Jurnal PAJAR (Pendidikan dan Pengajaran)
Volume 10 Nomor 1 January 2026 | ISSN Cetak : 2580 - 8435 | ISSN Online : 2614 - 1337
DOI : http://dx.doi.org/10.33578/pjr.v10i1.322

Stem-Integrated Project-Based Learning With Flipbook Media to Enhance Science Process Skills and Learning Outcomes

Sutanto[1], Mohammad Masykuri[1], Sukarmin[1]

[1] Master of Science Education Student, UNS, Surakarta, Central Java, Indonesia
[2]Lecturer Master of Science Education, UNS, Surakarta, Central Java, Indonesia
sutanto@student.uns.ac.id, mmasykuri@staff.uns.ac.id, sukarmin67@staff.uns.ac.id.
corresponding author: *sutanto@student.uns.ac.id*

ABSTRACT

The integration of STEM education and Project-Based Learning (PjBL) has been widely acknowledged as a practical approach to developing students' scientific competencies. However, empirical findings remain fragmented, particularly regarding the impact of flipbook media on science process skills and learning outcomes. This study aims to systematically review current research on the integration of STEM-based PjBL in science education. A Systematic Literature Review (SLR) was conducted using the PRISMA protocol. Articles were retrieved from Scopus, Google Scholar, and SINTA databases, yielding 45 studies published between 2020 and 2024. Based on predefined inclusion and exclusion criteria related to relevance, accessibility, and methodological rigor, 15 studies were selected for in-depth analysis. The findings indicate that STEM-integrated PjBL contributes significantly to the development of science process skills, particularly in observation, experimentation, data interpretation, and problem-solving. Several studies also report improvements in students' conceptual understanding and learning outcomes, particularly when flipbook media are used to enhance engagement and structured learning support. Nonetheless, challenges were identified, including students' readiness for project-based tasks and the need for sustained teacher scaffolding. In conclusion, STEM-integrated PjBL supported by flipbook media is a pedagogically robust approach to strengthening science learning. Future studies are recommended to employ more rigorous designs to improve generalizability.

Keywords*: *PjBL (Project-Based Learning), STEM, Science process skills, learning outcomes

Submitted	Accepted	Published
20 September 2025	06 January 2026	30 January 2026

Citation	**:**	Sutanto, S., Masykuri, M., & Sukarmin, S. (2026). Stem-Integrated Project-Based Learning With Flipbook Media to Enhance Science Process Skills and Learning Outcomes. *Jurnal PAJAR (Pendidikan dan Pengajaran), 10*(1), 49-62. DOI: http://dx.doi.org/10.33578/pjr.v10i1.322.

INTRODUCTION

Education plays a vital role in preparing students to meet the demands of the 21st century, characterized by rapid technological advancement and increasing complexity of real-world problems. Learning in this era requires not only conceptual understanding but also higher-order thinking skills, adaptability, collaboration, and problem-solving abilities. Consequently, educational practices must integrate technology and multidisciplinary approaches to foster meaningful, student-centered learning experiences (Tarigan et al., 2025; Mutiani et al., 2024). In science education, contextual and inquiry-oriented Learning is essential to support the development of science process skills and learning outcomes.

Multidisciplinary learning is one of the approaches considered effective in strengthening 21st-century competencies. Through multidisciplinary approaches, students are encouraged to connect knowledge from various scientific fields to solve problems comprehensively (Hero & Lindfors, 2019). This approach not only improves students' conceptual understanding but also enhances their learning outcomes, develops their skills, and prepares them to adapt to global changes (Utomo et al., 2025). Learning must be designed contextually by linking material to real-life situations so that students can construct knowledge through direct experience and inquiry, especially in science education (Ayu et al., 2024). Teachers need to innovate in learning models, approaches, methods, and strategies (Sumarni & Kadarwati, 2020). One innovative learning model suitable for use in the learning process with science subject content in the classroom is through a

Jurnal PAJAR (Pendidikan dan Pengajaran)
Volume 10 Nomor 1 January 2026 | ISSN Cetak : 2580 - 8435 | ISSN Online : 2614 - 1337
DOI : http://dx.doi.org/10.33578/pjr.v10i1.322

combination of models, PjBL (Project-Based Learning) and STEM (Science, Technology, Engineering, and Mathematics), and

Project-Based Learning (PjBL) is one of the learning models widely recognized as relevant to modern educational demands. It is a learning model that encourages students to be active, to apply their knowledge, and to develop various thinking and concrete skills (Sukacke et al., 2022). PjBL emphasizes student-centered Learning through collaborative project implementation, problem-solving, and authentic tasks that encourage students to build knowledge through meaningful learning activities (Firdausi et al., 2025). In PjBL, students are allowed to explore problems, design solutions, conduct investigations, and produce products that demonstrate their understanding (Hart, 2019). Previous research has emphasized that PjBL is efficacious in improving student activity, learning motivation, science process skills, and learning outcomes (Bariyah & Sugandi, 2022; Nurdiansah & Makiyah, 2021). Through PjBL, students not only learn concepts but also develop important skills such as communication, collaboration, and decision-making (Nora et al., 2022). The implementation of the PjBL model involves students' knowledge and skills, thereby making learning more effective in improving students' process skills, activities, responses, and learning outcomes (Okilanda et al., 2023).

STEM is a learning model in which each student involved uses four scientific fields: knowledge, technology, engineering, and mathematics in a real-life way, connecting schools, the workplace, and the global world (Muzana et al., 2021). STEM learning allows students to understand scientific concepts while simultaneously engaging in technological applications, engineering design, and mathematical reasoning (Izzah & Mulyana, 2021). This approach strengthens students' critical thinking skills and scientific competencies while preparing them to enter STEM-related academic pathways and careers (Gale, 2020; Topsakal et al., 2022). Previous studies have also shown that STEM education supports the development of conceptual understanding, scientific literacy, and process skills through meaningful and integrated learning activities (Izzah & Mulyana, 2021; Juškevičienė et al., 2021; Tulniza & Hidayati, 2020).

