

Project-Based Learning in Higher Education for Science and Education Students: A Bibliometric Analysis Using VOSviewer (2022–2026)

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Abstract

This study presents a bibliometric analysis of research on project-based learning (PjBL) in higher education, with a specific focus on science and education students, using the Scopus database for the period 2022–2026. Following the PRISMA screening protocol, 16 articles were identified from an initial pool of 1,394 records after duplicate removal and eligibility screening. Data were analyzed using VOSviewer software to generate performance analysis and science mapping outputs. The analysis addressed five research questions covering publication trends, productive authors and countries, active journals, keyword co-occurrence patterns, and dominant pedagogical strategies. Results reveal a sharp increase in publications in 2025 (75% of total), with Indonesia as the most prolific contributor (62.5%), largely driven by the Merdeka Belajar-Kampus Merdeka (MBKM) curriculum reform. Most publications appeared in Q1 and Q2 Scopus-indexed journals (75%). Keyword co-occurrence mapping via VOSviewer identified four thematic clusters: cognitive and higher-order thinking outcomes, collaborative and engagement-oriented learning, character and affective competency development, and disciplinary-specific applications. Collaborative and inquiry-driven project designs emerged as the most dominant pedagogical strategies across the corpus. The findings suggest emerging research frontiers in technology-enhanced PjBL, longitudinal outcome assessment, and cross-cultural project design, offering direction for future empirical and theoretical inquiry in this field.

Keywords: Bibliometric analysis, higher education, project-based learning, Scopus, VOSviewer

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INTRODUCTION

Project-based learning (PjBL) is a student-centered pedagogical approach that emphasizes active learning through the completion of real-world projects over an extended period. The lives of students in higher education are inextricably linked with the demands of the 21st century, particularly in developing critical thinking, collaboration, and problem-solving competencies. One component of modern education is the integration of innovative learning approaches. Education is the means by which future professionals are prepared, and the quality of learning methods shapes the readiness of graduates to face complex global challenges (Matt et al., 2022; Nardi & Farhatin,

2022). Project-based learning has emerged as one of the most widely discussed pedagogical strategies in contemporary educational research, particularly in science and education programs at the higher education level.

From a pedagogical, epistemological, and practical perspective, project-based learning is a dynamic instructional framework that bridges theoretical knowledge and authentic application. Without a doubt, its effectiveness does not emerge spontaneously; rather, it must be supported by carefully designed learning environments, collaborative structures, and reflective assessment practices before its full benefits are realized by students. Since its effectiveness has been demonstrated across multiple disciplines, project-based learning has become increasingly embedded in higher education curricula as a core strategy for developing student competencies (Siriat & Nurbayani, 2018; Zainil et al., 2024).

Project-based learning has been integrated into higher education programs worldwide, particularly in science and education disciplines. According to the constructivist learning framework, project-based learning is grounded in the principle that students construct meaningful knowledge through active engagement with authentic problems and collaborative inquiry. Project-based learning addresses the development of higher-order thinking skills, communication competencies, academic resilience, and professional readiness among university students (Rahmawati, 2019; Arwin et al., 2024). Such approaches are increasingly being recognized for their contributions to student engagement and learning outcomes, receiving growing attention from researchers and educators globally, and are considered essential to addressing the challenges of contemporary higher education.

The adoption of project-based learning aligns closely with current higher education policy initiatives worldwide. By providing students with opportunities to engage with complex, multidisciplinary problems and ensuring they develop both technical and interpersonal skills, project-based learning supports a comprehensive and student-centered educational philosophy (Mavuru & Ramnarain, 2017; Jusoh et al., 2023). This approach is particularly relevant in science and education programs, where the integration of disciplinary knowledge with practical competencies is paramount. Prior research has demonstrated that project-based learning can achieve high-quality educational outcomes, including fostering collaborative skills, critical thinking, and authentic engagement with disciplinary content among undergraduate and postgraduate students (Suherman, 2023; Hiltrimartin et al., 2024).

Project-based learning provides a distinctive setting for science and education programs by offering experiential frameworks that connect abstract concepts to real-world applications. Student competencies are maintained and enhanced when project-based approaches are incorporated into course design, and learning becomes more meaningful and transferable to professional contexts (Mavuru & Ramnarain, 2020; Solfema et al., 2024). It influences students' motivation and academic engagement, enables them to develop problem-solving skills and collaborative dispositions (Handayani, 2018), contextualizes disciplinary knowledge within authentic tasks and experiences (Mavuru & Ramnarain, 2017), and supports the development of students' conceptual and procedural understanding (Cherubini, 2019; Handrianto et al., 2025).

According to prior research, project-based learning in higher education encompasses a broad spectrum of instructional strategies, assessment practices, and collaborative configurations. The significance of project-based learning has been underscored by a growing body of research (Cronje, 2015). However, no comprehensive bibliometric review has been conducted to systematically map research trends, identify key contributors, and analyze the intellectual structure of this field using the Scopus database for the period 2022–2026. Therefore, this study aims to provide a comprehensive bibliometric mapping of project-based learning research in higher education, with a particular focus on science and education students.

This study is theoretically anchored in the constructivist paradigm of learning, which holds that knowledge is actively constructed by learners through engagement with authentic, ill-structured problems rather than passively transmitted through direct instruction. Within this paradigm, project-

based learning functions as a pedagogical mechanism that operationalizes constructivist principles by embedding disciplinary content within extended, real-world project structures that demand sustained inquiry, collaboration, and reflection. Mapping the bibliometric landscape of PjBL research through this theoretical lens allows the present study to identify not only quantitative publication patterns but also the extent to which the field's conceptual vocabulary — as captured through keyword co-occurrence structures — reflects a maturing constructivist research tradition within science and education programs specifically.

Research on project-based learning continues to evolve, with increasing emphasis on interdisciplinary collaboration, digital integration, and culturally responsive pedagogical practices. Insufficient bibliometric synthesis has been conducted to integrate findings from recent publications indexed in the Scopus database. There is still much to be systematically mapped and synthesized in this domain (Sudikan, 2023). Numerous earlier studies have attempted to examine project-based learning in various educational contexts and disciplinary settings, but relying solely on individual studies is insufficient, so bibliometric synthesis must be integrated with systematic analysis to advance the field.

