

The Effect of Project-Based Learning on Science Learning Outcomes in Elementary Schools: A Systematic Literature Review

Lulu Dwi Lestari ^{a, 1}, Eka Fajriyani ^{a, 2}, Kafita Risma Kamelia ^{a, 3},
Mey Prihandani Wulandari ^{a, 4}, Mawan Akhir Riwanto ^{a, 5}

^a Universitas Nahdlatul Ulama Al Ghazali, Cilacap, Indonesia

¹ luludwilestari985@gmail.com, ² fajriyanieka@gmail.com, ³ kafifafitaa@gmail.com,
⁴ meyprihandani@unugha.id, ⁵ mawan.pgds@unugha.id

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ABSTRACT

Science learning in elementary schools is expected to develop students' knowledge, scientific skills, and attitudes while fostering 21st-century competencies. However, conventional instructional approaches continue to limit students' science learning outcomes, highlighting the need for more student-centered learning models such as Project-Based Learning (PjBL). This study aims to systematically synthesize empirical research on PjBL in elementary school science learning by examining the patterns of science learning outcomes, research design and sample characteristics, implementation characteristics, and research trends. A Systematic Literature Review (SLR) was employed following the stages proposed by Triandini et al. Articles were retrieved from Google Scholar using the Publish or Perish software with the search period limited to publications from 2017 to 2026. A total of 105 articles were identified and screened using predetermined inclusion criteria, resulting in 20 eligible studies for qualitative synthesis. The findings show a consistent positive pattern in science learning outcomes, with empirical studies generally reporting an increase after the implementation of PjBL. The research base was dominated by quasi-experimental studies (45%), followed by Classroom Action Research (30%) and experimental studies (20%), which showed a strong emphasis on intervention-based research. In the studies reviewed, PjBL was applied to a wide range of science topics and grade levels, and was often supported by authentic learning media and project activities. However, sample sizes vary widely, ranging from 14 to 124 students, and most studies are conducted in specific classroom or school contexts, thus limiting the generalization ability of findings. Overall, the available evidence supports the potential of PjBL in improving science learning outcomes in primary education, while also showing that current research is still dominated by an effectiveness orientation and focus on the classroom scope.

Keywords: Learning Models, Learning Outcomes, Project Based Learning, Science



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Corresponding Author:

Mey Prihandani Wulandari, Universitas Nahdlatul Ulama Al Ghazali

meyprihandani@unugha.id

INTRODUCTION

Education is a key factor in the process of shaping a person's character to be of higher quality [1], [2]. Basically, education is the key to developing the abilities and potential that exist within each individual, by providing knowledge, various skills, and teaching values to face various challenges in life [3]. Education is not only a means of transferring knowledge, but also teaches how to form good personality and character [4]. Character education has been integrated into all subjects in elementary schools, which contain various character values and integrate them into the material. Additionally, education in the 21st century emphasizes six (6) essential skills, commonly referred to as the 6C's, critical thinking, creativity, collaboration, communication, character, and citizenship. If elementary school students can master these 6C skills, it will certainly be very helpful for their future lives in facing global [5]. One of the subjects that can integrate these 6C skills is science education.

In science education, students can acquire various knowledge to understand their environment, develop the ability and attitude to adapt to and change their environment [1]. Science education in elementary schools under the National Education Ministry's Curriculum for Educational Units states, "Science is a way of finding out about nature, so it is not just about mastering knowledge in the form of facts, concepts, or principles, but also about the process of discovery" [6]. Science has three main dimensions: products, which consist of existing facts; processes, which involve various scientific methods in producing science; and scientific attitudes.

Science is one of the most complex subjects, and its learning process often presents unique challenges compared to other subjects. Research conducted by [7] shows that the average score for science in six elementary schools in the Pangeran Diponegoro cluster was 66.8, with several issues arising, such as the use of traditional teaching methods or approaches. In the teaching and learning process, the learning approach is one of the important aspects. There are many approaches that can be applied in the teaching and learning process at school to achieve learning objectives, including strategies, learning methods, and pedagogical approaches tailored to students' needs [8].

The activities carried out by students in the teaching and learning process are one of the behaviors of students in learning. The changes in behavior caused by learning are referred to as learning outcomes. Nana Sudjana (2009) [9] states that student learning outcomes are changes that occur in behavior, encompassing cognitive, affective, and psychomotor aspects. Learning outcomes are one of the important processes in learning. One way to improve student learning outcomes is by using an interactive and enjoyable learning model. One such model is Project-Based Learning.