Integrating PjBL with STEM creates a strong pedagogical synergy in science education. PjBL provides authentic project-based learning activities that involve students directly in problem-solving, while STEM supports systematic scientific, technological, and mathematical thinking frameworks (Septi & Susilowati, 2020). Through PjBL-STEM integration, students engage in exploration, experimentation, data analysis, engineering design, and collaborative Learning, enabling them to construct knowledge meaningfully (Okulu & Unver, 2021). Several empirical studies have shown that PjBL-STEM integration improves students' problem-solving abilities, higher-order thinking, scientific literacy, ICT literacy, and learning outcomes (Purwaningsih et al., 2020; Chang & Chen, 2022; Schneider et al., 2022). This integration is also relevant to the development of 21st-century competencies and helps students engage actively in complex learning situations. In addition to learning models, learning media also play a significant role in facilitating effective learning processes. Digital media such as flipbooks can support student engagement and provide structured learning support. Flipbooks enable interactive learning experiences by combining text, images, and multimedia features that enhance student understanding and interest in Learning (Mutiani et al., 2024). When integrated with STEM-oriented PjBL, flipbooks can help guide students through the project implementation stages while supporting conceptual understanding.

Despite the growing number of studies examining PjBL, STEM education, and their integration, existing findings remain fragmented across different contexts and research designs. Most studies focus on empirical implementation without providing a comprehensive synthesis of evidence. To date, there has been no systematic literature review that explicitly researches PjBL–STEM integration in relation to science process skills and learning outcomes, particularly when supported by digital learning media. Therefore, this study aims to conduct a Systematic Literature Review (SLR) to analyze research trends, effectiveness, implementation characteristics, and methodological quality of studies on PjBL–STEM integration. This review seeks to provide a structured synthesis of existing evidence and highlight implications for science education practice, particularly in enhancing science process skills and student learning outcomes.

Jurnal PAJAR (Pendidikan dan Pengajaran)
Volume 10 Nomor 1 January 2026 | ISSN Cetak : 2580 - 8435 | ISSN Online : 2614 - 1337
DOI : http://dx.doi.org/10.33578/pjr.v10i1.322

LITERATURE REVIEW

Project-Based Learning (PjBL) is a student-centered instructional model that engages learners in authentic, inquiry-driven projects to solve real-world problems. Through stages such as problem identification, planning, investigation, product development, and presentation, PjBL facilitates active Learning and supports the development of science process skills, critical thinking, collaboration, and learning autonomy (Aureola & Septian, 2020; Fatimah & Bramastia, 2022). PjBL is particularly relevant in science education because its learning stages align with the scientific inquiry process, including observation, experimentation, and data interpretation. The technology-based PjBL model is believed to yield more optimal results in achieving learning objectives (Hart, 2019) the symbiosis of learning models with technology results in more productive Learning.

STEM education emphasizes the integration of science, technology, engineering, and mathematics to foster interdisciplinary Learning and problem-solving abilities (Sylvia et al., 2020). STEM-based instruction connects conceptual knowledge with real-world applications and encourages students to engage in inquiry, experimentation, and design-based activities (Gale, 2020). Previous studies indicate that STEM education enhances students' scientific literacy, conceptual understanding, problem-solving skills, and readiness for future STEM-related careers (Izzah & Mulyana, 2021; Okulu & Unver, 2021; Topsakal et al., 2022). STEM learning can be integrated with various learning models, one of which is Project-Based Learning (PjBL) (Okulu & Unver, 2021).

Integrated PjBL-STEM learning can provide students with contextual Learning through complex activities such as exploring, planning learning activities, implementing collaborative projects, and ultimately producing a product. PjBL-STEM integration will undoubtedly have a positive impact and provide optimal results in the subjects given if appropriately implemented. This is in accordance with the findings of researchers who found that PjBL-STEM integration is effective across various subject areas. The integration of the PjBL STEM model has a strong influence on student learning outcomes in knowledge and skills. Meanwhile, the attitude aspect is in the moderate category. Through PjBL-STEM integration, Learning becomes more meaningful, helping students in solving real-life problems and supporting future careers.

Recent empirical studies increasingly focus on their integration in science learning contexts. Across multiple studies, a consistent theme emerges: PjBL–STEM integration positively contributes to the development of science process skills, particularly observation, experimentation, data interpretation, and problem-solving (Bariyah & Sugandi, 2022; Mufida et al., 2020; Bhakti et al., 2020). These skills are developed as students engage in inquiry-based projects that require scientific reasoning and collaborative problem-solving. Another prominent theme identified in the literature is improving student learning outcomes. Studies report that students exposed to PjBL–STEM instruction demonstrate higher conceptual understanding and improved academic performance compared to conventional learning models (Purwaningsih et al., 2020; Chang & Chen, 2022; Selfiana et al., 2024). These improvements are attributed to meaningful learning experiences, interdisciplinary connections, and increased student engagement. In addition to cognitive outcomes, several studies highlight the contribution of PjBL–STEM integration to affective and skill-related domains, including motivation, collaboration, self-efficacy, and ICT literacy (Muzana et al., 2021; Schneider et al., 2022). The integration supports holistic Learning by fostering both academic and non-academic competencies relevant to 21st-century education.

Despite these strengths, the literature also identifies several limitations. Students often experience initial difficulties adapting to project-based tasks, particularly those requiring independent inquiry and sustained collaboration (Nora et al., 2022). Furthermore, the effectiveness of PjBL–STEM integration is highly dependent on teacher scaffolding, instructional design quality, and availability of supporting learning media. Methodologically, many studies rely on quasi-experimental designs with small sample sizes, thereby limiting the generalizability of their findings. Digital learning media play a crucial role in supporting the implementation of PjBL–STEM integration. Flipbook-based learning media, in particular, provide structured

Jurnal PAJAR (Pendidikan dan Pengajaran)
Volume 10 Nomor 1 January 2026 | ISSN Cetak : 2580 - 8435 | ISSN Online : 2614 - 1337
DOI : http://dx.doi.org/10.33578/pjr.v10i1.322

content presentation, interactive features, and visual support that enhance student engagement and comprehension (Mutiani et al., 2024). When integrated into PjBL–STEM learning, flipbooks serve as instructional guides that support students throughout the project stages, thereby fostering the development of science process skills and learning outcomes.

