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Trends in Project-Based Learning Implementation in Science Education (2015-2025): A Systematic Literature Review

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Abstract

The paramount goal of this study was to meticulously identify and critically analyze contemporary trends regarding the integration of the Project-Based Learning (PjBL) pedagogical model within science education settings. The adopted research strategy was a Systematic Literature Review (SLR), strictly adhering to the PRISMA framework guidelines, with rigorously defined inclusion and exclusion criteria. The literature sources for this review were exclusively focused on national journals indexed in the Science and Technology Index (SINTA), specifically tiers SINTA 2, SINTA 3, and SINTA 4. The search utilized core keywords encompassing the "PjBL learning model" in the context of physics and science. A comprehensive synthesis of 82 published Indonesian articles revealed key findings: The most frequently investigated learning outcome variable in PjBL implementations was creative thinking skills, cited in the largest proportion of studies at 25%, closely followed by critical thinking skills (17%). However, this review identifies a significant research gap: existing studies are heavily centralized at the senior high school level and rely predominantly on quantitative methodologies, leaving a deficiency in the deep exploration of student learning processes and affective-psychomotor impacts across diverse educational levels. Practically, these findings serve as a strategic roadmap for educators to diversify PjBL application beyond common topics like Fluids and Work-Energy, while providing a robust empirical foundation for developing more holistic 21st-century skill assessments in science classrooms. Methodologically, the quantitative research design featuring the Quasi-Experimental model emerged as the predominant approach, evidenced in 27 articles. In terms of temporal distribution, the highest volume of publications occurred in 2024, contributing 25 articles to the dataset. Furthermore, the content areas most frequently investigated were Static and Dynamic Fluids, covered in 9 articles, and the topic of Work and Energy, featuring in 7 published articles. The insights generated from this research are expected to offer a valuable and significant contribution to the educational sector, particularly in guiding the evaluation and subsequent enhancement of science instruction facilitated by the PjBL model.

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INTRODUCTION

In the current educational landscape, the requisite skills for navigating the challenges of the 21st century are continuously evolving, a progression intrinsically linked to technological advancements and the demands of the global job market. Reports from institutions such as the World Economic Forum consistently underscore that foundational competencies specifically critical thinking, creative thinking, communication, and collaboration are highly prioritized and essential (Houghton & Loy, 2024; Keane & Yeow, 2023; Vithanage & Nakashima, 2025). In response, educational curricula within Indonesia have begun to systematically integrate pedagogical approaches that emphasize the development of these 21st-century skills across various subjects, including physics and general science (Daeng Naba et al., 2024; Fitria et al., 2025; Nisa & Suprapto, 2024). These skills are instrumental in enabling students to cultivate imagination, exhibit flexible thinking, and generate original ideas directly applicable to solving complex scientific and physical problems. To successfully realize these pedagogical objectives, the adoption of innovative. and effective instructional methodologies is imperative (El Iq Bali et al., 2021; Kurniawan et al., 2024). Among the models receiving significant scholarly attention and deemed highly relevant is the Project-Based Learning (PjBL) model (Asnur et al., 2025; Mota et al., 2025; Tarigan et al., 2025).

However, despite concerted efforts to integrate these essential competencies, numerous studies consistently indicate that students' current level of 21st-century skills remains notably low (Mutohhari et al., 2021; Swandi et al., 2021). The central challenge encountered primarily stems from the scarcity of effective and relevant instructional methodologies. A significant proportion of educators still rely on conventional, traditional approaches that inadequately stimulate students to engage in critical and creative thinking (Wason, 2025). Furthermore, a major compounding factor is the limited provision of teacher training focused on the development and implementation of appropriate assessment instruments, which presents another significant pedagogical hurdle (Pastore & Mincu, 2024; Salani et al., 2025).

Prior research investigating the implementation of PjBL, as a strategic initiative aimed at fostering 21st-century skills, has frequently demonstrated varied and often inconsistent outcomes (Al-Kamzari & Alias, 2025; Asnur et al., 2025; Hidayat et al., 2024). While international SLR studies have extensively mapped PjBL's theoretical foundations and design principles on a global scale (Al-Kamzari & Alias, 2025; Yusri et al., 2024), they often overlook the specific pedagogical landscape and localized challenges within the Indonesian context. This present study addresses this critical gap by providing a targeted synthesis of a decade (2015–2025) of Indonesian research, revealing a unique trend: while international trends focus on broad implementation, Indonesian PjBL research is heavily centralized at the Senior High School (SMA) level (70% of studies) and predominantly utilizes quantitative quasi-experimental designs (33%). Unlike previous reviews that may generalize outcomes, this study meticulously identifies that in the Indonesian science education context, PjBL is most frequently applied to specific physics topics like Fluids and Work-Energy to specifically address creative thinking skills (25%). By highlighting the deficiency in research at the primary and higher education levels, as well as the scarcity of qualitative exploration into the learning process, this study offers a distinct contribution that establishes a more precise roadmap for future localized pedagogical interventions and curriculum development in Indonesia.