Project-Based Learning emerges as an innovative approach/learning model to enhance critical thinking skills in students, requiring interdisciplinary knowledge, collaboration among students as a team, and creative problem-solving [10]. Project-based learning is a learning model that uses projects as its medium and centers on students conducting investigations into a topic [6]. According to Wena in [11] through project-based learning, students can engage in long-term activities where they design, create, and present their products. By focusing on the principles and core of the discipline, it provides students with the opportunity to seek knowledge on their own, ultimately producing tangible products. To succeed in project-based learning, students must take responsibility for the process by setting goals, monitoring, reflecting, and maintaining their motivation to avoid a decline from the start of the project until its completion [12]. Another effective way to achieve PjBL is to encourage students to participate more in the teaching and learning process by involving them in real-world tasks and solving problems collaboratively [13]. The learning environment is designed with the aim of supporting independent learning to increase students' sense of responsibility [14]. The Project

Based Learning model makes the teaching and learning process more active, because students are directly involved in solving the problems that have been presented and make learning more meaningful so that later the students' learning outcomes will improve.

Research on the implementation of Project-Based Learning (PjBL) in science education has expanded rapidly, aiming to enhance the quality of the learning process, understanding of scientific concepts, critical thinking skills, collaboration, creativity, scientific literacy, and learning outcomes. Integrating PjBL into student-centered instruction also frequently aims to foster 21st-century skills, thereby encouraging active student participation. Various studies indicate that PjBL has been widely adopted as an instructional model in primary school science education. However, existing empirical evidence remains fragmented across various aspects—such as learning outcomes, learning contexts, project characteristics, and research designs. Consequently, although numerous studies have reported the positive impact of PjBL, the overall pattern of evidence regarding its implementation and effectiveness in primary school science education remains unclear.

Previous research has largely examined the effectiveness of PjBL through individual classroom-level experiments. While such studies provide valuable evidence at the classroom level, they are limited in their ability to explain broader patterns emerging across various studies. In particular, there is a lack of synthesis regarding how PjBL is implemented in primary school science education, the learning outcomes most frequently investigated, the research designs and assessment approaches employed, and the trends characterizing the empirical literature over time. Furthermore, existing literature has not provided a comprehensive synthesis specifically focusing on empirical studies of PjBL in primary school science education published between 2017 and 2026. This gap makes it difficult to determine whether the reported benefits of PjBL reflect consistent patterns across studies or are instead influenced by specific learning contexts and implementation characteristics.

To address this gap, this systematic literature review synthesizes empirical research on the implementation of Project-Based Learning (PjBL) in primary school science education, covering studies published between 2017 and mid-2026. Unlike studies examining PjBL within the context of a single classroom, this review integrates evidence from various empirical studies to identify patterns in learning outcomes, research designs, implementation characteristics, and research trends. This review contributes to the literature by presenting a focused synthesis of PjBL implementation specifically in primary school science education, thereby offering a broader evidence base for understanding how PjBL contributes to students' science learning outcomes and how the method is applied across diverse research contexts. The findings are expected to provide evidence-based implications for teachers, researchers, and future studies regarding the implementation and development of PjBL in primary school science education. Consequently, this study aims to systematically synthesize empirical evidence concerning the implementation and effects of Project-Based Learning on science learning outcomes in primary schools during the 2017–2026 period.

Therefore, this systematic literature review aims to synthesize empirical evidence regarding the implementation of Project-Based Learning (PjBL) in primary school science education, covering studies published between 2017 and 2026. Specifically, the review seeks to answer four research questions: (1) What patterns of science learning outcomes have been reported following the implementation of PjBL in primary school science education? (2) What research designs and sample characteristics typify empirical studies on PjBL in primary school science education? (3) What are the key characteristics of PjBL implementation in primary school science education? and (4) What research trends can be identified in empirical studies on PjBL in primary school science education published between 2017 and 2026? By addressing these questions, the review presents a systematic synthesis of reported learning outcomes,

methodological characteristics, implementation patterns, and research directions for PjBL, thereby identifying the current state of evidence and areas requiring further research.

METHOD

This study employed a Systematic Literature Review (SLR) approach. This method is carried out by reviewing and processing existing and published scientific sources or works by identifying, examining, evaluating, and interpreting available research. The researcher also conducted a review of articles relevant to the topic under discussion, systematically and structurally for each process according to the predetermined stages [15]. The Systematic Literature Review (SLR) technique was carried out in five stages, namely: (1) formulating research questions, (2) determining and searching for articles relevant to the research theme, (3) conducting inclusion and exclusion by sorting the collected articles, (4) presenting and processing data, (5) interpreting the findings in the articles and drawing conclusions.

The first step taken was to determine the theme to be studied. The literature search employed the following search string: ("project-based learning" OR "project based learning" OR PjBL) AND (science OR "science education" OR "science learning" OR biology OR physics OR chemistry) AND ("elementary school" OR "primary school" OR "elementary education" OR "primary education"). Articles were retrieved from Google Scholar using the Publish or Perish (PoP) software on July 4, 2026. The search was limited to articles published between 2017 and 2026. The literature search identified 105 records from Google Scholar using Publish or Perish. After removing 18 duplicate records, 87 records remained for title and abstract screening. During the screening stage, 52 records were excluded because they did not meet the inclusion criteria. Subsequently, 35 full-text articles were assessed for eligibility. After full-text review, 15 articles were excluded for not fulfilling the predefined eligibility criteria. Finally, 20 studies were included in the literature review.