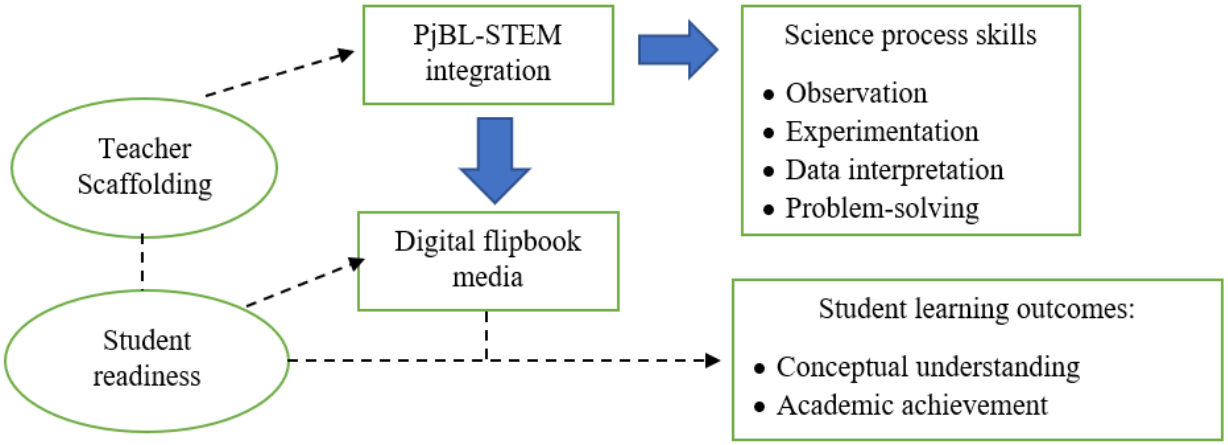

Figure 1. Conceptual Framework of PjBL-STEM Integration with Flipbook Media

Based on the synthesis of previous studies, this review proposes a conceptual framework in which PjBL–STEM integration serves as the primary instructional approach. Digital flipbook media support this approach as a facilitating tool. The instructional process influences science process skills (observation, experimentation, data interpretation, and problem-solving), which in turn contribute to improved student learning outcomes. Teacher scaffolding and student readiness serve as moderating factors that affect the effectiveness of the instructional approach.

Table 1. Summary of Previous Research on PjBL, STEM, and PjBL–STEM Integration

No	Authors	Year	Focus / Context	Main Findings
1	Aureola & Septian	2020	PjBL-STEM vs non-STEM	PjBL-STEM is more effective in improving critical thinking
2	Ayu et al.	2024	PjBL–STEM	Consistent positive effects on skills and learning outcomes
3	Baran et al.	2021	PjBL–STEM & 21st-century skills	Improved collaboration, creativity, and problem-solving
4	Bariyah & Sugandi	2022	PjBL & science process skills	Significant improvement in science process skills
5	Bhakti et al.	2020	Integrated PjBL–STEM	Enhanced science process skills and inquiry abilities
6	Caccamo et al.	2022	Knowledge integration	Integration supports innovation and interdisciplinary Learning
7	Çevik & Bakioğlu	2022	STEM-integrated Learning	STEM integration significantly improves learning outcomes
8	Chang & Chen	2022	I-STEM PjBL	Improved learning outcomes; challenges in implementation
9	Esthi	2020	PjBL–STEM & scientific literacy	Increased students' scientific literacy
10	Fatimah & Bramastia	2022	ICT-based PjBL	ICT enhances PjBL effectiveness
11	Firdausi et al.	2025	PjBL & SPS	PjBL consistently improves science process skills
12	Gale	2020	Integrated STEM curriculum	Identified key components of effective STEM integration
13	Hart	2019	Interdisciplinary PjBL	Improved employability and collaboration skills

Jurnal PAJAR (Pendidikan dan Pengajaran)
Volume 10 Nomor 1 January 2026 | ISSN Cetak : 2580 - 8435 | ISSN Online : 2614 - 1337
DOI : http://dx.doi.org/10.33578/pjr.v10i1.322

No	Authors	Year	Focus / Context	Main Findings
14	Hero & Lindfors	2019	Multidisciplinary innovation projects	Positive student learning experiences
15	Izzah & Mulyana	2021	PjBL–STEM	Strong positive effect on learning outcomes
16	Jatmika et al.	2020	PjBL–STEM in physics	Improved science process skills
17	Juškevičienė et al.	2021	Integrated STEM activities	Practical methodology for STEM integration
18	Mufida et al.	2020	E-learning PjBL–STEM	Significant gains in science process skills
19	Mutiani et al.	2024	Flipbook-based blended Learning	Improved thinking skills and achievement
20	Muzana et al.	2021	E-STEM PjBL	Increased ICT literacy and problem-solving
21	Nora et al.	2022	PjBL evaluation	PjBL is effective but requires strong scaffolding
22	Okilanda et al.	2023	PjBL in blended Learning	Positive impact on cognitive and psychomotor outcomes
23	Okulu & Unver	2021	STEM activity characteristics	Valid tool for evaluating STEM activities
24	Onto et al.	2024	PjBL–STEM & learning outcomes	Significant improvement in science learning outcomes
25	Purwaningsih et al.	2020	STEM-PjBL vs discovery learning	STEM-PjBL superior in problem-solving skills
26	Schneider et al.	2022	STEM intervention initiatives	STEM interventions increase participation and interest
27	Selfiana et al.	2024	PjBL–STEM & collaboration	Improved learning outcomes and collaboration
28	Septi & Susilowati	2020	PjBL–STEM & critical thinking	Increased critical and cooperative skills
29	Sumarni & Kadarwati	2020	Ethno-STEM PjBL	Improved critical and creative thinking
30	Sylvia et al.	2020	PjBL–STEM & HOTS	Significant improvement in higher-order thinking
31	Tarigan et al.	2025	Media-supported Learning	Learning media enhances outcomes
32	Topsakal et al.	2022	Problem-based STEM	Improved critical thinking and problem-solving
33	Tulniza & Hidayati	2020	STEM-PjBL digital media	Digital media supports STEM-PjBL effectiveness
34	Utomo et al.	2025	STEM-PjBL	STEM-PjBL develops future competencies

METHOD

This study employed a Systematic Literature Review (SLR) approach to synthesize empirical and review-based research on the integration of Project-Based Learning (PjBL) and STEM education in science learning contexts (Caccamo et al., 2022). The SLR was conducted following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines to ensure transparency, rigor, and replicability in the article selection and screening process.

The literature search was conducted using international and national academic databases, including Scopus, Google Scholar, DOAJ, ERIC, and nationally accredited journals. The search process was carried out between January and March 2025. The following keywords and Boolean operators were used: "Project-Based Learning" OR "PjBL" AND "STEM education" OR "STEM integration" AND "science process skills" OR "learning outcomes".