The present research seeks to address this existing gap by undertaking a Systematic Literature Review (SLR) specifically focused on the usage trends of the Project-Based Learning (PjBL) Model in science education spanning the decade from 2015 to 2025. By rigorously employing the PRISMA framework, this study is designed to systematically

identify and analyze relevant scholarly works, in addition to evaluating the effectiveness of the various pedagogical approaches that have been implemented. This investigation is particularly significant within the Indonesian context, where science education currently faces critical challenges, most notably the consistently low level of students' 21st-century thinking skills. This issue is primarily driven by a widespread reliance among educators on conventional, traditional teaching methods that fail to stimulate critical and creative engagement. Furthermore, the limited availability of specialized teacher training for developing appropriate assessment instruments remains a major pedagogical hurdle in Indonesian schools. Consequently, this article delineates the findings of the literature synthesis concerning trends in pedagogical model utilization in science learning, derived exclusively from research articles published in national journals indexed in the Science and Technology Index (SINTA).

This research is expected to contribute new insights regarding best practices for the implementation of PjBL within physics and science classrooms, ultimately providing tangible recommendations for both educators and educational policymakers. Theoretically, the findings are anticipated to enrich the existing body of literature concerning PjBL in the context of science learning, simultaneously establishing a robust foundation for subsequent, deeper research in this specific pedagogical domain. Practically, the results are intended to be directly utilized by educators to design more effective curricula and instructional methodologies aimed at enhancing students' skills, thereby better preparing them to successfully navigate real-world challenges. Consequently, this comprehensive review is poised to make a significant contribution to the advancement of physics and science education in Indonesia and will serve to elevate the overall quality of classroom instruction. Specifically, this research aims to address the following detailed research questions:

- How have the developmental trends in research concerning the Project-Based Learning (PjBL) model evolved within the landscape of science education from 2015 to 2020?
- Which research variables are most prominently featured in PjBL implementations, and which scientific subjects or topics demonstrate the most effective integration with this model?
- What pedagogical methodologies predominantly characterize studies on PjBL in physics instruction, and how do these approaches capture the complexity of student learning outcomes?
- Based on the synthesized findings, what are the primary implications for instructional practice to optimize the application of the PjBL model in diverse classroom settings?
- What critical gaps and emerging opportunities exist in the current literature that should define the future research directions for the advancement of the PjBL model in science education?

METHODS

This research constitutes a literature review focused specifically on the Project-Based Learning (PjBL) model within the context of physics and science instruction. The sources considered were exclusively derived from physics and science education journals indexed in the Science and Technology Index (SINTA), specifically within the SINTA 2, SINTA 3, and SINTA 4 categories. SINTA is the official platform developed by the Ministry of Research, Technology, and Higher Education of the Republic of Indonesia (accessible at: https://sinta.kemdikbud.go.id/journals), which is utilized for monitoring scientific and technological progress. Following a rigorous identification process, 15 journals were deemed relevant and aligned with the scope of this study. The analyzed articles were published over the last ten years (2015–2025) and unanimously discussed the implementation of the PjBL model in science learning. From these 15 reputable national

journals, a total of 82 articles were retrieved, with the detailed breakdown presented in Figure 1.

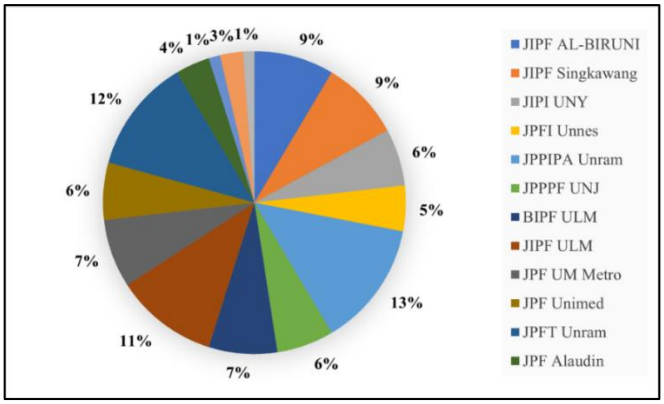

Figure 1 Distribution of article sources

The systematic literature review model employed in this research adheres strictly to the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) framework, complemented by specific inclusion and exclusion criteria established by the researchers. The selection of articles for review was based on rigorous criteria: all included articles were required to be indexed in the SINTA database, their content must specifically discuss the Project-Based Learning (PjBL) model within science instruction, and they must be published strictly in the form of a journal article (excluding publications in conference proceedings). Additionally, all selected articles had to be open access and fully accessible. The detailed stages of this article selection process, utilizing the PRISMA methodology, are visually presented in Figure 2.