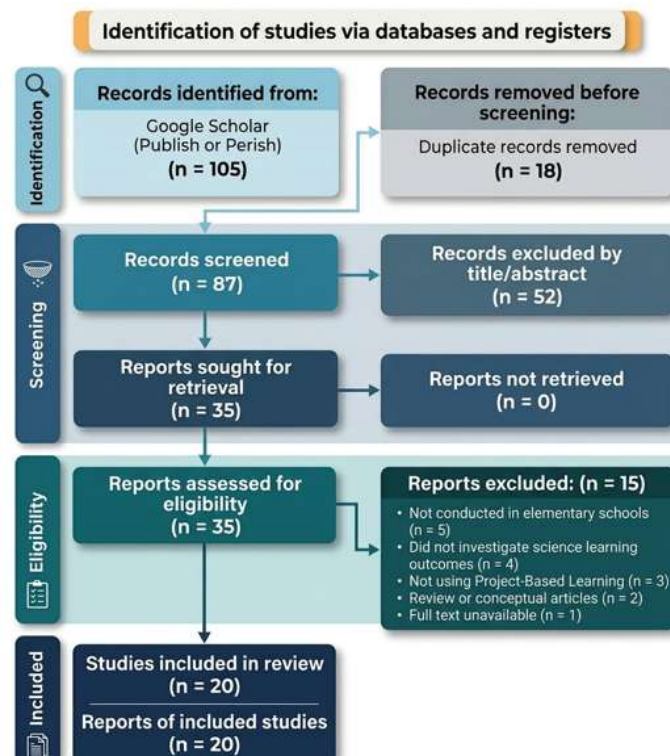


Figure 1. PRISMA flow diagram of the study selection process

The selected articles were analyzed using qualitative content analysis by identifying research objectives, participants, implementation of Project-Based Learning, and reported science learning outcomes. The findings were then synthesized descriptively to identify common patterns and trends across studies.

RESULTS AND DISCUSSION

Results

The results of research on the effect of project-based learning (PjBL) on student learning outcomes based on the Systematic Literature Review (SLR) method are presented in Table 1.

Table 1. Research Article The Effect of Project-Based Learning Models on Science Learning Outcomes in Elementary Schools.

No.	Research Title	Results	Reference Source	Types of research	Journal Qualification
1.	Keefektifan Model <i>Project Based Learning</i> Berbantu Multimedia <i>Power Point</i> Terhadap Hasil Belajar IPA	The project-based learning model is effective in improving the learning outcomes of fifth-grade students at SD Negeri 1 Pasar Banggi Rembang in science learning, with a higher average posttest score than the pretest score. This is reinforced by the t-test calculation, which yielded a t-value of 15.600 for learning outcomes and a t-table value of 2.023. Since t-value > t-table, this indicates that the t-test for learning outcomes is significant.	[11]	quasi-experiment	Sinta 3
2.	Penerapan Model <i>Project Based Learning</i> (PjBL) Untuk Meningkatkan Hasil Belajar IPAS Pada Siswa Kelas V Sekolah Dasar	The implementation of the Project-Based Learning (PjBL) model is effective in improving the learning outcomes of fifth-grade elementary school students in the IPAS subject, specifically regarding the topic of Indonesia's flora and fauna.	[16]	Classroom Action Research	Sinta 4
3.	Penerapan Model <i>Project Based Learning</i> (PjBL) Berbantuan Media <i>Wordwall</i> untuk Meningkatkan Hasil Belajar IPA Siswa Kelas V SDN 47 Dumbo Raya	The implementation of the media-assisted project-based learning model can improve the science learning outcomes of fifth-grade students at SD N 47 Dumbo Raya on the material of the human respiratory system. In cycle I, there was an increase of 7 students (39%) who achieved the minimum competency standard (KKM). In cycle II, there was an increase in student learning outcomes, with 14 students (78%) achieving the minimum competency standard (KKM).	[17]	Classroom Action Research	Sinta 4
4.	Pengaruh Model <i>Project Based Learning</i> Berbantuan Media Sederhana Terhadap Hasil Belajar IPA	There is an effect of the PjBL model assisted by simple media on the science learning outcomes of fifth-grade students at SDN 3 Kabila Bone on the topic of pure substances and mixtures, with an average initial score of 52.86	[18]	quasi-experiment	Sinta 4