To ensure the relevance and quality of the reviewed studies, explicit inclusion and exclusion criteria were applied. Inclusion criteria were: Articles published between 2019 and 2025; Peer-reviewed journal articles, conference proceedings, and systematic reviews; Studies written in English or Indonesian; Studies focusing on PjBL, STEM education, or PjBL–STEM integration; and Studies reporting empirical findings or systematic analyses related to science process skills, learning outcomes, or 21st-century skills. The exclusion criteria were: Non-peer-reviewed sources (e.g., theses, dissertations, opinion papers); Studies not related to educational contexts; Articles focusing solely on STEM or PjBL without educational implementation; and Duplicate publications across databases.

The initial search yielded 40 articles. After removing duplicates and screening titles and abstracts based on relevance, 22 articles were retained for full-text review. After applying the inclusion and exclusion criteria, 15 articles were selected for final analysis. This selection process is summarized in a PRISMA flow diagram that illustrates the identification, screening, eligibility, and inclusion stages.

Jurnal PAJAR (Pendidikan dan Pengajaran)
Volume 10 Nomor 1 January 2026 | ISSN Cetak : 2580 - 8435 | ISSN Online : 2614 - 1337
DOI : http://dx.doi.org/10.33578/pjr.v10i1.322

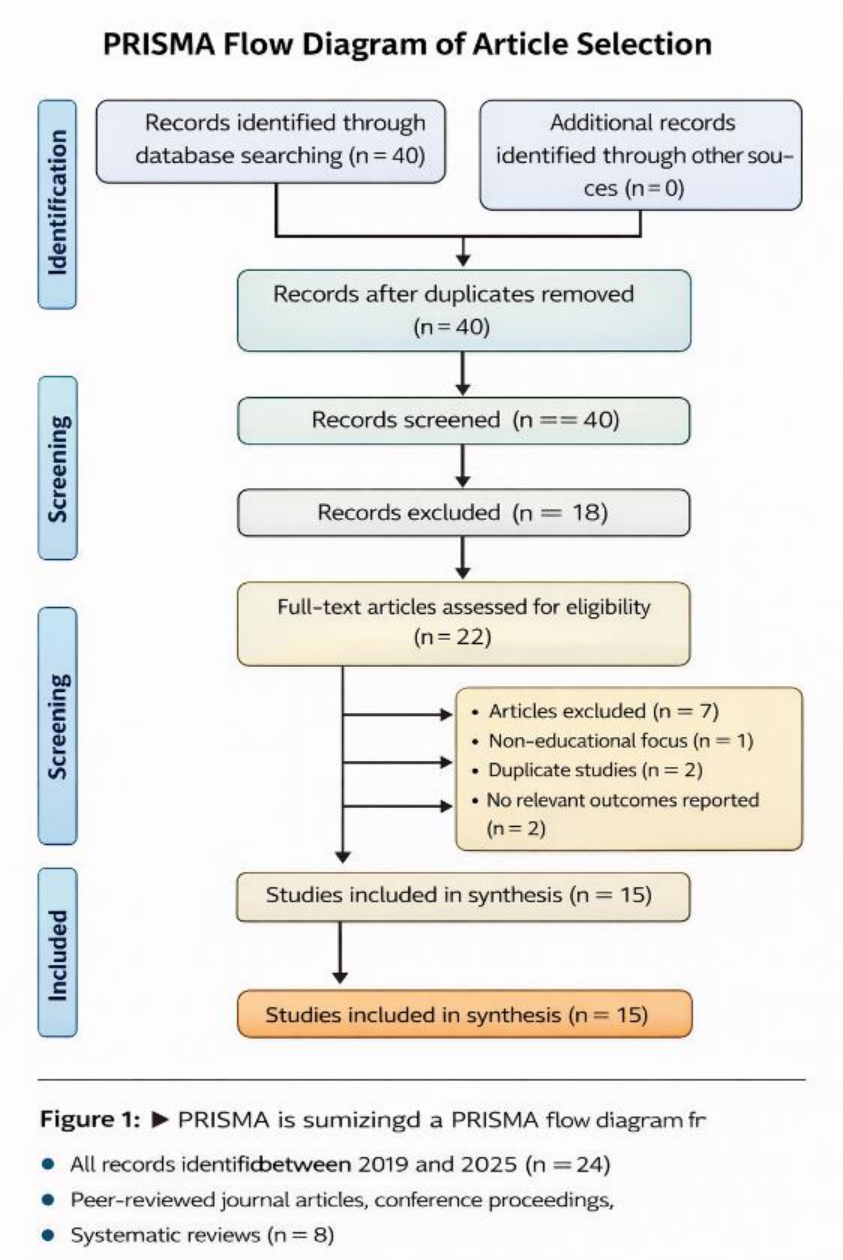

Figure 2. PRISMA Flow Diagram of Article Selection

Data extraction and organization were conducted using Microsoft Excel to systematically record article metadata, including authors, publication year, research focus, methodology, and key findings. Mendeley Reference Manager was used to manage citations and ensure consistency between in-text citations and references.

The selected studies were analyzed using thematic content analysis. Data coding was conducted in several stages: Open coding, identifying key concepts related to PjBL, STEM integration, science process skills, learning outcomes, and instructional media; Axial coding, grouping codes into broader thematic categories such as instructional design, learning outcomes, skill development, and implementation challenges; and Selective coding, synthesizing patterns to identify dominant themes, strengths, limitations, and research

Jurnal PAJAR (Pendidikan dan Pengajaran)
Volume 10 Nomor 1 January 2026 | ISSN Cetak : 2580 - 8435 | ISSN Online : 2614 - 1337
DOI : http://dx.doi.org/10.33578/pjr.v10i1.322

gaps across studies. The analysis focused on identifying common trends, methodological approaches, outcome variables, and limitations, rather than describing individual studies separately. This approach enabled a comprehensive synthesis of evidence on the effectiveness and implementation characteristics of PjBL–STEM integration.

To enhance the credibility of the review, all stages of article selection and analysis were documented systematically, and data interpretation was cross-checked to ensure consistency. The use of PRISMA guidelines, explicit criteria, and structured coding procedures strengthens the validity and reliability of the review findings.

RESULTS AND DISCUSSION

Main Findings

Based on an analysis of 15 selected studies, the results indicate a consistent research interest in integrating Project-Based Learning (PjBL) with STEM education over the last five years (2019–2025). The majority of studies (approximately two-thirds) employed quasi-experimental or experimental designs, while the remainder consisted of systematic literature reviews, meta-analyses, and mixed-methods studies (e.g., Aureola & Septian, 2020; Baran et al., 2021; Izzah & Mulyana, 2021; Ayu et al., 2024).