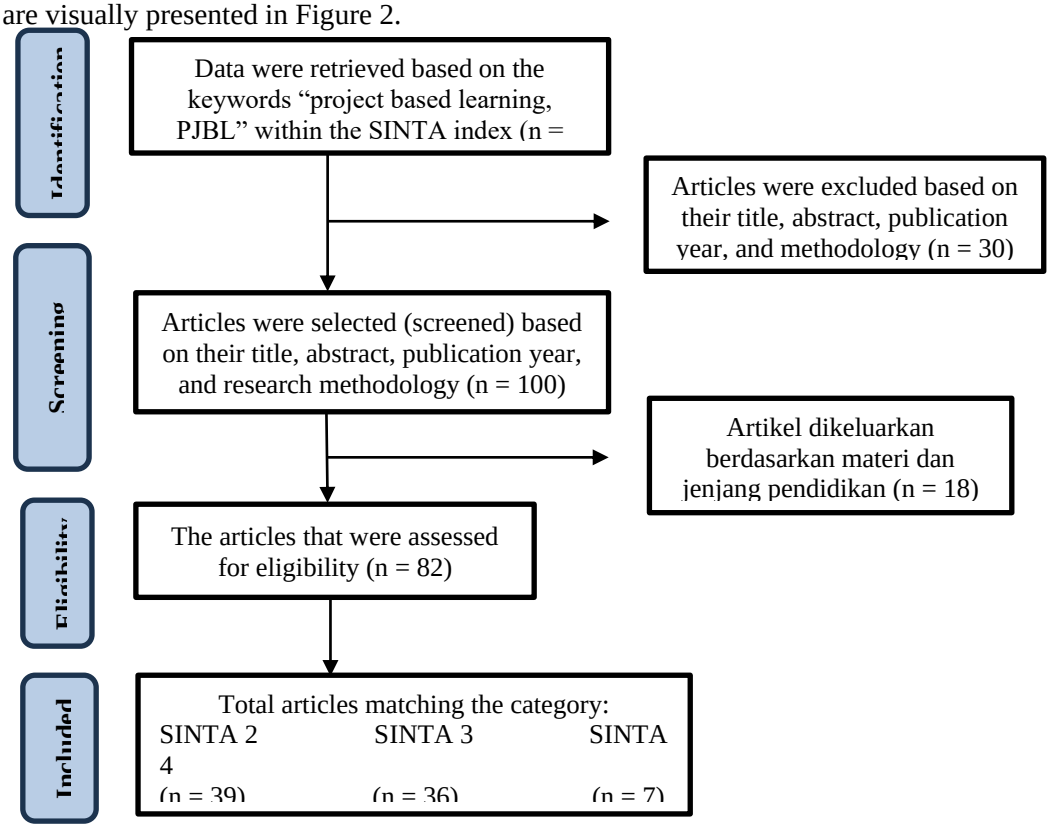

Figure 2 Article selection process using the PRISMA method

Information derived from all reviewed articles was managed and analyzed based on specific indicators that met the criteria defined by the researchers. These indicators included year of publication, research design, study subjects, topic focus, methodology, education level, and key study findings. To analyze the correlation between the article titles and abstracts, the VOSviewer software was utilized. Conversely, the remaining indicators were analyzed using manual descriptive analysis. The resulting analytical data are subsequently represented in tables, as well as line and bar diagrams for visualization.

RESULT AND DISCUSSION

Initially, the literature search yielded 16 journals and a total of 85 articles deemed relevant to the discussion of the Project-Based Learning (PjBL) model within the context of physics and science instruction. Following a rigorous screening phase and adaptation to the specific inclusion criteria focusing on science learning studies, the number of journals meeting the established criteria remained at 15, covering a total of 82 relevant articles. The comprehensive list of articles that successfully passed this selection process is presented in Table 1.