No.	Research Title	Results	Reference Source	Types of research	Journal Qualification
	Siswa Di Kelas V SDN 3 Kabila Bone	increasing to an average of 87.14 on the posttest.			
5.	Pengaruh Penggunaan Model <i>Project Based Learning</i> Berbantuan Media <i>Wordwall</i> terhadap Hasil Belajar Siswa Sekolah Dasar pada Pembelajaran IPA	There is an effect of the use of the Project-Based Learning model assisted by Wordwall media on student learning outcomes in science education on the water cycle topic in Grade V at SDN 65 Kota Timur. The results show higher scores in the experimental class on the posttest with an average of 82.32, while the control class had an average score of 55.79.	[19]	quasi-experiment	Sinta 4
6.	Keefektifan Model <i>Project Based Learning</i> Berbantu Media Audio Visual Terhadap Hasil Belajar IPA Tema 2 Subtema 1 Di SD Negeri 4 Tambahrejo	The effectiveness of the Project-Based Learning model assisted by audio-visual media for fifth-grade students at SD Negeri 4 Tambahrejo can assist in the learning process, making it easier for students to understand the material, remember the material, and improve their learning outcomes. Based on the calculation results, the pretest scores showed an average of 49.62, and the posttest scores showed an average of 81.54, indicating an increase.	[20]	quasi-experiment	Sinta 4
7.	Meningkatkan Hasil Belajar IPA Menggunakan Model Pembelajaran <i>Project Based Learning</i> Siswa Kelas VI SD Negeri Gunung Sari II	Research on the Project-Based Learning model using PTK can improve student learning outcomes in science subjects. In cycle 1, only 4 students met the minimum competency standard (KKM), while 16 students did not meet the KKM. In cycle 2, there was a significant improvement, with 19 students meeting the KKM and only 1 student not meeting the KKM.	[21]	Classroom Action Research	Sinta 4
8.	Peningkatan Proses Dan Hasil Belajar IPA Menggunakan Model <i>Project Based Learning</i> di Kelas V Sdit Al-Akhyar Muara Bungo	The Project-Based Learning model applied to science education with the topic "Seeing Because of Light" can improve student learning outcomes, as evidenced by the research results using PTK in Cycle I at 73% with an average of 14.50, and in Cycle II, there was an increase to 95% with an average of 17.90. In each cycle, students experienced a 40% improvement in learning outcomes.	[22]	Classroom Action Research	Sinta 4
9.	Penerapan Model Pembelajaran <i>Project Based Learning</i> (PJBL) Terhadap Hasil Belajar Pada Mata Pelajaran	The PjBL model can improve student learning outcomes in higher grades (IV and V), with scores increasing from Cycle I to Cycle II, or from pretest to posttest scores showing a significant improvement.	[23]	Systematic Literature Review	Sinta 4

No.	Research Title	Results	Reference Source	Types of research	Journal Qualification
	IPA Siswa Di Sekolah Dasar				
10.	Meningkatkan Motivasi dan Hasil Belajar IPA dengan Menggunakan Model Pembelajaran <i>Project Based Learning</i> (PjBL)	In grade V of SD Negeri Gendongan 03 Salatiga, the implementation of the PjBL learning model in science education made learning more enjoyable, increasing student motivation and learning outcomes. The pre-cycle results showed only 40% completion, which increased to 62% in cycle I, and to 81% in cycle II, with 30 students completing the course and 7 students not completing it.	[24]	Classroom Action Research	Sinta 4
11.	Pengaruh Model Pembelajaran <i>Project Based Learning</i> terhadap hasil belajar IPA siswa kelas V Madrasah Ibtidaiyah Al-Munawwaroh Kota Tangerang	There was an impact on the science learning outcomes of fifth-grade students at MI AL-Munawwaroh by using the Project-Based Learning model, with the average posttest score of the experimental class being higher than that of the control class, namely 81.7 and 71.2 for the control class, and the t-test results obtained a hypothesis value of Sig. (2-tailed) of 0.00. The sig. $0.00 < 0.05$ indicates a significant difference in the average scores between the experimental and control groups.	[25]	Experiment	sinta 5
12.	Pengaruh Penggunaan Model Project Based Learning (PJBL) Terhadap Hasil Belajar IPA Siswa Kelas V SD Negeri 100 Palembang	The research results show that the average posttest score in the control group was 70.45, while the average in the experimental group was 83.04. This indicates that the PjBL learning model has an impact on the learning outcomes of fifth-grade students at SD Negeri 100 Palembang.	[26]	Experiment	Sinta 5
13.	Pengaruh Model Pembelajaran <i>Project Based Learning</i> Terhadap Hasil Belajar IPAS Kelas V SD Negeri 060938 Medan Tahun Pembelajaran 2023/ 2024	The PjBL learning model has an effect on student learning outcomes in the subject matter of ecosystem components and food chains in fifth grade at SD Negeri 06093 Medan Johor, with an average pretest score of 43.62 and an average posttest score of 81.96. When presented as a percentage, 28% of students did not achieve mastery, while 72% did.	[27]	quasi-experiment	Sinta 5
14.	Pengaruh Model Pembelajaran <i>Project Based Learning</i> (PjBL) terhadap Hasil Belajar IPA Kelas IV SD	The results of the study indicate that the PjBL model has an effect on student learning outcomes in grade IV at Epil Public Elementary School. The results in the control class, which used conventional learning, were lower than those in the experimental class, which used PjBL learning. The average	[28]	Experiment	Sinta 5