In terms of research focus, science process skills, learning outcomes, critical thinking, and 21st-century skills emerged as the most frequently examined variables. Several studies reported statistically significant improvements in students' science process skills and cognitive outcomes when PjBL was integrated with STEM approaches (Bhakti et al., 2020; Jatmika et al., 2020; Mufida et al., 2020; Purwaningsih et al., 2020). Additionally, recent studies increasingly incorporate digital and blended learning media, such as e-learning platforms and flipbook-based resources, to support PjBL–STEM implementation (Muzana et al., 2021; Mutiani et al., 2024).

Thematic Analysis of Previous Studies

A thematic synthesis of the reviewed literature revealed four dominant themes. First, the effectiveness of PjBL–STEM integration is consistently highlighted across empirical studies. Research demonstrates that combining project-based activities with interdisciplinary STEM content enhances students' inquiry skills, problem-solving abilities, and conceptual understanding (Septi & Susilowati, 2020; Sylvia et al., 2020; Onto et al., 2024). Meta-analytical and review studies further confirm the positive impact of STEM-integrated instructional models on learning outcomes (Çevik & Bakioğlu, 2022; Izzah & Mulyana, 2021).

Second, the role of instructional design and learning media appears as a critical factor influencing learning effectiveness. Studies integrating PjBL–STEM with digital tools, such as e-STEM modules, flipbooks, and blended learning environments, report improved student engagement and skill development (Muzana et al., 2021; Mutiani et al., 2024). However, variations in instructional quality and technological readiness remain a challenge, particularly in resource-limited educational contexts.

Third, the development of 21st-century skills, including collaboration, creativity, and critical thinking, is a recurring outcome of PjBL–STEM implementation (Baran et al., 2021; Hart, 2019; Sumarni & Kadarwati, 2020). These findings align with broader STEM education objectives emphasizing interdisciplinary problem-solving and real-world relevance (Gale, 2020; Juškevičienė et al., 2021).

Fourth, methodological limitations are evident across prior studies. Most empirical research relies on small sample sizes and short intervention durations, limiting generalizability. In addition, several studies focus on isolated educational levels or specific science topics, resulting in fragmented evidence. Although recent SLRs exist (Ayu et al., 2024; Firdausi et al., 2025; Utomo et al., 2025), many do not explicitly synthesize the intersection of PjBL, STEM integration, and instructional media within science education. The results of this research assessment are presented in Table 3.

Jurnal PAJAR (Pendidikan dan Pengajaran)
Volume 10 Nomor 1 January 2026 | ISSN Cetak : 2580 - 8435 | ISSN Online : 2614 - 1337
DOI : http://dx.doi.org/10.33578/pjr.v10i1.322

Table 3. Research Quality Assesment

No	Year	Authors	Title	QA1	QA2	QA3	Conclusion
1	2020	Mufida, S. N., Sigit, D. V., & Ristanto, R. H.	Integrated Project-Based E-Learning With Science, Technology, Engineering, and Mathematics (PjBL-STEM): Its Effect On Science Process Skills	√	√	√	√
2	2020	Sylvia, N. W., Yamtinah, S., & Susanti, E. V.	Pengaruh Model Project Based Learning Terintegrasi STEM (PjBL-STEM) Terhadap Kemampuan Berpikir Tingkat Tinggi pada Materi Asam dan Basa Kelas XI Di SMA Negeri 3 Surakarta	√	√	√	√
3	2020	Esthi, R. & Srigati.	Uji Pembelajaran Berbasis Proyek (PjBL-STEM) untuk Meningkatkan Literasi Sains pada Siswa MTsN 28 Jakarta Timur	√	√	√	√
4	2020	Aureola, A. D., & Septian, G. A.	Efektivitas Model Pembelajaran Project Based Learning Berbasis STEM dan Tidak Berbasis STEM Terhadap Keterampilan Berpikir Kritis Siswa	√	√	√	√
5	2020	Purwaningsih, E., Sari, S. P., Sari, A. M., & Suryadi, A.	The Effect of STEM-PJBL and Discovery Learning On Improving Students' Problem-Solving Skills Of The Impulse and Momentum Topic	√	√	√	√
6	2020	Septi, R. I., & Susilowati.	The Effect of Model Project-Based Learning Approach on STEM (Science, Technology, Engineering, and Mathematics) on Science Learning to Junior High School Students Critical Thinking Skills and Cooperative Skills	√	√	√	√
7	2020	Sumarni, W., & Kadarwati, S.	Ethno-STEM Project-Based Learning: Its Impact on Critical And Creative Thinking Skills	√	√	√	√
8	2020	Tulniza, F. & Hidayati, N.	Pengembangan Aplikasi Android Komik Interaktif Berbasis STEM-PjBL Sebagai Media Pembelajaran pada Materi Sistem Pernapasan Pada Manusia	√	√	√	√
9	2020	Bhakti, Astuti, Okyranida, Asih, Marhento, G., Leonard & Yusro, A. C.	Integrated STEM Project-Based Learning Implementation to Improve Student Science Process Skills	√	√	√	√
10	2021	Izzah, N. & Mulyana, I.	Meta Analisis Pengaruh Integrasi Pendidikan STEM dalam Model Project Based Learning Terhadap Hasil Belajar Siswa	√	√	√	√
11	2021	Muzana, S. R., Jumadi, Wilujeng, I., Yanto, B. E., & Mustamin, A.	E-STEM Project-Based Learning In Teaching Science To Increase ICT Literacy And Problem Solving	√	√	√	√
12	2021	Baran, M., Karakoyun, F., & Maskan, A.	The Influence of Project-Based STEM (PjBL-STEM) Applications on the Development of 21st-Century Skills	√	√	√	√

Jurnal PAJAR (Pendidikan dan Pengajaran)
Volume 10 Nomor 1 January 2026 | ISSN Cetak : 2580 - 8435 | ISSN Online : 2614 - 1337
DOI : http://dx.doi.org/10.33578/pjr.v10i1.322