This gap carries both theoretical and practical significance. Theoretically, a systematic mapping of the intellectual structure of project-based learning research allows scholars to identify conceptual convergences and divergences across disciplinary boundaries, thereby clarifying how constructivist and experiential learning theories have been operationalized differently across science and education contexts. Practically, a clear picture of publication trends, productive contributors, and dominant pedagogical strategies can inform institutional decision-making regarding curriculum reform, faculty development, and research funding priorities. Given the accelerating pace of publication in this domain since 2022, a timely and discipline-specific bibliometric synthesis is warranted to consolidate scattered findings into an accessible and structured evidence base for future researchers and policymakers.

Project-based learning is now recognized as a critical pedagogical strategy for preparing students to navigate the complexities of the 21st century; critical thinking, collaboration, communication, and creativity are the foundational competencies required in an increasingly interconnected and knowledge-driven global landscape (Sudikan, 2023). Prior studies have demonstrated that implementing project-based learning in higher education produces more contextually meaningful and competency-oriented learning experiences. Using structured project-based learning modules in higher education improves students' disciplinary literacy and collaborative skills (Widana, 2023).

Since 2022, studies examining project-based learning in higher education have continued to grow, with a notable concentration of publications in science and education disciplines. In a bibliometric study, Misbah, (2022) investigated research trends in a related pedagogical domain using the Scopus database, revealing network structures and thematic clusters. Similarly, Tiro, (2024) investigated a comparable educational topic using bibliometric mapping and VOSviewer, identifying the most productive countries, authorship patterns, citation structures, and keyword co-occurrence networks based on the Scopus database.

Furthermore, (Sudikan, 2023) reported bibliometric trends in an educational research domain using Scopus data from 2015–2022. To the best of our knowledge, a bibliometric analysis specifically focused on project-based learning in higher education for science and education students using the Scopus database for the 2022–2026 period has not yet been conducted. While Sudikan, (2023) covered the pre-pandemic and early-pandemic period, and Tiro, (2024) conducted a broader PjBL bibliometric mapping without a specific disciplinary focus, neither study addressed the post-pandemic acceleration of PjBL research within science and education programs in higher education during 2022–2026 — a period marked by major curriculum reform, particularly Indonesia's Merdeka Belajar-Kampus Merdeka (MBKM) initiative. Although several previous studies have utilized the Scopus database, Scopus is recognized as one of the most comprehensive and widely used data sources for bibliometric analysis in education research (Handayani, 2018). Therefore, we chose Scopus as the data source for this study (Misriani, 2023).

This study examines the development and trends in this research domain, drawing on peer-reviewed publications indexed in the Scopus database. The following research questions were investigated:

1. How many publications in this field were published from 2022 to 2026?
2. Who are the most cited authors and countries in publications on project-based learning in higher education science and education programs?
3. Which journals are most active in producing scientific papers in this area?
4. What keywords are most frequently used by authors on project-based learning in higher education?
5. What pedagogical strategies are most widely applied in project-based learning for science and education students in higher education?

RESEARCH METHOD

In science and education research, as well as in scientific publications on topics such as active learning, STEM education, and pedagogical innovation, bibliometric analysis has gained considerable popularity in recent years. This comprehensive review aims to understand the evolution of project-based learning research in higher education, particularly among science and education students. Bibliometric analysis is one method for examining research co-authorship networks, citation patterns, and keyword co-occurrence structures (Priliyanti, 2021). This is because bibliometric analysis aids in (a) identifying and charting the cumulative scientific landscape of a research domain and (b) producing a comprehensive image of scientific output and its evolution over time within the field of study (Muti'ah, 2023)

Deliberate choices were made to design our bibliometric study, which aimed to map the research landscape on project-based learning in higher education science and education programs from 2022 to 2026. Therefore, we adapted the method suggested by and the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) framework ((Tiro, 2024)) to structure our investigation of this research topic:

1. Study design: identifying the research questions and selecting the database
2. Data collection: searching, screening, and exporting bibliographic data following PRISMA protocol
3. Data analysis: selecting bibliometric methods appropriate for clarifying the research topic and identifying suitable software for data analysis
4. Data visualization: selecting appropriate visualization methods and mapping software
5. Interpretation: evaluating and synthesizing the results of the bibliometric analysis

Data Collection

Bibliometric data for this study were obtained from the Scopus database(Tiro, 2024). Data collection was conducted in early 2026, covering publications from January 2022 to 2026. Several keywords were selected for the literature collection: project-based learning, project based learning, PjBL, higher education, university students, science education, and education students. Data were gathered only from studies published between 2022 and 2026. Only bibliographic records from articles and proceedings published in peer-reviewed journals were considered. The language was restricted to English-language publications. A description of the precise data search procedures is provided in Table 1.

Table 1. Scopus Database Search Procedure

Database	Search Query	Refinement	Result
Scopus	TITLE-ABS-KEY "project-based learning" AND "higher education"	Articles and proceedings; English language; 2022– 2026; education area	1,394

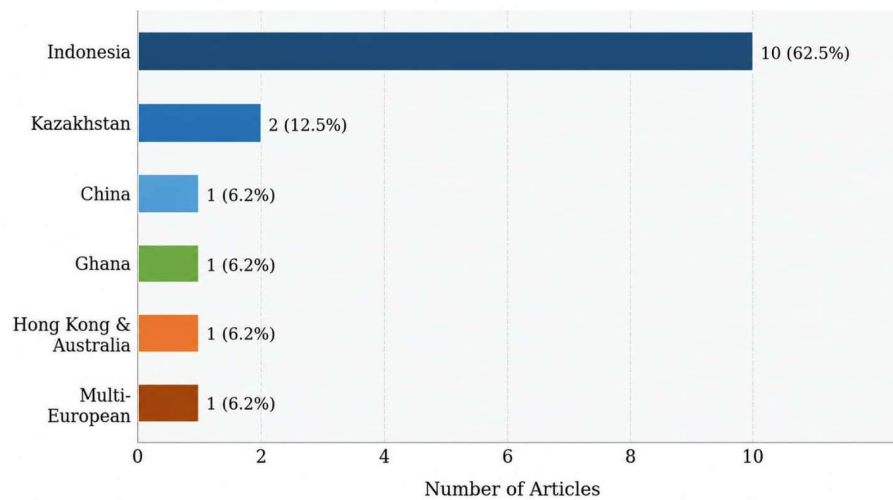


Figure 1. Country Distribution of PjBL Publications (n = 16)

To ensure the rigor and transparency of the article selection process, this study adopted the PRISMA framework as a systematic screening protocol. The identification stage retrieved a total of 1,394 records from the Scopus database. Prior to screening, 647 duplicate records were removed, resulting in 747 records eligible for further screening. During the screening stage, 584 records were excluded, leaving 163 reports for retrieval. Of these, 126 reports could not be retrieved, resulting in 37 reports assessed for eligibility. In the eligibility assessment stage, 21 reports were excluded: 10 articles were not directly related to project-based learning, 4 articles were not within the scope of education, and 7 articles were not related to science programs. Consequently, a final total of 16 articles were included in the bibliometric analysis (see Figure 2).