Table 1 Articles meeting the specified criteria

No	Author	Journal
1	Rachmawati et al. (2023)	IPF Unesa
2	Putri & Dwikoranto (2022)	IPF Unesa
3	Sahid et al. (2024)	JPI Lensa UNM
4	Astuti et al. (2024)	ORBITA: Jurnal Pendidikan dan Ilmu Fisika
5	Asrar & Z (2024)	JPF UIN Alaudin Makassar
6	Nailufari et al. (2024)	JPF UIN Alaudin Makassar
7	Swandi et al. (2022)	JPF UIN Alaudin Makassar
8	Ramadhani et al. (2023)	Berkala Ilmiah Pendidikan Fisika
9	Sambite et al. (2019)	Berkala Ilmiah Pendidikan Fisika
10	Ananda & Johari (2024)	Berkala Ilmiah Pendidikan Fisika
11	Venalia et al. (2022)	Berkala Ilmiah Pendidikan Fisika
12	Damayanti et al. (2023)	Berkala Ilmiah Pendidikan Fisika
13	Munawarah et al. (2023)	Berkala Ilmiah Pendidikan Fisika
14	Rahmawati et al. (2021)	JIPF ULM
15	Nida et al. (2021)	JIPF ULM
16	Erin et al. (2020)	JIPF ULM
17	Dwiyanti (2020)	JIPF ULM
18	Kurniasih (2021)	JIPF ULM
19	Pujaningsih & Arunde (2022)	JIPF ULM
20	Octapera & Mahtari (2024)	JIPF ULM
21	Luh et al. (2023)	JIPF ULM
22	Intan et al. (2025)	JIPF ULM
23	Sodikin et al. (2014)	JPF UM METRO
24	Lili et al. (2025)	JPF UM METRO
25	Riswanto et al. (2024)	JPF UM METRO
26	Sumo & Kholida (2025)	JPF UM METRO
27	Ningsih et al. (2023)	JPF UM METRO
28	Putri et al. (2020)	JPF UM METRO
29	Dinamis et al. (2020)	JPF UNIMED
30	Dwi et al. (2020)	JPF UNIMED
31	Simanjuntak et al. (2023)	JPF UNIMED
32	Mahulae et al. (2023)	JPF UNIMED
33	Kurnia et al. (2024)	JPF UNIMED
34	Nurwahyuningsih et al. (2019)	JPFT UNRAM
35	Nurdiansah et al. (2021)	JPFT UNRAM

36	Karuniawati et al. (2021)	JPFT UNRAM
37	Lumbantobing et al. (2022)	JPFT UNRAM
38	Wahono et al. (2021)	JPFT UNRAM
39	Made et al. (2016)	JPFT UNRAM
40	Berliana et al. (2024)	JPFT UNRAM
41	Hasani et al. (2024)	JPFT UNRAM
42	Maemum & Ardhuha (2025)	JPFT UNRAM
43	Baharuddin & Setiawan (2024)	JPFT UNRAM
44	Rizki et al. (2022)	JIPF Al-Biruni
45	Kaniawati et al. (2021)	JIPF Al-Biruni
46	Yulianti & Masiroh (2024)	JIPF Al-Biruni
47	Mukti et al. (2020)	JIPF Al-Biruni
48	Saputro (2019)	JIPF Al-Biruni
49	Erlangga et al. (2024)	JIPF Al-Biruni
50	Anugrah et al. (2023)	JIPF Al-Biruni
51	Husin & Raddhin (2023)	JIPF Singkawang
52	Wibowo & Ahmad (2023)	JIPF Singkawang
53	Yennita et al. 2022)	JIPF Singkawang
54	Swandi et al. (2022)	JIPF Singkawang
55	Saefullah et al. (2021)	JIPF Singkawang
56	Sekarningrum et al. (2025)	JIPF Singkawang
57	Sumo et al. (2024)	JIPF Singkawang
58	Panigrahi & Hanum (2024)	JIPI UNY
59	Afriana et al. (2016)	JIPI UNY
60	Maolida et al. (2024)	JIPI UNY
61	Imron et al. (2025)	JIPI UNY
62	Subekti et al. (2025)	JIPI UNY
63	Zhauna et al. (2024)	JPFI UNNES
64	Paminto et al. (2023)	JPFI UNNES
65	Nurdiansah et al. (2024)	JPFI UNNES
66	Khaeruddin et al. (2023)	JPFI UNNES
67	Pratama et al. (2023)	JPIPA UNRAM
68	Syukri et al. (2021)	JPIPA UNRAM
69	Luh et al. (2023)	JPIPA UNRAM
70	Paramita & Fitria (2025)	JPIPA UNRAM
71	Setyani et al. (2024)	JPIPA UNRAM
72	Husna (2025)	JPIPA UNRAM
73	Sholehuddin & Wilujeng (2025)	JPIPA UNRAM
74	Zahirah (2024)	JPIPA UNRAM
75	Yolanda & Yolanda (2025)	JPIPA UNRAM
76	Puspitaningrum et al. (2025)	JPIPA UNRAM
77	Sujud et al. (2024)	JPIPA UNRAM
78	Rohman et al. (2022)	JPPPF UNJ
79	Astri et al. (2022)	JPPPF UNJ
80	Ilma et al. (2024)	JPPPF UNJ
81	Lisa & Efwinda (2024)	JPPPF UNJ
82	Ellianawati et al. (2024)	JPPPF UNJ

The connection among the reviewed articles was determined through a co-occurrence analysis of keywords found within the titles and abstracts. The exclusion process was governed by rigorous criteria to maintain the analytical integrity of the review. Studies were systematically omitted if they were published outside the 2015–2025 period or originated from journals beyond the SINTA 2, 3, and 4 classifications. Furthermore, articles exhibiting a scope mismatch, particularly those not specifically addressing the PjBL model within

science or physics education, were disqualified. Methodological grounds for exclusion included non-peer-reviewed proceedings, incomplete manuscripts, and studies lacking transparent research designs. Ultimately, any literature failing to align with the predefined educational variables was excluded to ensure a high-quality synthesis of the final 82 articles. The results of this clustering analysis are visually represented in Figure 3.