13	2022	Chang, C & Chen, Y.	Educational Values And Challenges Of I-STEM Project-Based Learning: A Mixed-Methods Study With Data-Transformation Design	√	√	√	√
14	2024	Selfiana, Putri, R. E., Sari, M. P., Yurnetti & Muttaqiin.	Pengaruh Penerapan Model PjBL Terintegrasi STEM terhadap Hasil Belajar dan Keterampilan Kolaborasi Siswa Kelas VIII SMP	√	√	√	√
15	2024	Onto, E. A., Gustina, Paramita, I., dan Saehana, S.	Pengaruh Model Project-Based Learning Terintegrasi Science Technology Engineering And Mathematics Terhadap Hasil Belajar IPA Siswa SMP Negeri 13 Sigi	√	√	√	√

Discussions

The reviewed journal articles reveal that the Project-Based Learning (PjBL) model can improve student motivation, process skills, and learning outcomes. Across the reviewed studies, a consistent pattern emerges: PjBL is predominantly implemented in science learning contexts at the elementary, middle, and high school levels, suggesting its broad applicability across educational stages**.** The research population and samples generally involved elementary, middle, and high school students. The research method used was a quasi-experimental design with a pre-test and post-test, and a control class was used as a comparison. Some also used a Systematic Literature Review (SLR). This methodological trend indicates that prior research primarily emphasizes outcome measurement rather than long-term or longitudinal impacts.

The Project-Based Learning model in this study required students to engage in observation and question-forming activities. Project-Based Learning models can stimulate curiosity, thereby increasing students' interest in Learning. The research instruments included a science process skills test that encompassed observation, interviews, questionnaires, classification, prediction, data interpretation, and communication. These recurring indicators suggest that science process skills are a central focus in prior PjBL research, reinforcing the model's inquiry-based activities as a core pedagogical strength. The reviewed journal articles reported increases in average science process skill scores and learning outcomes following the implementation of the Project-Based Learning model. Project-Based Learning is effective for students of varying levels of understanding. The journal articles indicated that students with lower initial abilities experienced greater improvements than those with higher initial abilities. The journal article also states that Project-Based Learning is suitable for presenting material, language, and process skills.

Project-Based Learning (PjBL) is a well-structured pedagogical approach that encourages active student engagement in authentic investigations of real-life, open-ended problems through collaborative Learning (Firdausi et al., 2025). Many researchers agree that PjBL is an excellent model for enhancing general student skills such as problem-solving, creativity, and teamwork. PjBL fosters independent thinking and Learning, as it teaches not only what students should learn but also how they should learn. Students deliver results that enable them to solve problems within a topic using problem-solving and active learning methods (Izzah & Mulyana, 2021). However, despite these strengths, previous studies often focus on short-term interventions, which limits the generalizability of findings across different instructional durations and contexts.

STEM (Science, Technology, Engineering, and Mathematics) is a student-centered approach that encourages students to solve problems through a scientific method. STEM education is evolving to meet current educational needs. Many students from various countries believe that the STEM approach can secure their future careers (Purwaningsih et al., 2020). This aligns with research by Sylvia et al. (2020), which found that students reported increased interest in science and a greater desire to pursue future careers after implementing a STEM learning approach. In other words, the main goal of the STEM approach is to provide students with 'real-world problems' to solve using skills learned in each discipline, while at the same time

Jurnal PAJAR (Pendidikan dan Pengajaran)
Volume 10 Nomor 1 January 2026 | ISSN Cetak : 2580 - 8435 | ISSN Online : 2614 - 1337
DOI : http://dx.doi.org/10.33578/pjr.v10i1.322

developing critical thinking that is highly desirable in the world of work (Selfiana et al., 2024). The STEM approach helps students generate solutions to problems from multiple perspectives. These findings demonstrate a clear trend in the literature toward positioning STEM as a bridge between academic Learning and future workforce readiness. Furthermore, because STEM is an interdisciplinary approach, STEM can be taught through several learning models such as Project-Based Learning (PjBL).

The PjBL model, integrated with the STEM approach, is an innovative learning approach that provides students with the opportunity to collaboratively plan the learning process and produce a specific product to serve as a learning resource. This STEM-integrated PjBL can help students develop 21st-century skills. PjBL-STEM has the potential to influence student learning and enhance their problem-solving skills positively. PjBL-STEM also produces significant positive improvements in students' academic, social, and emotional Learning (Scheider et al., 2022). Furthermore, integrating PjBL into classroom STEM learning can develop students' complex knowledge and skills. Research by Muzana et al. (2021) also shows that PjBL-STEM has a significant impact on improving literacy and problem-solving. Collectively, these studies indicate strong convergence in findings on the effectiveness of PjBL–STEM integration, particularly in supporting multidimensional learning outcomes.

PjBL-STEM integration helps students complete projects by integrating science into problems, processing data, and utilizing the latest techniques and technologies. The result is more innovative projects, as students think logically and use technological literacy independently. In addition to improving literacy and ICT problem-solving, PJBL-STEM can also increase students' self-efficacy. The integration of PJBL-STEM can increase students' self-efficacy, as well as make students interested in pursuing STEM careers and professions. Despite these advantages, several reviewed studies note challenges in implementation, particularly students' initial unfamiliarity with project-based tasks and the increased demand on teachers to provide scaffolding and facilitation.

In addition, PJBL can improve students' learning outcomes. However, in the application of PJBL-STEM, there are also challenges, namely students are not used to working on projects, so the role of the teacher, namely as a facilitator in Learning, can provide scaffolding to students, so that with the scaffolding, the implementation of PJBL-STEM in Learning, especially physics learning, can make students learn with fun and make the Learning delivered meaningful (meaningful Learning). These findings suggest that teacher readiness and instructional support are critical moderating factors in the successful implementation of PjBL–STEM.

The implementation of PjBL-STEM integration in the cognitive domain is categorized as good; the affective domain is categorized as very good; and the psychomotor domain also achieved good results. The integration of STEM education with the PjBL model is highly effective, as it can improve student learning outcomes. Compared with previous systematic literature reviews that focus on either PjBL or STEM independently, this review contributes novel insights by synthesizing evidence at the intersection of PjBL, STEM integration, and learning outcomes across cognitive, affective, and psychomotor domains.

Based on the research results presented, the following suggestions can be given to teachers. Among them, teachers can use the PjBL model to integrate STEM education into school learning. The Project-Based Learning model has significant advantages and benefits students, but it is rarely used. By integrating it with STEM education, it is very effective for use in schools because it integrates or combines four disciplines at once, namely science, technology, engineering, and mathematics so that students are interested in participating in lessons in class and learning activities become more meaningful. The application of PjBL-STEM integration begins with ill-defined, context-driven problems, using STEM and other materials to master concepts and insights and produce products (well-defined outcomes). This study not only reinforces existing evidence but also provides a more comprehensive synthesis of patterns, strengths, limitations, and pedagogical implications of PjBL–STEM integration for future research and classroom practice.