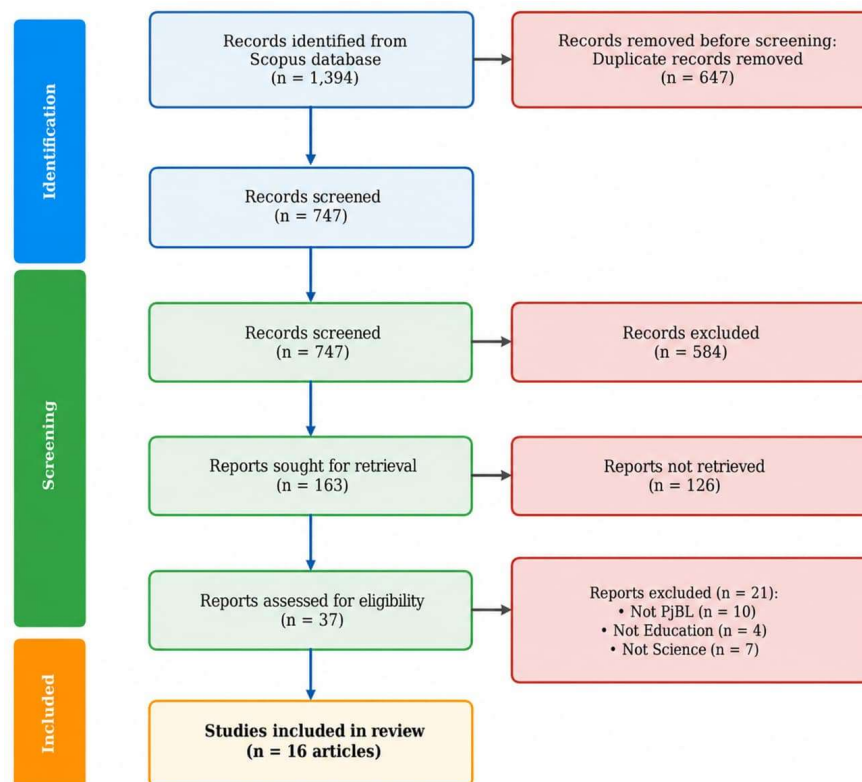


Figure 2. PRISMA Flowchart of Article Selection Process

(Project-Based Learning in Higher Education ...)

Data Analysis and Visualization

Scientific mapping and performance analysis are the two main approaches to bibliometric analysis (Abah et al., 2015). Performance analysis uses indicators such as the average number of citations per article and the number of publications to assess scientific output in a research field (Mavuru & Ramnarain, 2020). Scientific mapping provides a spatial representation of the connections among various subject areas, papers, or authors for a particular study field (Misbah, 2022). The data analysis framework is presented in Table 2.

Table 2. A review of data analysis conducted to answer the research questions

Research Questions	Main Technique
RQ1. Publications per year (2022–2026)?	Performance analysis: number of articles published per year and average citations
RQ2. Most cited authors and countries?	Performance analysis: most productive authors over time and most active contributor countries
RQ3. Most active journals?	Performance analysis: most referenced sources in terms of quantity and chronological progression
RQ4. Most frequently used keywords?	Science mapping: co-word analysis
RQ5. Most widely applied pedagogical strategies?	Science mapping: co-word analysis and pedagogy-related content analysis

VOSviewer software version 1.6.20 was utilized for the visualization of science mapping results, as it effectively manages the graphical representation of bibliometric maps and is particularly useful for displaying large bibliometric networks (Masita, 2012). VOSviewer was employed to generate keyword co-occurrence maps and citation-based visualizations to address all research questions outlined in this study.

The choice of VOSviewer over alternative bibliometric software, such as CiteSpace or Bibliometrix, was guided by its accessibility, its capacity to generate intuitive network, density, and overlay visualizations without requiring advanced programming expertise, and its widespread adoption in prior education-focused bibliometric studies, which facilitates comparability of the present findings with existing literature. Full counting was applied for co-authorship and keyword co-occurrence analysis, and a minimum keyword occurrence threshold of two was set to reduce noise from idiosyncratic or singly occurring terms while preserving the representativeness of the resulting thematic clusters.

Limitation

The primary limitation of this study concerns the exclusive use of the Scopus database as the single data source, as well as the relatively small number of final articles included ($n = 16$) following the PRISMA screening process. Future studies are encouraged to replicate and expand this analysis using complementary databases such as Web of Science and Google Scholar, as well as broader date ranges, to obtain a more comprehensive picture of project-based learning research trends in higher education.

Notwithstanding these limitations, the PRISMA-guided screening protocol applied in this study enhances the transparency and reproducibility of the article selection process, thereby strengthening the methodological trustworthiness of the resulting bibliometric map. The relatively small final sample size, while limiting the statistical generalizability of citation-based performance indicators, is consistent with the emerging and still-narrow disciplinary focus of project-based learning research specifically situated at the intersection of science and education programs, as opposed to the broader and more heterogeneous PjBL literature spanning all fields of higher education.

FINDING AND DISCUSSIONS

RQ1: Publication Trends (2022–2026)

The bibliometric analysis of project-based learning research in higher education for science and education students across the 2022–2026 period reveals a distinctive and highly concentrated trajectory of scholarly output. The corpus of 16 articles exhibits a markedly uneven temporal distribution: 2023 and 2024 each contributed a modest volume — 2 articles and 1 article respectively — while 2025 emerged as the overwhelmingly dominant year, accounting for 12 of the 16 publications (75%). A single article from 2026 completes the corpus, reflecting the nascent stage of publication activity in the most recent year of the study window.