No.	Research Title	Results	Reference Source	Types of research	Journal Qualification
		posttest score in the experimental class was 95, while in the control class it was 76.			
15.	Model <i>Project Based Learning</i> Untuk Meningkatkan Kemampuan Berpikir Kreatif dan Hasil Belajar IPA Kelas V SD	The implementation of the project-based learning model has a positive effect on students' creative thinking skills and science learning outcomes in Grade V of Gugus 1 Elementary School in Busungbiu District, as evidenced by the results of the independent samples test and manova analysis.	[29]	quasi-experiment	Sinta 5
16.	Pengaruh Model Pembelajaran <i>Project Based Learning</i> Terhadap Peningkatan Hasil Belajar Siswa Materi IPA	The implementation of the Project-Based Learning model applied at SD Negeri 2 Gembonganmekar in the lesson plan for the material on changes in form can improve student learning outcomes, as seen from the control class with an average of 72.20 and the experimental class with an average score of 88.13.	[30]	quasi-experiment	Sinta 5
17.	Penerapan Model Pembelajaran <i>Project Based Learning</i> untuk Meningkatkan Hasil Belajar IPA pada Siswa Kelas V	The PjBL model can improve science learning outcomes on the topic of the life cycle of animals for fifth-grade students at SD Negeri Kemasan 01 in Polokarto District, with 16 students (69.57%) showing improvement in Cycle 1 and 21 students (91.0%) showing improvement in Cycle 2.	[9]	quasi-experiment	Sinta 5
18.	Keefektifan Model <i>Project Based Learning</i> Terhadap Keaktifan Dan Hasil Belajar IPA Kelas V SDN Sumberejo 2 Bonang	The Project-Based Learning model is effective in enhancing student activity and science learning outcomes for fifth-grade students at SD Negeri Sumberejo 2 Bonang Demak, as evidenced by a 20.31% increase in student learning outcomes and significantly higher student activity during the learning process using the Project-Based Learning model compared to the conventional model.	[31]	quasi-experiment	Sinta 5
19.	Pengaruh Model Pembelajaran <i>Project Based Learning</i> terhadap Pencapaian Hasil Belajar IPA Siswa Sekolah Dasar	There is a significant influence of the project-based learning model on the science learning outcomes of fifth-grade elementary school students at SDN 02 Kota Salak, Dharmasraya Regency, in Theme 8 Subtheme 1 with the theme "Our Environment as Our Friend," with a post-test score of 82.631, while the control class using the conventional approach scored 71.105.	[32]	quasi-experiment	Sinta 6
20.	Pengaruh Penerapan Model Pembelajaran <i>Project Based Learning</i> (PJBL)	There is an effect of the PjBL learning model on students' cognitive learning outcomes in the ecosystem material at the comprehension, application, and reasoning levels. This is evidenced by	[33]	quasi-experiment	Sinta 6

No.	Research Title	Results	Reference Source	Types of research	Journal Qualification
	terhadap Hasil Belajar Kognitif Siswa pada Mata Pelajaran IPA di Kelas V SD Negeri 5 Kota Bengkulu	the post-test scores being higher than the pre-test scores. There are 30 questions to measure students' learning outcomes, with 10 comprehension questions, 10 application questions, and 10 reasoning questions.			

Project-based learning is one of the learning models that falls under the scientific approach. Project-based learning is an innovative learning model that emphasizes contextual learning applied to complex learning activities, involving students who learn in groups to develop a project, report, or other experiments related to their learning material [9]. In this learning model, student involvement plays a crucial role, as students are encouraged to plan a project, design their own project plans, and prepare the tools and materials needed for project creation. The independent learning activities students undertake in creating projects are easier to understand compared to traditional lecture-based learning.

This learning model has many advantages [9], [32], namely: (1) increasing students' motivation to learn through project-based learning, (2) enhancing students' creativity and innovation in the learning process and problem-solving, (3) fostering positive collaboration among students, (4) cultivating scientific attitudes in students, (5) and enabling students to understand the material more quickly. The focus of project-based learning lies in the principles and concepts of the discipline, involving students in problem-solving through investigative activities and providing them with the opportunity to construct their own knowledge, which ultimately results in the creation of a product.