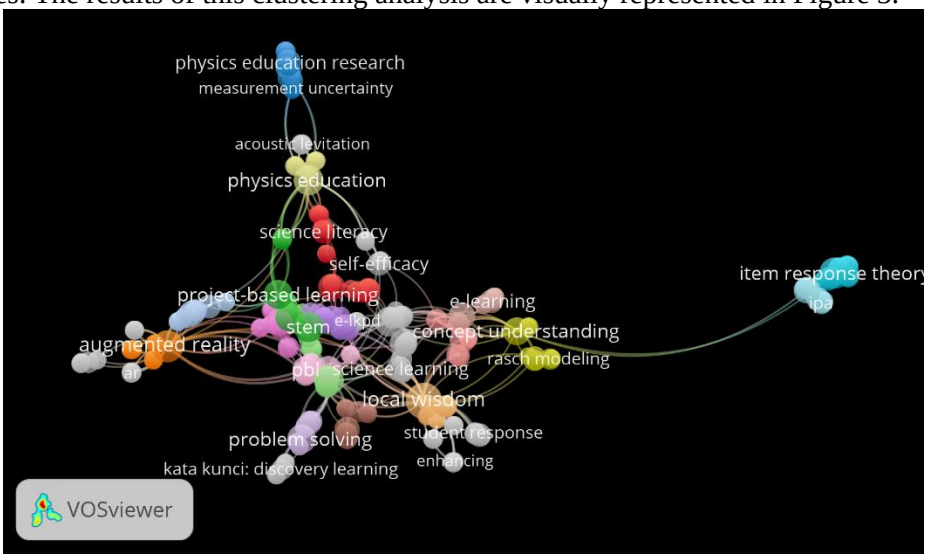

Figure 3 VOSviewer screenshot showing word co-occurrence network

The density map visualization using VOSviewer is shown in Figure 4.

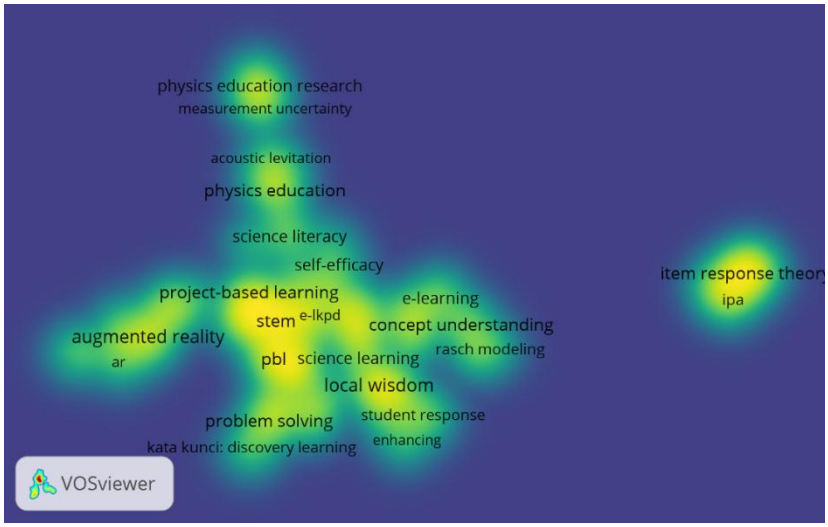

Figure 4 VOSviewer visualization of the density map

The density map analysis visualized in Figure 4 indicates that the most significant research trends are concentrated on the integration of the Project-Based Learning (PjBL) model with the STEM approach and the utilization of digital technology (e.g., Augmented Reality or AR). The primary focus of these studies is consistently aimed at enhancing students' thinking skills, problem-solving abilities, and other learning outcome variables, such as scientific literacy and students' self-efficacy in the context of science education. Furthermore, these investigations also show a keen interest in the development of digital learning tools (such as e-learning platforms and e-student worksheets/e-LKPD) and the use

of sophisticated evaluation methods, including Item Response Theory (IRT), to ensure measurement validity. This underscores a strong research focus on innovative implementation supported by reliable assessment.

The visual mapping results of the titles and abstracts, which were presented in Figure 4 using the VOSviewer software, were subsequently substantiated by an in-depth analysis of the full content of each article. This process of re-identification and detailed review aimed to comprehensively describe the research trends based on several indicators: year of publication, type of study, research subject, research variables, methodology, learning materials (topics), and educational level relevant to the implementation of the PjBL model in science instruction.