From a citation-impact perspective, the concentration of publications in 2025 also means that most articles in the corpus have had limited time to accumulate citations, which constrains the reliability of citation-based performance indicators for this study and underscores the value of complementing citation counts with publication-count and journal-quality indicators, as adopted in the present analysis. Nonetheless, the sheer volume and disciplinary concentration of 2025 publications signal that project-based learning in science and education programs has moved from a peripheral pedagogical interest to a mainstream empirical research priority, a trend that is likely to continue as more institutions formalize project-based curricula in response to accreditation standards emphasizing student-centered and competency-based learning outcomes.

This pronounced surge in 2025 is not incidental; it mirrors broader structural shifts in higher education research globally. The period between 2022 and 2024 corresponds to a transitional phase during which educational institutions worldwide were repositioning their pedagogical frameworks in the wake of the COVID-19 pandemic. The integration of project-based learning into hybrid and blended learning environments, combined with the global momentum toward competency-based education, created an enabling condition for the rapid escalation of empirical research in this domain. Particularly in the Indonesian context, the implementation of the Merdeka Belajar-Kampus Merdeka (MBKM) curriculum framework from 2020 onward provided a structural mandate for experiential, project-oriented learning in higher education, generating a substantial body of applied research by 2025.

This publication trajectory mirrors patterns observed in other pedagogically oriented bibliometric studies, where a lag of two to three years typically separates policy initiation from a measurable surge in empirical output, as researchers require time to design, implement, and report classroom-based interventions. The relatively sparse output in 2023 and 2024 may also reflect the residual disruption of research and publication pipelines during the pandemic recovery period, when many higher education institutions prioritized curriculum stabilization over experimental pedagogical research. The single 2026 publication captured in this corpus should be interpreted cautiously, as the Scopus database indexing for the current year remains incomplete at the time of data collection, suggesting that the true volume of 2026 publications is likely to be considerably higher once indexing catches up.

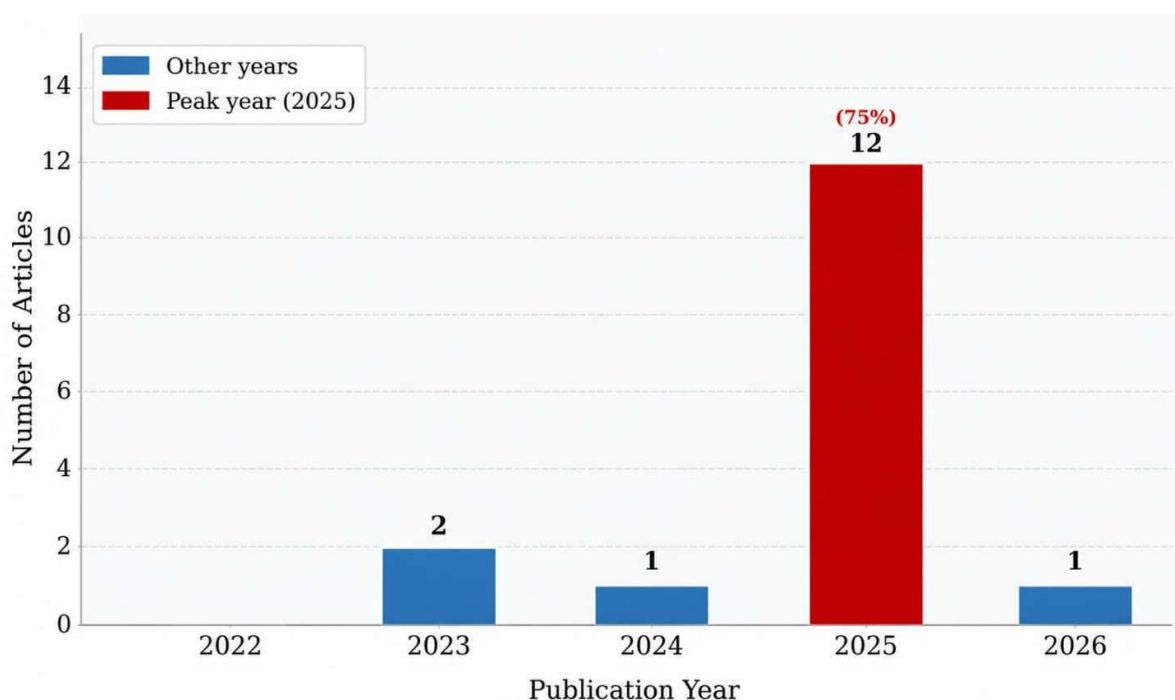


Figure 3. Publication trends per year 2022–2026

RQ2: Most Productive Authors and Countries

The authorship and geographic distribution of the 16 analyzed publications reveals a pronounced concentration of scholarly activity centered in Indonesia and a clear pattern of collaborative multi-author research teams. Indonesia emerges as the overwhelmingly dominant national contributor, accounting for 10 of the 16 publications (62.5%), a proportion that reflects the direct relationship between national educational reform initiatives and the volume of empirical research they generate. The implementation of the Merdeka Belajar-Kampus Merdeka (MBKM) curriculum framework in Indonesia has created a structural incentive for university-based researchers to investigate project-based learning as both a pedagogical strategy and a policy instrument.

Beyond Indonesia, the corpus reflects meaningful international representation. Kazakhstan contributes two publications — Madybekova et al., (2026) on analytical chemistry education and Ospankulova et al., (2025) on student attitudes and critical thinking engagement — reflecting the growing interest in active learning methodologies within Central Asian higher education systems. China is represented by Wang, (2025), whose mixed-methods investigation of physics education in a project-based context contributes a distinctive disciplinary and geographic perspective. The remaining publications originate from Ghana(Boakye-Yiadom et al., 2025), a joint Hong Kong and Australian collaboration (Kee et al., 2025), and a multi-European consortium study (García-Llamas, 2025). Detailed information on the most productive authors is presented in Table 3.