Jurnal PAJAR (Pendidikan dan Pengajaran)
Volume 10 Nomor 1 January 2026 | ISSN Cetak : 2580 - 8435 | ISSN Online : 2614 - 1337
DOI : http://dx.doi.org/10.33578/pjr.v10i1.322

Implication for Practice

This study contributes to the existing literature by systematically synthesizing empirical and review-based studies on PjBL–STEM integration with a specific emphasis on science process skills, learning outcomes, and instructional media. Unlike previous SLRs that focus either on PjBL or STEM independently, this study highlights the pedagogical synergy between both approaches and maps implementation patterns across diverse educational contexts.

From a practical perspective, the findings suggest that educators should prioritize structured project design, interdisciplinary alignment, and appropriate technological support when implementing PjBL–STEM learning. Policymakers and curriculum developers may also use these results to inform instructional frameworks that promote inquiry-based and technology-enhanced science learning.

Furthermore, this study identifies clear research gaps, including the need for longitudinal studies, standardized measurement of science process skills, and broader cross-disciplinary applications. Addressing these gaps will strengthen the evidence base and support more effective implementation of PjBL–STEM integration in future educational research.

CONCLUSIONS AND RECOMMENDATION

The integration of Project-Based Learning (PjBL) with the STEM approach constitutes an effective and innovative strategy for science education. This systematic literature review confirms that PjBL–STEM integration consistently improves students' science process skills and learning outcomes across elementary, secondary, and upper secondary education levels. The reviewed studies demonstrate that learners actively engage in inquiry-based activities, such as observing, questioning, experimenting, analyzing data, and communicating results, which are core indicators of science process skills. It also establishes that PjBL–STEM functions not only as an instructional model but also as a comprehensive framework for assessing cognitive, affective, and psychomotor learning outcomes. The synthesized evidence indicates that PjBL–STEM enhances problem-solving skills, scientific literacy, self-efficacy, and learning motivation, while promoting meaningful Learning through real-world and interdisciplinary problem contexts. These findings reinforce the patterns identified in the discussion, showing that PjBL–STEM supports both academic achievement and 21st-century skill development.

The findings provide important implications for teachers, curriculum developers, and educational policymakers**.** Teachers are encouraged to implement PjBL–STEM to foster active, student-centered Learning and inquiry-oriented science instruction. Curriculum designers may integrate PjBL–STEM principles to ensure alignment between learning objectives, instructional activities, and assessment of science process skills. Policymakers can facilitate broader implementation through professional development programs and institutional support for interdisciplinary and project-based Learning. This study also highlights directions for future research. Further studies should conduct meta-analyses to quantify the magnitude of PjBL–STEM effects on specific learning outcomes. In addition, experimental and longitudinal research designs are needed to examine the sustainability and generalizability of its impact across different subject areas and educational contexts. Research focusing on teacher readiness, implementation challenges, and the integration of digital learning media within PjBL–STEM environments would further strengthen the empirical foundation of this approach. The study provides a focused, synthesized understanding of PjBL–STEM integration, distinguishing it from prior reviews by explicitly linking instructional design, science process skills, and learning outcomes**.** The findings confirm the pedagogical value of PjBL–STEM and provide clear guidance for both educational practice and future research.

Credit authorship contribution statement

Sutanto: Conceptualization; Methodology; Data curation; Formal analysis; Investigation; Writing – original draft; Writing – review & editing; Visualization; Supervision; Project administration.

Declaration of competing interest

The author declares that there are no known competing financial interests or personal relationships that could have influenced the work reported in this paper.

Ethical Declaration

This article has not been previously published, and the author has not transferred any rights to it elsewhere. This article is the author's original work and correctly cites the work of others in accordance with the reference format. The author does not provide any personal information that could identify respondents in any form, including descriptions, photographs, or genealogies. If photographs of respondents are essential for scientific information, the author has obtained written consent and clearly states this.

Acknowledgment

The author would like to express sincere gratitude to all the researchers whose work was reviewed in this study. Appreciation is also extended to colleagues and reviewers for their valuable feedback and suggestions, which contributed to the improvement of this manuscript.

REFERENCES

Aureola, A. D., & Septian, G. A. (2020). Efektivitas Model Pembelajaran Project Based Learning Berbasis STEM dan Tidak Berbasis STEM Terhadap Keterampilan Berpikir Kritis Siswa. *Jurnal Basicedu*, 4(2), 344-354

Ayu, H. D., Alfianda, F. V., Sabrina, F., Prameswari, I., Putri, A. N., & Hudha, M. N. (2024). Systematic Literature Review: Project-Based Learning Terintegrasi dengan STEM. *Wiyata Dharma: Jurnal Penelitian Dan Evaluasi Pendidikan*, 11(2), 89-106. https://doi.org/10.30738/wd.v11i2.16492

Baran, M., Karakoyun, F., & Maskan, A. (2021). The Influence of Project-Based STEM (PjBL-STEM) Applications on the Development of 21st-Century Skills. *Journal of Turkish Science Education*, 18(4), 798–815. https://doi.org/10.36681/tused.2021.104

Bariyah, I. L. N., & Sugandi, M. K. (2022). Project Based Learning Untuk Meningkatkan Keterampilan Proses Sains Siswa Pada Konsep Ekosistem. *Prosiding Seminar Nasional Pendidikan* 4, 135-144. https://prosiding.unma.ac.id/index.php/semnasfkip/article/view/791

Bhakti, Y. B., Astuti, I. A., Okyranida, I. Y., Asih, D. A., Marhento, G., Leonard & Yusro, A. C. (2020). Integrated STEM Project Based Learning Implementation to Improve Student Science Process Skills. *IOP Conf. Series: Journal of Physics: Conf. Series*. 1-5. doi:10.1088/1742-6596/1464/1/012016

Caccamo, M., Pittino, D., & Tell, F. (2022). Boundary Objects, Knowledge Integration, And Innovation Management: A Systematic Review Of The Literature. *Journal Technovation*, 102645. https://doi.org/10.1016/j.technovation.2022.102645