The implementation of the project-based learning (PjBL) model in teaching has a positive impact on students' creative thinking skills and significantly improves their learning outcomes [34]. This is because the syntax of this project-based learning model has several stages, as follows [28]: (1) the project determination stage, where the educator presents the topic, followed by a question and answer session with students regarding problem-solving solutions and how students find the right steps to solve them; (2) the project completion planning stage, where the educator divides students into several groups, and students discuss how to solve the problem; (3) the project implementation schedule preparation stage, the process of determining the steps and schedule for completing the project; (4) the project completion stage with teacher facilitation and monitoring, where the educator monitors student activity in the project completion process and the realization of problem-solving; (5) the project report and presentation stage, where the educator and students discuss the realization of the project, which can be used as material for future presentations; and (6) the project and project results evaluation stage, where educators provide guidance on the presentation process carried out by their students, reflect on the students' work, and draw conclusions based on the observation sheets filled out during the monitoring process throughout the project creation or problem-solving stages.

Some of the project activities carried out include creating projects on complete and incomplete metamorphosis in animals. In the science subject on food chains, students can be assigned the task of creating a mind map of the food chain with each ecosystem divided into groups, then discussing the concepts to be created. On the following day, students create the actual results of the determined concepts in the form of dioramas.

The use of the project-based learning model has been researched by previous researchers and has been proven to significantly improve student learning outcomes. Research conducted by Misra (2023) showed that the average learning outcomes of students improved in the post-

test with an average score of 84.44 compared to the pre-test with an average learning outcome of 66.11. Thus, there was a significant increase in the average learning outcome score of 18.33, representing a 27% increase. Research conducted by Rauf (2024), with 18 students as the research subjects at the beginning of the observation, showed that students' ability in science learning outcomes was still very low, with only 4 students achieving learning outcomes above the minimum competency standard. Rauf conducted research using classroom action research. In cycle I, there was an increase in 7 students (39%) who achieved the minimum competency standard, followed by cycle II, which saw an increase in 14 students (78%) achieving the minimum competency standard in learning outcomes. In line with the analysis of 20 research articles, all research results indicate a significant influence of the project-based learning model on students' learning outcomes.

Table 2. Percentage of Articles Based on the Type of Research

No	Types of researc	Number of articles	Percentage
1	Quasi-experiment	9	45%
2	Classroom Action Research	6	30%
3	Experiment	4	20%
4	Systematic Literature Review	1	5%

The distribution of research types shows that research on Project-Based Learning (PjBL) in science learning in primary schools is currently dominated by intervention-oriented studies, especially quasi-experimental research. Of the 20 studies analyzed, 9 studies (45%) used quasi-experimental design, making it the most frequently used research approach. These findings indicate that current research primarily focuses on testing the effectiveness or impact of PjBL on students' science learning outcomes by comparing learning outcomes before and after treatment. The relatively large proportion of quasi-experimental studies show that researchers generally position PjBL as a learning intervention whose effectiveness can be measured empirically through student learning outcomes.

Classroom Action Research (PTK) was the second most frequently used approach, covering 6 studies (30%), while experimental research included 4 studies (20%). Overall, quasi-experimental and experimental studies represented 65% of the included studies. This pattern further suggests that the existing evidence base is more oriented towards measuring the impact of PjBL than investigating broader aspects of its implementation. Of the 19 empirical studies on the data obtained, the sample size ranged from 14 to 124 students. Some studies used relatively small samples of 14, 18, and 20 students while few studies involved large samples. This significant variation suggests that the reported impact of Project-Based Learning is often derived from relatively specific classroom contexts, rather than from large and diverse samples that are representative of the primary school student population broadly. One Systematic Literature Review article in this dataset discusses the effectiveness of implementing PjBL, the research methods employed, and the classes involved; however, it does not yet review patterns in research findings, research design patterns, considerations regarding sample sizes, or trends in media usage.

While these designs provide empirical evidence regarding the potential effectiveness of Project-Based Learning, the findings come mostly from specific schools, classrooms, and learning contexts. The observed improvement in science learning outcomes cannot be considered to represent the real impact of Project-Based Learning on the broader population of elementary school students. So there is a need for future research involving a larger, more diverse, and multi-school sample to ensure consistency and student ability as an impact of PjBL in science learning in elementary schools.

PjBL research in elementary school science education is currently still dominated by questions about the effectiveness of PjBL, especially in improving students' science learning outcomes. The question of how PjBL is implemented, under what conditions this method is most effective, and how contextual or instructional characteristics can affect the results has not received much attention.

Discussion

Patterns in Science Learning Outcomes

Findings from the included studies show a very consistent pattern of positive outcomes related to Project-Based Learning (PjBL) in science education in primary schools. Nineteen of the empirical studies reported an improvement, significant difference, or positive impact after the implementation of PjBL, although the results were reported using different indicators and study designs. Most studies focus specifically on students' science learning outcomes, which are generally measured through pretest and posttest comparisons, comparisons between experimental and control groups, or improvements during classroom action research cycles. For example, some quasi-experimental studies reported substantial improvements in mean scores after the implementation of PjBL, including an increase from 52.86 to 87.14, from 49.62 to 81.54, and from 43.62 to 81.96. Experimental studies also reported similar results, namely higher posttest scores in the PjBL group compared to the comparison group, such as 83.04 versus 70.45 and 95 versus 76. These findings point to a relatively consistent direction of evidence supporting the use of PjBL to improve science learning outcomes.