The predominance of multi-author teams across nearly all 16 publications further indicates that project-based learning research in this domain is conducted through collaborative rather than solitary scholarship, consistent with the collaborative pedagogical philosophy that PjBL itself promotes. This pattern of co-authorship also suggests the presence of established research groups or laboratories that specialize in experiential and project-based pedagogical inquiry, rather than isolated single-study contributions, which may facilitate cumulative knowledge-building within national and institutional contexts. The concentration of Indonesian authorship, in particular, points to the formation of a distinct national research community actively responding to domestic curriculum policy through empirical inquiry.

Table 3. Most Productive Authors in PjBL Research in Higher Education (2022–2026)

No.	Author(s)	Country	Year	Journal	Q	Research Focus
1	Novalia, T., et al.	Indonesia	2025	Social Sciences & Humanities Open	Q1	Learning independence (SEM)
2	Hulyadi, A., et al.	Indonesia	2025	Social Sciences & Humanities Open	Q1	Teaching factory soft skills
3	Yusuf, M.	Indonesia	2025	Thinking Skills and Creativity	Q1	AR-PjBL biology education
4	Wang, H., et al.	China	2025	Int. J. STEM Education	Q1	Physics education (ANABLE)
5	Ospankulov a, G., et al.	Kazakhstan	2025	Thinking Skills and Creativity	Q1	Attitudes, CT, engagement
6	Garcia-Llamas, J.L., et al.	Multi-European	2025	European Journal of Education	Q1	STEAM European context
7	Kee, C., et al.	HK & Australia	2025	Int. J. Technology & Design	Q1	Design thinking integration
8	Hasibuan, A.M., et al.	Indonesia	2025	Eurasia J. Math. Sci. Tech.	Q2	Creative thinking meta-analysis
9	Syamra, I. & Suryadi, A.	Indonesia	2025	J. Turkish Science Education	Q2	PjBL-STEM scientific creativity
10	Segara, N.B., et al.	Indonesia	2025	J. Physics: Conference Series	Q2	Scientific thinking TBPR
11	Susetyo, B., et al.	Indonesia	2025	J. Language Teaching & Research	Q2	Academic literacy needs analysis
12	Boakye-Yiadom, M., et al.	Ghana	2025	Heliyon	Q2	Adinkra symbols STEM
13	Madybekov a, G., et al.	Kazakhstan	2026	J. Chemical Education	Q2	Analytical chemistry education
14	Indriati, D., et al.	Indonesia	2024	J. Science Education & Tech.	Q2	Authentic assessment large-class
15	Riyanti, A.	Indonesia	2023	J. Education and Practice	Q3	Implementation perspectives
16	Sudarmin, et al.	Indonesia	2023	J. Turkish Science Education	Q3	Ethno-STEM chemistry Four-D

RQ3: Most Active Journals

The 16 analyzed publications are distributed across 13 distinct journals, indicating a broad and varied dissemination landscape with minimal concentration in a single venue. This pattern of journal diversity suggests that project-based learning research in higher education science and education programs is being published across a wide range of disciplinary and interdisciplinary outlets rather than being consolidated within a single flagship journal. Social Sciences & Humanities Open (Elsevier) is the most productive single source, contributing two publications to the corpus: Novalia et al., (2025) and Hulyadi, (2025), both from Indonesian research teams.

The quality distribution of journals in the analyzed corpus is particularly noteworthy. Of the 16 publications, 7 articles (43.75%) appeared in Q1 journals, 5 articles (31.25%) in Q2 journals, and 4 articles (25%) in Q3 journals. This distribution indicates that 75% of the identified research on project-based learning in higher education was published in Q1 or Q2 Scopus-indexed journals,

confirming that this body of research has achieved a high level of scholarly quality and institutional legitimacy. Detailed journal data are presented in Table 4. The absence of a single dominant flagship journal, coupled with the presence of well-established interdisciplinary outlets such as Social Sciences & Humanities Open and Thinking Skills and Creativity, suggests that project-based learning research in science and education programs is still consolidating its identity as a distinct field of inquiry rather than being anchored within a specialized subject-specific journal ecosystem. This dispersion across publishers, including Elsevier, Springer, Wiley, and IOP Publishing, further indicates that the topic resonates across multiple disciplinary communities, from general education research to discipline-specific science education outlets, reflecting the inherently interdisciplinary character of project-based pedagogy.

Table 4. Most Active Journals in PjBL Research in Higher Education (2022–2026)

No.	Journal Name	n	Publisher	Q	ISSN
1	Social Sciences & Humanities Open	2	Elsevier	Q1	2590-291X
2	Thinking Skills and Creativity	2	Elsevier	Q1	1871-1871
3	Eurasia Journal of Mathematics, Science and Technology Education	1	Modestum	Q2	1305-8215
4	Journal of Chemical Education	1	ACS Publications	Q2	0021-9584
5	International Journal of STEM Education	1	Springer	Q1	2196-7822
6	European Journal of Education	1	Wiley	Q1	0141-8211
7	International J. Technology & Design Education	1	Springer	Q1	0957-7572
8	Journal of Turkish Science Education	2	TUSED	Q3	1304-6020
9	Heliyon	1	Elsevier	Q2	2405-8440
10	Journal of Physics: Conference Series	1	IOP Publishing	Q2	1742-6596
11	Journal of Language Teaching and Research	1	Academy Publisher	Q3	1798-4769
12	Journal of Science Education and Technology	1	Springer	Q2	1059-0145
13	Journal of Education and Practice	1	IISTE	Q3	2222-1735
TOTAL	13 journals, 16 articles	16	Q1: 7 (43.75%)	Q2: 5 (31.25%)	Q3: 4 (25%)

