have been published in Scopus-indexed journals. This data indicates a potential increasing trend in project-based learning research, although there was a decrease in publications in 2024 compared to 2023. The year 2019 marked the peak, with 84 documents published on PjBL in science education. this is possible because 2019 coincided with the start of the COVID-19 pandemic, where many learning processes must be carried out independently by students at home. Project-based assignments have become a common way for teachers to ensure that students keep learning at home.

The implementation of project-based learning greatly opens up opportunities for independence for students. Skills such as collaboration, communication, creative thinking, and problem solving can be improved by maximizing its implementation in the learning phase. By doing many activities, children do not feel bored while learning, because it is accompanied by appropriate learning instructions according to the project assignment given by the teacher.

Another notable aspect of Project-Based Learning is its suitability for integrated learning, which is essential in the context of 21st century education trends (Louis et al., 2021) (Worlitz et al., 2018). The implementation of Project-Based Learning shifts the paradigm from teacher-centered learning to student-centered learning. By employing Project-Based Learning, educators transition into new roles as learning designers, facilitators, coaches, and learning managers. They no longer serve solely as authoritative sources of knowledge. Instead, Project-Based Learning promotes diverse learning interactions, not only between teachers and students but also among students themselves (Yoo & Kang, 2021)(Muslim et al., 2020).

Based on Scopus data, the United States leads in Project Based Learning related publications, followed by Indonesia, as shown in Table 3. This indicates that Project Based Learning research trends remain prominent in Indonesia. Many studies have concluded that implementing the Project Based Learning model enhances students' collaboration and communication skills. In Indonesia, the adoption of PjBL has increased significantly following the introduction of the Merdeka Curriculum(Hunaepi & Suharta, 2024)(Fauzan et al., 2023).

Over the 15-year period (2010–2024), the United States accounted for approximately 35% of all Project Based Learning related publications. This dominance is unsurprising given the U.S.'s position as a global superpower with a large population. Additionally, its robust educational system and well-established infrastructure contribute to the high volume of Project Based Learning research publications. While this assumption

may be subject to debate, it offers a compelling avenue for further investigation(Bolick et al., 2024)(List et al., 2020).

The bibliometric analysis of countries contributing significantly to Project Based Learning research trends raises numerous intriguing questions for future discussion. For instance, in Southeast Asia, Indonesia and Malaysia rank among the top 15 countries for Project Based Learning related publications. Indonesia ranks second globally with 55 documents, whereas. Malaysia is 10th with 16 documents. This disparity warrants further investigation to understand the factors influencing the differences in research trends between these two countries. Such comparative analysis could provide valuable insights for researchers and policymakers seeking to enhance the adoption and effectiveness of Project Based Learning in diverse educational contexts(Lin et al., 2023)(Tauro et al., 2017).

Moreover, what draws significant attention is the authors who have contributed to the publication trends of Project-Based Learning models indexed in Scopus over the past 15 years (2010–2024). Based on bibliometric analysis focusing on the top 10 authors with the most contributions to Project-Based Learning research indexed in Scopus, Robert M. Capraro occupies the top position with five published articles and 75 citations. One of his works, titled "*Using Project-Based Learning to Teach Electromagnetic and Wave Concepts,"* has been extensively referenced by various researchers in the field of Project Based Learning (Chai et al., 2020). The high citation count is believed to reflect the influence of his research recommendations, which advocate for further studies, development, and exploration within the scope of science education that align with the Project-Based Learning model(Cutri et al., 2022)(Tsybulsky & Muchnik-Rozanov, 2021).

Based on the visualization, the emphasis on project-based learning as a keyword has resulted in the emergence of several interconnected major clusters. According to the visualization results from VosViewer, there are elevev clusters represented by different colors, corresponding to their frequency of occurrence. The colors indicate the groupings, while the labeled nodes represent keywords or terms that frequently appear. Clustering is used to gain insights or an overview of bibliometric groupings, whereas image mapping provides a comprehensive depiction of a bibliometric network. This study reveals that scientific publications on the Project-Based Learning model from 2010 to 2024 indexed in Scopus have strong and direct connections to science education, STEM education, active learning, collaboration, problem-based learning, and technology(Muslim et al., 2020) (Miranda et al., 2020).

D. Conclusions

This bibliometric review mapped global research trends on Project-Based Learning (PjBL) in science education from 2010 to 2024 using 702 Scopus-indexed documents.

The analysis shows a generally upward trajectory of publications with a peak in 2019, followed by a slight decline in recent years, indicating that PjBL remains a sustained area of interest rather than a short-lived trend. ASEE Annual Conference and Exposition Conference Proceedings, Journal of Physics Conference Series, and Frontiers in Education (FIE) emerge as the most productive outlets, suggesting that PjBL research in science education is still strongly rooted in conference-based dissemination. In terms of scholarly influence, authors such as Robert M. Capraro, C.C. Chang, R. Woll, and S.J. Lou stand out as key contributors, both in publication output and citation impact. At the country level, the United States dominates PjBL publications, with Indonesia, Spain, Germany, Taiwan, and several other countries forming an emerging cluster of active contributors. Keyword mapping further indicates that PjBL is closely connected to themes such as science education, STEM/STEAM, active learning, collaboration, technology integration, and 21st-century skills.

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This study has several limitations that should be acknowledged. First, the exclusive reliance on the Scopus database introduces both database and language bias. Scopus tends to under-represent non-English and regional journals, which means that important PjBL studies particularly those published in local languages or national journals may not be captured. Second, the search strategy focused on the keyword combination "Project-Based Learning; Science Education." While this ensures relevance to the field, it may have excluded studies that implemented PjBL in science-related contexts without explicitly using these terms in the title, abstract, or keywords (e.g., STEM, engineering education, environmental education, or integrated curricula using alternative labels). Third, as a bibliometric review, this study emphasizes publication patterns, co-authorship, and keyword networks rather than the quality of

instructional design, depth of implementation, or actual learning outcomes. Consequently, the findings provide a macro-level map of the field but cannot directly inform which specific PjBL models, strategies, or conditions are most effective in improving student learning and 21st-century skills.

Building on these limitations, several concrete directions for future research can be proposed. First, future studies should expand the database coverage by including Web of Science, ERIC, and major regional databases (e.g., DOAJ, Sinta, or other national indexing systems) to obtain a more inclusive picture of PjBL research, especially in non-English-speaking and developing contexts. Second, beyond mapping output, future works should conduct qualitative content analyses of the most cited PjBL articles to identify: (a) which instructional models, scaffolding strategies, and assessment approaches are most frequently associated with positive cognitive and non-cognitive outcomes; and (b) how PjBL is adapted for different science topics and educational levels. Third, given the high contribution of countries such as Indonesia, research is needed to explore the barriers and facilitators of PjBL implementation in developing countries with strong research output.

Fourth, more empirical research should connect bibliometric trends with classroom realities by investigating how the dominant themes identified (e.g., STEM/STEAM, technology-enhanced PjBL, hybrid/online environments) are actually enacted and with what effects on students' science literacy, critical thinking, collaboration, and creativity. Mixed-methods designs that combine large-scale surveys, learning analytics, and classroom observations would be particularly valuable. Finally, future bibliometric studies could focus on longitudinal changes in PjBL networks examining how international collaboration, funding patterns, and open-access publishing influence the spread of PjBL innovations in science education worldwide.

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