Number of Publications

The total number of published articles serves as a strong indicator of the intensity of research dedicated to a specific topic. As illustrated in Figure 5, research concerning the PjBL model in physics and science within Indonesia spanned the period from 2015 to 2025. A remarkable surge in publications was observed in 2024, when the article count reached its highest point with 25 publications. This sharp increase reflects a growing enthusiasm among researchers to deeply explore the PjBL model within the field of science education. Nevertheless, a subsequent reduction in the quantity of recorded publications occurred in the following year.

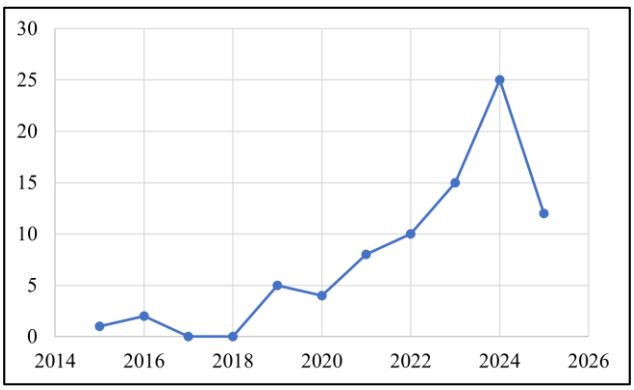

Figure 5 Distribution of publication years

Prevalent in the surrounding environment, based on a systematic analysis of 82 articles published between 2015 and 2025, the research landscape is predominantly characterized by quantitative approaches (52.5%), specifically utilizing quasi-experimental and Research and Development (R&D) designs. The pedagogical focus is significantly concentrated on the senior high school level, with primary thematic areas encompassing fluid dynamics and renewable energy. Furthermore, publication trends reached a peak in 2024, with a primary scholarly orientation toward the enhancement of higher-order thinking skills, particularly focusing on creative thinking (25%) and critical thinking (17%) within the domain of science education.

The primary motivation underpinning the majority of studies is a direct response to contemporary issues that carry significant social relevance (Daeng Naba et al., 2024; Gargani et al., 2022; Murni & Suprapto, 2023). One of the most prominent current pedagogical challenges is the consistently low level of students' thinking skills in Indonesia, often attributable to the misalignment or insufficient optimization of learning models applied in the classroom (Gurdi et al., 2025; Swandi et al., 2021). Therefore, scientific research is regarded as a vital instrument for addressing such persistent problems. Through rigorous investigation, academics can successfully identify the most effective

pedagogical strategies and learning media, particularly those associated with the Project-Based Learning (PjBL) model, to significantly enhance students' thinking skills (Agustira et al., 2025; Batubara et al., 2023; Sari et al., 2025). Accordingly, the increasing volume of publications focused on the PjBL model is expected to provide a substantive contribution toward the transformation of the Indonesian education system. This perspective aligns with the core mission of research: to provide an informative foundation and support efforts for the improvement of current educational practices.

Type of Research

The primary focus of a research study is often fundamentally determined by the specific type and design of the study applied. Table 2 indicates that the quantitative approach constitutes the predominant methodology utilized by researchers investigating the Project-Based Learning (PjBL) model within the context of physics and science. This is evidenced by 43 articles, which represents 52.5% of the total reviewed publications, having employed the quantitative method. This finding is consistent with prior studies that also reported a tendency among researchers to favor quantitative designs in the field of education, particularly in physics and science education, compared to other approaches (Setiawan & Musaffak, 2021; Nabilah & Jumadi, 2022). Consequently, this preference for the quantitative methodology within the context of physics and science education research is both clear and highly relevant.

Table 2 Distribution of PjBL model research articles in science education based on research methodology

Research Method	(n)	Percentage
Quantitative	43	52.5%
R & D	28	34%
Qualitative	9	11%
Mix Method	2	2.5%
Total	**82**	**100%**

In addition to identifying the type of study employed, this research also aimed to delineate the distribution of specific research designs selected by academics, as presented in Table 3. The table clearly shows that the quasi-experimental design is the most dominant choice, encompassing 27 published articles. This design allows researchers to effectively compare the most successful treatment interventions aimed at enhancing students' thinking skills through the Project-Based Learning (PjBL) model (Nurkanti et al., 2025; Sari et al., 2025; Suharsono et al., 2025). This finding aligns with previous studies asserting that quasi-experimental designs are frequently utilized in educational contexts to assess the effectiveness of pedagogical interventions (Abraham & Supriyati, 2022; Al-Buraiki et al., 2025). Thus, this approach provides significant insights into the causal impact of the treatment on student learning outcomes.