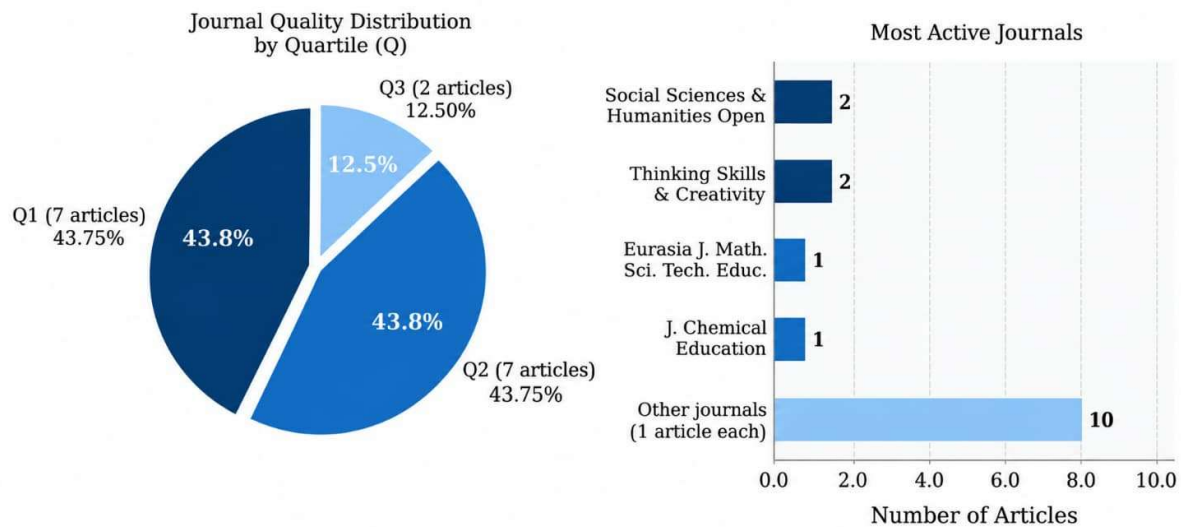


Figure 4. Journal Quality Distribution and Most Active Sources

RQ4: Keyword Co-occurrence Analysis

The keyword co-occurrence network generated by VOSviewer reveals a richly interconnected conceptual structure organized around two primary intellectual hubs — project-based learning and higher education — which function as the central nodes of the entire bibliometric network. These two nodes exhibit the largest node sizes, indicating the highest frequency of co-occurrence with other keywords across the corpus, and occupy the most central spatial position within the network visualization (Figure 5).

The network structure identifies four distinct thematic clusters, each representing a coherent research orientation within the broader domain of project-based learning in higher education. The first cluster, predominantly rendered in green in the network visualization, is oriented toward cognitive and evaluative outcomes and encompasses keywords such as critical thinking, learning, attitudes, authentic assessment, students, and project based learning, along with the European universities initiative, indicating a policy-linked research stream. The second cluster, appearing in blue, reflects the collaborative and engagement dimension of PjBL research and includes collaborative learning, student engagement, 21st century skills, and collaborative design. The third cluster, functioning as a thematic hub rendered in brown, connects the foundational concept of project-based learning with character and affective competency outcomes, including academic resilience, entrepreneurial intention, creative thinking skills, alternative energy, and academic literacy. The fourth cluster, in orange, represents disciplinary-specific applications, particularly analytical chemistry education and adinkra symbols, reflecting culturally and contextually grounded PjBL research from Kazakhstan and Ghana respectively.

The density visualization (Figure 6) corroborates the network analysis by identifying four zones of high conceptual density, with the most prominent zones centered on project-based learning and higher education in the network core, critical thinking and collaborative learning in the upper-left region, authentic assessment in the right cluster, and emerging nodes in the lower periphery.

The overlay visualization (Figure 7) introduces a temporal dimension to the keyword analysis by representing the average publication year of each node through a color gradient from blue (2024.5) to yellow-green (2026.0). This analysis reveals that academic literacy and analytical chemistry education are among the most recently emerging keywords, with average publication years approaching 2026.0, indicating that these disciplinary-specific and literacy-oriented applications of PjBL represent the current research frontier. Conversely, established themes such as critical thinking, attitudes, and authentic assessment display earlier average publication years (approximately 2024.5), suggesting their status as foundational and more mature research streams.

The nodes project-based learning, higher education, and academic resilience occupy intermediate temporal positions, reflecting their sustained relevance across the full study period.

These findings resonate with, yet also extend, prior bibliometric mappings of project-based learning conducted by Sudikan, (2023) and Tiro, (2024), both of which similarly identified critical thinking and collaborative learning as central nodes within the broader PjBL literature. However, the present analysis reveals a more pronounced emphasis on character and affective competency development, as well as disciplinary-specific applications such as analytical chemistry education, which were not prominently featured in earlier bibliometric syntheses covering broader time periods and less discipline-specific corpora. This divergence suggests a maturation of the field, in which researchers are moving beyond generic cognitive outcome measures toward more nuanced investigations of affective, motivational, and context-embedded dimensions of project-based learning, particularly within science and education programs where disciplinary content knowledge and pedagogical practice must be simultaneously addressed.

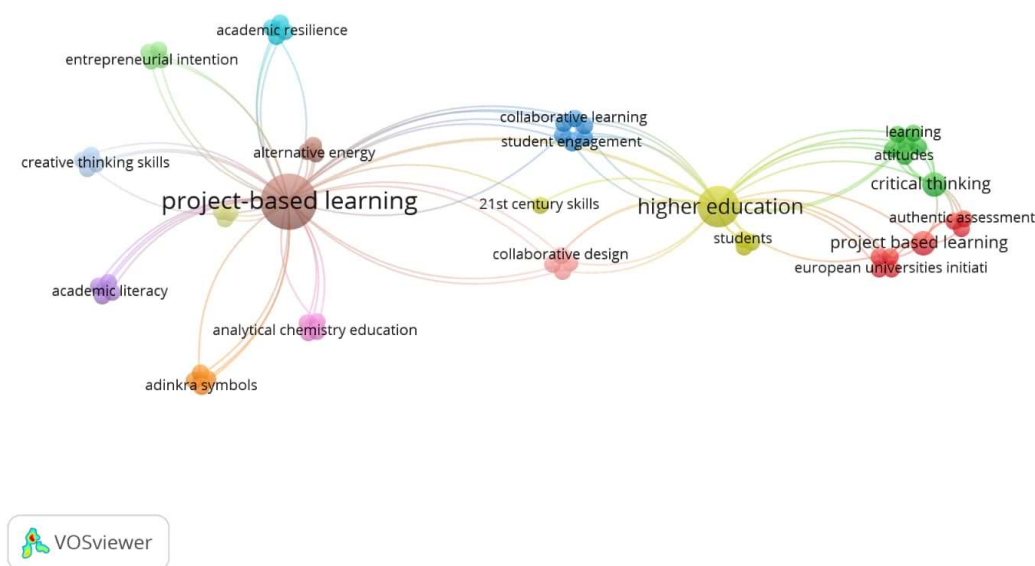


Figure 5. Keyword Co-occurrence Network Visualization (VOSviewer)