This pattern is also evident in the Classroom Action Research study, where students' mastery levels increase with each cycle of actions carried out gradually. For example, one study reported an increase in mastery from 39% in Cycle I to 78% in Cycle II, while another study recorded an increase from 73% to 95%. Similar patterns were also reported in other studies, which showed an increase in mastery from 40% in the pre-cycle stage to 62% in Cycle I and 81% in Cycle II. Thus, the evidence not only shows positive post-intervention results, but also shows a consistent pattern of improvement along with the repeated implementation of PjBL.

However, the results studied were not entirely uniform. Although science learning outcomes were the most dominant outcomes, some studies also examined students' motivation, activities, and creative thinking skills. This shows that PjBL is not only studied as a means to improve cognitive achievement, but also as a model that can affect the dimensions of affective, behavioral, and high-level learning. However, these additional results are less common than conventional science learning outcomes. Overall, the evidence base is very oriented towards measurable academic achievement, particularly students' cognitive science learning outcomes.

One important limitation of this pattern is that all empirical studies in the dataset report positive findings. None of the studies in the included datasets reported negative impacts, statistically insignificant impacts, or failure of PjBL to improve learning outcomes.

Patterns in Research Design

Existing research designs show a strong focus on intervention-based approaches. Of the 20 included studies, 9 studies (45%) used quasi-experimental design, 6 studies (30%) used Classroom Action Research (PTK), 4 studies (20%) used experimental design, and 1 study (5%) was a Systematic Literature Review. Thus, 95% of the studies were empirical intervention-oriented research, while only one study was in the form of a literature-based synthesis.

The dominance of quasi-experimental research is striking. Nine studies used a quasi-experimental design, making it the most frequently used methodological approach. These studies generally used a one-group pretest-posttest or nonequivalent control group design to

determine whether PjBL resulted in an improvement in science learning outcomes. This predominance of design indicates that the main research question in the existing findings data is whether PjBL is effective when compared to previous student achievement or conventional learning approaches.

Classroom Action Research is the second most common design, accounting for 30% of all studies. Classroom Action Research studies generally apply PjBL through a learning cycle in the classroom that is carried out in stages and evaluates improvements based on changes in the mastery of the material or student achievements. This design is very much aligned with the practical orientation of elementary school education because it emphasizes solving learning problems in the classroom through instructional improvement

The characteristics of the sample further reinforce the class-context-oriented nature of the evidence. The relatively small sample size of some studies as well as the focus on a specific class or school limits the extent to which the findings can be generalized to a broader population of elementary school students. Thus, the available evidence provides strong enough support for the potential effectiveness of PjBL in the context of the classes studied, but not strong enough to generalize at the population level.

Characteristics of PjBL Implementation

Implementation characteristics suggest that PjBL is rarely studied as a stand-alone learning intervention. Some studies have integrated PjBL with additional learning media, such as PowerPoint, Wordwall, simple learning media, and audiovisual media. This indicates a tendency to combine PjBL with supporting technology or learning media, and places the PjBL model as the main learning framework. In particular, Wordwall appeared in more than one study, which hinted at a growing interest in combining project-based learning with interactive digital media.

The implementation of this method was also concentrated mainly in the high grades of elementary schools, particularly Class V. Most of the identified studies involved Class V students, while some other studies involved Class IV or Class VI students. This concentration shows that PjBL's research in elementary school science education is more targeted at high-grade students; This may be due to the assumption that students at this level are better prepared to conduct investigations, project development, collaboration, and the completion of relatively complex learning tasks. However, the lack of representation of primary school lower grades means that the application of PjBL to younger primary school students is still relatively underexplored in the evidence that has been reviewed.

The science topics discussed are very diverse, including the human respiratory system, the water cycle, ecosystems and food chains, changes in the form of matter, pure and mixed substances, the life cycle of animals, light, flora and fauna, and environmental themes. This diversity shows that PjBL is not limited to a specific science topic and has been applied in a variety of contexts, from biology, physics, and the environment to everyday life. This shows that PjBL can be applied relatively in elementary science materials.

Another important characteristic is that such studies generally emphasize measurable learning outcomes after the implementation of PjBL. Reported procedures show that projects are used to engage students in learning and problem-solving activities, while supporting media are used to facilitate the learning process. However, the available data provide relatively limited information regarding the detailed characteristics of project implementation, such as project duration, group composition, student autonomy, teacher support (scaffolding), project complexity, assessment rubric, and specific stages of project development. As a result, although the literature presents strong evidence that PjBL can be implemented successfully,

evidence on which implementation characteristics play a role in producing better outcomes is still lacking.