Table 3 Distribution of PjBL model research articles in science education based on research design methodology

Research Method			(n)
Quantitative	Experimental	Quasi Experiment	27
		Pre-Experiment	6
		Experiment	9
	Non-Experimental	Descriptive Quantitative	1
Qualitative		Descriptive Qualitative	6
		Qualitative and Action Research (CAR)	3

Research Method		(n)
R & D	R&D	13
	R&D ADDIE	10
	R&D 4D	2
	R&D Borg & Gall	2
	R&D Rowntree	1
Mixed Method	Embedded Design	2
Total		82

Research Subjects

Researchers require the categorization of educational levels for study subjects to validate their hypotheses. As clearly observed in Figure 6, high school students (SMA) constitute the most frequently selected group as research subjects. This finding aligns with previous studies that similarly reported the prevalence of high school students in research samples (Chen et al., 2023; Mugendi et al., 2024; Rushton et al., 2021). Conversely, the primary school (SD) and university (higher education) levels were the least frequently utilized educational stages. This phenomenon reflects earlier findings which positioned the keyword "students" as one of the most frequently searched terms in educational research. The selection of student subjects is often prioritized due to their close association with the contextual educational problems under investigation (Güth & van Vorst, 2024).

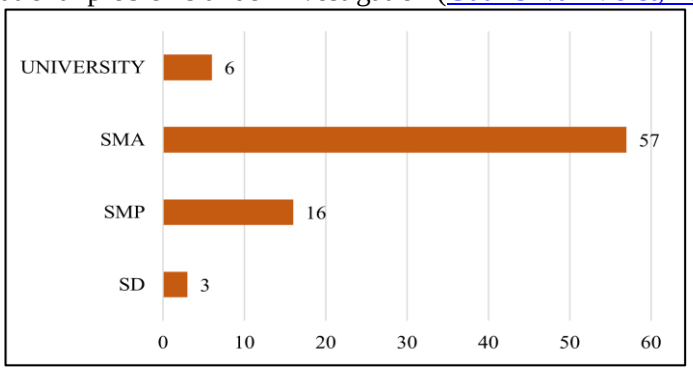

Figure 6 Distribution of PjBL model research articles in physics and science instruction by educational level

Figure 6 not only visualizes the comparative distribution of research subjects across primary, junior high, senior high, and university levels but also reveals a significant trend: a considerable concentration of studies at the Senior High School (SMA) level. This tendency strongly suggests that the central focus of current educational research on the PjBL model is heavily centralized at the SMA level. This pattern is theoretically associated with several factors, including the accessibility of the student population, the subjects' cognitive maturity, and the measurability of the transitional curriculum at this stage (Muhtar et al., 2025; Suyono et al., 2025; Wibowo & Ahmad, 2023). Notwithstanding this concentration, the selection of research subjects within the SMA level itself is often restricted to Grade X and Grade XI. Prior studies indicate that restrictive school policies, particularly as the academic year approaches final examination periods, frequently serve as a significant limiting factor in subject selection, especially for Grade XII students (Deng & Zhang, 2025; Leeds & Mokher, 2022).

Science Topics Selected in the Studies

Science learning is often perceived as an arduous subject and is frequently reported as less engaging for students. The difficulty experienced by learners in internalizing concepts

constitutes a central issue in educational research (Anastasiou, 2024; Ursachi et al., 2025). Based on Table 4, the material concerning Fluids (Static and Dynamic) was found to be the most frequently selected research topic, totaling nine published articles. The analysis of Table 6 suggests that Fluids likely serve as a primary focus due to a significant gap between the level of student mastery and curriculum demands. This finding is substantiated by previous research affirming the suitability of the PjBL model for Fluid topics (Alnaimat & Mathew, 2025; Kim & Wootton, 2021). Furthermore, the topics of Work and Energy, Renewable Energy, and Waves also drew notable attention from researchers, each contributing seven articles that applied the PjBL model. This pattern reflects a continuous effort to develop more effective pedagogical strategies to overcome the challenges encountered by students.

Table 4 Distribution of research articles on creative thinking skills in physics based on research topic

Science Material	n
Static and Dynamic Fluids	9
Work and Energy	7
Renewable Energy	7
Vibration and Waves	7
Changes in the State of Matter	6
Optics	6
Dynamic Electricity	5
Temperature and Heat	5
Thermodynamics	3
Global Warming	2
Linear Motion and Circular Motion	2
Momentum and Impulse	2
Structure and Layers of the Earth	2
Environmental Pollution	2
Ecology and Biodiversity	3
Solar System	2
Physics Learning Multimedia	2
Newton's Laws	1
Electrostatics	1
Astronomy	1
Applied Physics	1
Electronics	1
Projectile Motion	1
Elasticity and Hooke's Law	1
Basic Physics 1	1
Simple Harmonic Motion	1
Measurement	1
Total	**82**