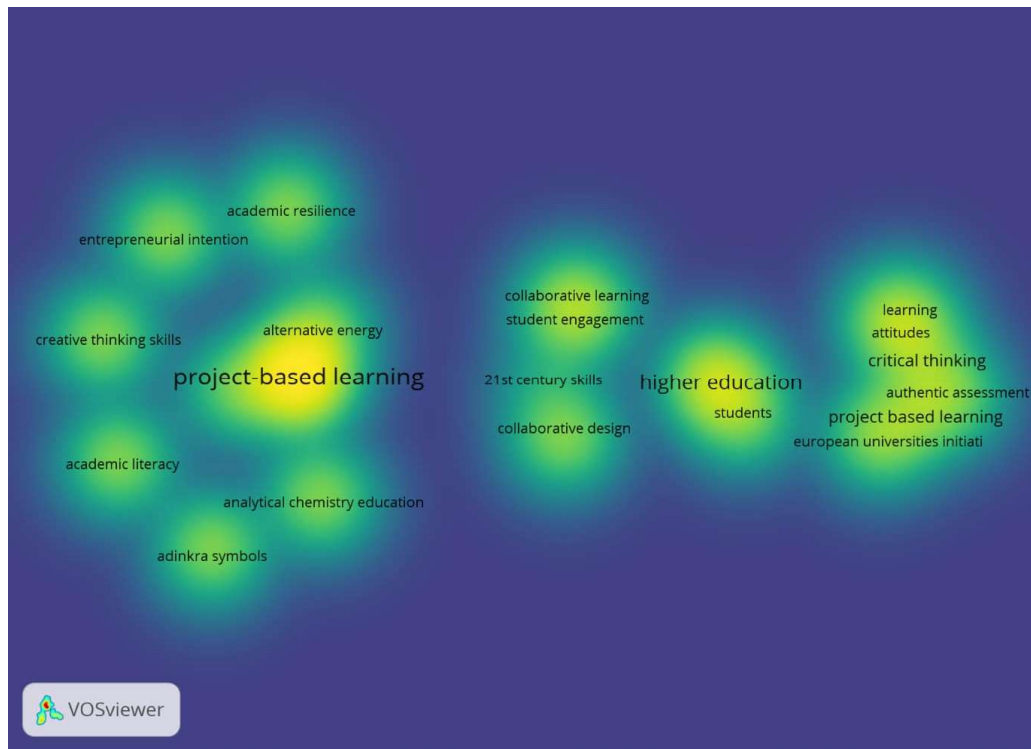


Figure 6. Keyword Co-occurrence Density Visualization (VOSviewer)

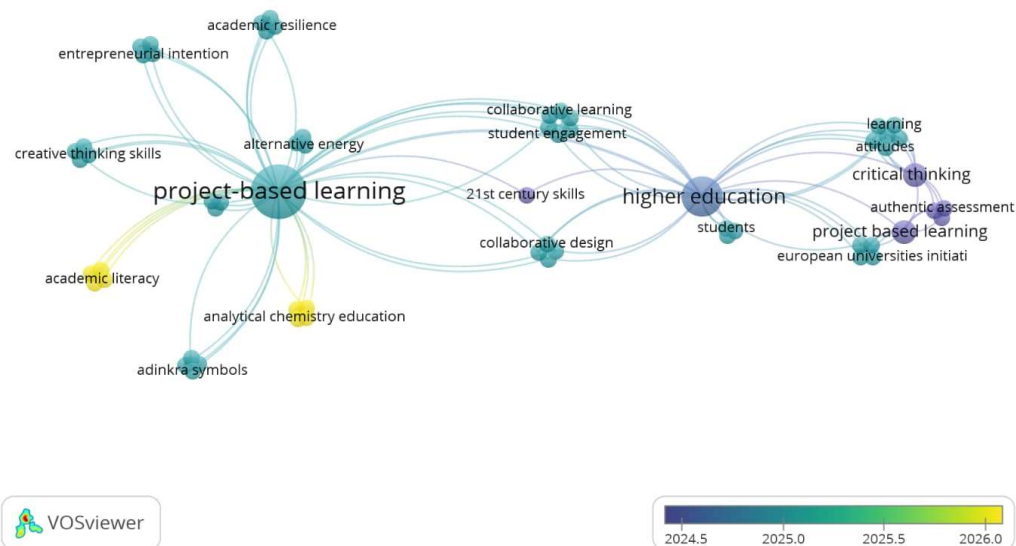


Figure 7. Keyword Co-occurrence Overlay Visualization – Average Publication Year (VOSviewer)

RQ5: Dominant Pedagogical Strategies

The thematic analysis of the 16 included publications reveals five dominant pedagogical strategy clusters that characterize the implementation of project-based learning in higher education science and education programs during the 2022–2026 period. These clusters reflect both the theoretical

orientations and the practical configurations through which PjBL has been operationalized across diverse disciplinary and cultural contexts.

The first and most pervasive cluster is collaborative project implementation, identified in 14 of the 16 articles. Across the corpus, project-based learning is almost universally configured as a collaborative endeavor in which students work in groups or teams to complete a shared project. The meta-analytic evidence from Hasibuan, (2025) provides the strongest quantitative support for this cluster, reporting a pooled effect size of 1.18, which is classified as a large effect, confirming that collaborative PjBL implementation produces substantially superior outcomes relative to conventional instruction across a diverse range of learning settings.

This near-universal reliance on collaborative structuring aligns with Vygotskian sociocultural learning theory, which posits that higher-order cognitive development is mediated through social interaction within a zone of proximal development. In the context of project-based learning, group-based project work provides a structured opportunity for peer scaffolding, distributed expertise, and negotiated meaning-making, which may explain the consistently large effect sizes reported across the collaborative PjBL studies included in this corpus. At the same time, the dominance of collaborative implementation raises an important methodological consideration for future research: because nearly all studies in this domain confound project-based instruction with group-based collaboration, it remains difficult to isolate the unique contribution of the project-based task structure itself from the collaborative learning arrangement in which it is typically embedded, pointing to a need for more finely controlled experimental designs in future PjBL research.