Research Trends and Emerging Directions

Overall, the findings suggest that the current research landscape regarding PjBL in science learning in primary schools is mainly characterized by three trends. First, research is very effectiveness-oriented. The dominance of quasi-experimental, experimental, and classroom action research designs suggests that researchers are primarily seeking to determine whether PjBL can improve students' science learning outcomes. Second, the research is highly class-centric, with relatively small sample sizes and limited implementation to specific schools or classes. Third, PjBL is increasingly being researched in combination with supporting learning media, including digital and audiovisual resources.

The study's concentration on science learning outcomes also shows that the research agenda is still largely focused on cognitive achievement. Although several studies have examined student motivation, activity, and creative thinking, these results are less prominent than conventional measures of learning achievement. This opens up opportunities for future research to examine broader outcomes related to PjBL, including collaboration, communication, creativity, science literacy, problem-solving, independent learning, and other 21st-century competencies.

The evidence reviewed also revealed methodological gaps. Although quasi-experimental and experimental designs provide evidence regarding the effectiveness of PjBL, they provide limited explanations for the reasons, methods, and conditions that allow PjBL to produce certain outputs. Similarly, classroom action research provides valuable evidence regarding improved classroom learning, but it generally has limitations in terms of broad generalizations. Therefore, future research can complement intervention studies with qualitative, mixed-method, and cross-school research designs to examine the implementation process, contextual influences, teacher roles, student experiences, and the sustainability of PjBL's impact.

CONCLUSION

This systematic literature review synthesizes empirical research on the application of Project-Based Learning (PjBL) in science learning in elementary schools published between 2017 and 2026. The findings show a consistent positive pattern in reported science learning outcomes, with empirical studies generally showing improved student achievement after the implementation of PjBL. However, the existing evidence base is largely from classroom-level intervention studies, specifically quasi-experimental studies which accounted for 45% of the studies studied, followed by Classroom Action Research (30%) and experimental research (20%). This methodological concentration indicates that current research focuses more on determining the effectiveness of PjBL than examining how and under what conditions the method produces optimal learning outcomes. The application of PjBL is also characterized by its use in various science topics and elementary school grade levels, which are often supported by learning media and learning activities designed to encourage active student participation. However, the studies studied generally involved relatively specific classroom contexts and heterogeneous sample sizes, thus limiting the extent to which the findings could be generalized to a broader population of primary school students. Overall, the current evidence supports the potential of PjBL in improving science learning outcomes in primary education, but this field of research is still very effectiveness-oriented and centered in the classroom. Therefore, future research should use a larger and more diverse sample, a design involving multiple schools or contexts, as well as more varied methodological approaches to examine the implementation

process, contextual factors, long-term impacts, and conditions under which PjBL is most effectively applied.

CONFLICT OF INTEREST

The authors declare no conflict of interest

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AUTHORS

Lulu Dwi Lestari is affiliated with Universitas Nahdlatul Ulama Al Ghazali, Cilacap, Indonesia. She contributes to research on elementary education, particularly project-based learning and science learning outcomes. In this systematic literature review, she examines evidence on the effectiveness of project-based learning in elementary schools. She can be contacted at luludwilestari985@gmail.com.

Eka Fajriyani is affiliated with Universitas Nahdlatul Ulama Al Ghazali, Cilacap, Indonesia. She contributes to research concerning elementary education, science learning, and project-based learning. In this systematic literature review, she participates in examining research evidence on how project-based learning influences science learning outcomes in elementary schools. She can be contacted at fajriyanieka@gmail.com for academic correspondence, research discussion, and educational collaboration.

Kafita Risma Kamelia is affiliated with Universitas Nahdlatul Ulama Al Ghazali, Cilacap, Indonesia. She contributes to research related to elementary education and science learning. In this systematic literature review, she examines evidence concerning the effect of project-based learning on science learning outcomes among elementary school students. She can be contacted at kafifafitaa@gmail.com for academic correspondence, research discussion, and educational collaboration.

Mey Prihandani is affiliated with Universitas Nahdlatul Ulama Al Ghazali, Cilacap, Indonesia. She contributes to research in elementary education, with particular attention to science learning and project-based learning approaches. In this systematic literature review, she examines evidence on science learning outcomes in elementary schools. She can be contacted at meyprihandani@unugha.id for academic correspondence, research discussion, professional development, and educational collaboration.

Mawan Akhir Riwanto is affiliated with Universitas Nahdlatul Ulama Al Ghazali, Cilacap, Indonesia. He contributes to research in elementary education, including science learning and project-based learning. In this systematic literature review, he examines evidence on the effect of project-based learning on elementary students' science learning outcomes. He can be contacted at mawan.pgisd@unugha.id for academic correspondence, research discussion, and educational collaboration.