Research Variables in the Literature Study

The review of the PjBL model in science education (2015–2025) demonstrates that the research variables are highly concentrated on higher-order cognitive aspects and 21st-century skills. Data presented in Table 5 indicate that the variable Creative Thinking Skills predominates with a proportion of 25% (n=19), closely followed by Critical Thinking Skills at 17% (n=13), and Scientific Literacy Skills at 14% (n=11). This suggests that researchers consistently view PjBL as a highly effective model for stimulating students' capacity to generate novel ideas, logically analyze information, and apply scientific knowledge in real-world contexts. This focus is aligned with the core objectives of PjBL, which emphasize deep inquiry processes and the solution of complex problems, naturally demanding the

activation of these thinking skills (Al-Busaidi & Al-Seyabi, 2021; Eswaran, 2024). The variables Learning Outcomes and Science Process Skills also hold significant importance, contributing 12% and 11%, respectively. This further reinforces the perspective that PjBL is considered effective not only in terms of the final product but also in the mastery of scientific methodology (Mutanga, 2024; Rohman et al., 2024).

Table 5 Distribution of research variables in the PjBL model within science education

Research Variables	n	%
Creative Thinking Skills	19	25%
Critical Thinking Skills	13	17%
Scientific Literacy Skills	11	14%
Learning Outcomes	10	12%
Science Process Skills	9	11%
HOTS (Higher-Order Thinking Skills)	4	5%
Analytical Ability	2	2%
Experimental Ability	2	2%
Laboratory Simulation	1	1%
Learning Motivation	1	1%
Improvement of Teaching Materials	1	1%
Collaboration and Problem-Solving Skills	1	1%
Self-Learning Ability	1	1%
Communication Skills	1	1%
Misconceptions	1	1%
Laboratory Equipment	1	1%
Digital Literacy	1	1%
Scientific Problem-Solving Ability	1	1%
Learning Interest	1	1%
Development of Laboratory Apparatus	1	1%
Total	**82**	**100%**

Other research variables exhibited a much more dispersed and minority distribution, yet still provided crucial insights into the multi-faceted impact of PjBL. Higher-Order Thinking Skills (HOTS) appeared in only 5% (n=4) of the studies, which can be interpreted as the variable often being represented implicitly or integrated within more specific variables like creative and critical thinking. Meanwhile, variables such as analytical ability, experimentation skills, collaboration and problem-solving skills, learning motivation, digital literacy, and learning interest each appeared only 1% (n=1). The presence of non-cognitive variables like motivation and learning interest indicates that while the main focus remains on cognitive outcomes, there is an acknowledgment of PjBL's role in shaping students' attitudes and affect toward science, even if the research proportion is currently very small (Chhabra & Gawande, 2025; Salazar-Tabima, 2025). The focus on these minority variables underscores the great potential of PjBL as a holistic intervention but also suggests underexplored areas (e.g., the impact on affective and psychomotor aspects) that can serve as recommendations for future research.

CONCLUSION

This Systematic Literature Review (SLR) analyzed the trends in the utilization of the Project-Based Learning (PjBL) model within science education in Indonesia from 2015 to 2025, based on a total of 82 national articles indexed in SINTA 2, SINTA 3, and SINTA 4. The publication trend demonstrated a significant increase, peaking in 2024 with 25 articles. Methodologically, the primary focus of the research was on enhancing higher-order skills, where the most dominant problem variable investigated was creative thinking skills, with the highest percentage of 25% (n=19), closely followed by critical thinking skills (17% or

n=13). The studies were overwhelmingly dominated by the quantitative approach (52.5%, or 43 articles), with the quasi-experiment being the most frequently employed design (27 articles). Research subjects predominantly focused on senior high school students (57 articles), and the material most frequently integrated with the PjBL model was fluids (static and dynamic) (9 articles). Furthermore, the VOSviewer analysis revealed an innovative trend integrating PjBL with the STEM approach and digital technology such as augmented reality (AR), aiming to specifically boost problem-solving and science literacy skills. While providing a clear overview of current trends, this study is limited by the predominance of quantitative methodologies and a concentration on specific topics, which restricts a deep exploration of student learning processes across various educational levels. Nevertheless, these findings offer vital implications, serving as a strategic roadmap for researchers to investigate more complex physics concepts and providing a robust empirical foundation for educators to implement innovative learning models aimed at strengthening classroom instruction.

CONFLICTS OF INTEREST

The authors declare that there is no conflict of interest.

AUTHOR CONTRIBUTIONS STATEMENT

Conceptualization, supervision, and consultation were conducted by Heru Kuswanto; methodology and writing—original draft preparation were carried out by Kharisma Sulistya Akhmadi; and formal analysis was performed by Suldaeng. All authors have made significant contributions to the research and the preparation of this manuscript.

AI DISCLOSURE STATEMENT

The authors used ChatGPT during the preparation of this work for language refinement and editing purposes. After using this tool, the authors thoroughly reviewed and revised the content as necessary and take full responsibility for the final version of the manuscript.

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