The second cluster, inquiry-based and problem-driven project design, is discernible in 13 of the 16 articles. Studies in this cluster position authentic problems or real-world challenges as the initiating premise of the project, requiring students to engage in systematic inquiry, evidence gathering, and iterative problem-solving. Segara et al., (2025) exemplify this orientation with their quasi-experimental investigation of scientific thinking development through TBPR (Task-Based Project Research), reporting a large effect size ($\eta^2 = 0.868$) for inquiry-driven PjBL.

The strength of this inquiry-based cluster suggests that authentic problem framing functions as a critical design principle that distinguishes genuinely project-based instruction from more superficial applications of group project work, reinforcing the theoretical expectation that student engagement and deep learning are maximized when tasks are perceived as personally and disciplinarily meaningful rather than as artificial classroom exercises.

The third cluster, technology-enhanced and blended PjBL, is represented in five publications. Yusuf, (2025) introduces augmented reality integration in the AR-PjBL model for biology education, demonstrating significant MANOVA effects for student learning outcomes. (Wang, 2025) employ the ANABLE framework in a physics education context in China, combining flipped classroom elements with project-based tasks to create a blended learning environment.

The fourth cluster, interdisciplinary and STEM-integrated project design, encompasses four publications that situate PjBL within Science, Technology, Engineering, and Mathematics frameworks. Syamra & Suryadi, (2025) examine the combined effects of PjBL and STEM integration on students' scientific creativity in chemistry education in Indonesia. Sudarmin et al., (2023) implement an Ethno-STEM approach within a chemistry project framework, while García-Llamas, (2025) explore STEAM integration across European university contexts.

The fifth cluster, design thinking-integrated PjBL, is represented by a single study Kee, (2025) which investigates how design thinking principles, operationalized through the five-stage Stanford d.school framework (empathize, define, ideate, prototype, test), can be systematically integrated into PjBL to enhance students' collaborative design competencies in Hong Kong and Australia.

Taken together, these five pedagogical strategy clusters are not mutually exclusive but frequently co-occur within individual studies, with collaborative implementation serving as a near-universal structural foundation upon which inquiry-driven, technology-enhanced, interdisciplinary, and design-oriented elements are variably layered. This layering pattern suggests that project-based learning in higher education science and education programs has evolved into a flexible pedagogical

architecture rather than a single standardized instructional model, allowing instructors to calibrate the specific configuration of PjBL to the disciplinary content, institutional resources, and desired learning outcomes of their particular context. The relatively limited representation of technology-enhanced and design thinking-integrated approaches, compared to the near-ubiquity of collaborative implementation, further indicates that these represent promising but still underexplored directions for future pedagogical innovation and research.

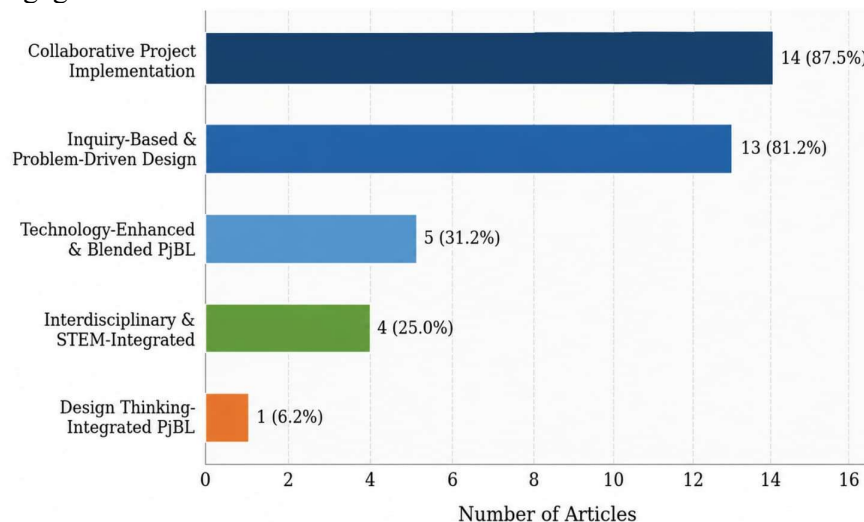


Figure 8. Dominant Pedagogical Strategy Clusters in PjBL Research

CONCLUSION AND IMPLICATION

In this paper, we present the findings of a bibliometric study of 16 articles published in peer-reviewed journals between 2022 and 2026, focusing on project-based learning in higher education science and education programs. Using specified search parameters and the PRISMA screening protocol, we retrieved bibliographic information from the Scopus database, and five research questions were addressed using scientific mapping and performance analysis approaches. The study's findings indicate that research on project-based learning in higher education has experienced a significant acceleration in scholarly output, with 2025 representing the most productive year, accounting for 75% of all publications in the analyzed corpus. Indonesia consistently emerges as the dominant contributor to this field, accounting for 62.5% of all publications, a pattern that underscores the central role of national educational reform initiatives — particularly the Merdeka Belajar-Kampus Merdeka (MBKM) curriculum — in stimulating empirical research on active and experiential learning approaches. The journal landscape is broadly characterized by high scholarly quality, with 75% of publications appearing in Q1 and Q2 Scopus-indexed journals, led by Social Sciences & Humanities Open as the most productive single source. The keyword co-occurrence analysis reveals a richly interconnected conceptual network organized around four primary thematic clusters: cognitive and higher-order thinking outcomes, collaborative and engagement-oriented learning, character and affective competency development, and disciplinary-specific applications, with the overlay visualization indicating that emerging research frontiers are visible in the areas of disciplinary applications — particularly analytical chemistry education — and culturally embedded project designs. Despite its potential benefits, the integration of project-based learning in higher education science and education programs remains uneven across disciplines, institutions, and geographic regions, and many pedagogical factors — particularly those relating to technology-enhanced implementations, longitudinal outcome assessment, and cross-institutional collaborative project frameworks — have not yet been comprehensively examined. The findings of this study can serve as a guide for researchers seeking to conduct new investigations into the application of project-based learning in higher education, and future studies should consider broader multi-database integration, longitudinal research designs, and the development of theoretically grounded

frameworks that systematically address the contextual, disciplinary, and technological dimensions of project-based learning implementation in higher education science and education programs. Taken together, these findings carry practical implications for curriculum designers and policymakers, particularly in signaling the need to institutionalize project-based learning through structured faculty training, cross-disciplinary collaboration schemes, and sustained investment in technology-enhanced learning infrastructure.

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