Çevik, M., & Bakioğlu, B. (2022). The Effect of STEM Education Integrated Into Teaching-Learning Approaches (SEITLA) On Learning Outcomes: A Meta-Analysis Study. *International Journal of Progressive Education*, 18(2), 119–135. https://doi.org/10.29329/ijpe.2022.431.8

Chang, C & Chen, Y. (2022). Educational Values And Challenges Of I-STEM Project-Based Learning: A Mixed-Methods Study With Data-Transformation Design. *Journal Frontiers in Psychology*. 13:976724. doi: 10.3389/fpsyg.2022.976724

Esthi, RR Srigati. (2020). Uji Pembelajaran Berbasis Proyek (PjBL-STEM) untuk Meningkatkan Literasi Sains pada Siswa MTsN 28 Jakarta Timur. *Jurnal Balai Diklat Keagamaan Jakarta*. 1(2), 141-152

Fatimah, H. & Bramastia. (2022). Literature Review Project Based Learning Berbasis TIK. *Edukatif: Jurnal Ilmu Pendidikan*, 4(5), 7347-7357. DOI : https://doi.org/10.31004/edukatif.v4i5.3782

Firdausi, N., Sugiharto, B., & Karyanto, P. (2025). A Systematic Literature Review: Project-Based Learning to Empower Students' Science Process Skills. *Jurnal PAJAR (Pendidikan dan Pengajaran)*, 9(3), 315-325. DOI: http://dx.doi.org/10.33578/pjr.v9i3.112.

Gale, J. (2020). Exploring Critical Components Of An Integrated STEM Curriculum: An Application Of The Innovation Implementation Framework. *International Journal of STEM Education*, 7(1), 1–17

Hart, J. (2019). Interdisciplinary Project-Based Learning As A Means Of Developing Employability Skills In Undergraduate Science Degree Programs. *Journal of Teaching and Learning for Graduate Employability*, 10(2), 50–66. https://doi.org/10.21153/jtlge2019vol10no2art827

Hero, L. M. & Lindfors, E. (2019). Students Learning Ecperinece in a Multidiciplinary Innovation Project. *Journal Education*, 61(4), 500–522. https://doi.org/10.1108/ET-06-2018-0138

Izzah, N. & Mulyana, I. (2021). Meta Analisis Pengaruh Integrasi Pendidikan STEM dalam Model Project Based Learning Terhadap Hasil Belajar Siswa. *Journal of physics Learning Research*. 7(1), 65 – 76

Jatmika, S., Lestari, S., Rahmatullah, R., Pujianto, P., & Dwandaru, W. S. B. (2020). Integrasi Project Based Learning Dalam Science Technology Engineering And Mathematics Untuk Meningkatkan Keterampilan Proses Sains Dalam Pembelajaran Fisika. *Jurnal Pendidikan Fisika Dan Keilmuan (JPFK)*, 6(2), 107-119

Juškevičienė, A., Dagienė, V., & Dolgopolovas, V. (2021). Integrated Activities in STEM Environment: Methodology and Implementation Practice. *Computer Applications in Engineering Education*, 29(1), 209-228.

Mufida, S. N., Sigit, D. V., & Ristanto, R. H. (2020). Integrated Project-Based E-Learning With Science, Technology, Engineering, and Mathematics (PjBL-STEM): Its Effect On Science Process Skills. *Biosfer: Jurnal Pendidikan Biologi*, 13(2), 183-200

Mutiani, M., Syarifuddin, S., Syaharuddin, S., Hassan, M. I. bin A., Jumriani, J., & Nur'aini, F. (2024). The Effectiveness of Flipbook-Based Blanded Leaning Technology on Thinking Skills and Student Learning Outcomes. *International Journal of Social Learning (IJSL)*, 5(1), 264–275. https://doi.org/10.47134/ijsl.v5i1.350

Muzana, S. R., Jumadi, Wilujeng, I., Yanto, B. E., & Mustamin, A. A. (2021). E-STEM Project-Based Learning In Teaching Science To Increase ICT Literacy And Problem Solving. *International Journal of Evaluation and Research in Education*, 10(4), 1386–1394. https://doi.org/10.11591/IJERE.V10I4.21942

Nora, Y., Ambiyar., & Aziz, I. (2022). Evaluation Of Project-Based Learning In Social Sciences Learning Subjects In Elementary Schools. *Jurnal PAJAR (Pendidikan dan Pengajaran)*, 7(1), 75-82. DOI: http://dx.doi.org/10.33578/pjr.v7i1.9060.

Okilanda, A., Suganda, M. A., Mardesia, P., Suryadi, D., Wahyuni, D., Widyastuti, S. R., Samodra, J., Touvan, Y. & Kurniawan, F. (2023). Blended Learning And Online Learning With Project-Based Learning: Do They Affect Cognition And Psychomotor Learning Achievement In Physical Conditions?. *Retos: Nuevas Perspectivas de Educación Física*, 50, 556-565. DOI: 10.47197/retos.v50.99965

Okulu, H. Z., & Unver, A. O. (2021). The Development and Evaluation of a Tool to Determine the Characteristics of STEM Activities. *European Journal of STEM Education*, 6(1), 1–14. DOI: 10.20897/ejsteme/10894

Onto, E. A., Gustina, Paramita, I. dan Saehana, S. (2024). Pengaruh Model Project Based Learning Terintegrasi Science Technology Engineering And Mathematics Terhadap Hasil Belajar Ipa Siswa SMP Negeri 13 Sigi. *Jurnal Pendidikan Fisika Tadulako (JPFT)*, 12(2), 118-125, DOI: 10.22487/jpft.v12i2.3505

Purwaningsih, E., Sari, S. P., Sari, A. M., & Suryadi, A. (2020). The Effect of STEM-PJBL and Discovery Learning On Improving Students' Problem-Solving Skills Of The Impulse and Momentum Topic. *Jurnal Pendidikan IPA Indonesia*, 9(4), 465–476. https://doi.org/10.15294/jpii.v9i4.26432

Schneider, B., Chen, C., Bradford, & Bartz, K. (2022). Intervention Initiatives To Raise Young People's Interest and Participation in STEM. *Journal Frontiers in Psychology*. doi: 10.3389/fpsyg.2022.960327

Selfiana, Putri, R. E., Sari, M. P., Yurnetti & Muttaqiin. (2024). Pengaruh Penerapan Model PjBL Terintegrasi STEM terhadap Hasil Belajar dan Keterampilan Kolaborasi Siswa Kelas VIII SMP. *Jurnal Pendidikan Tambusai*, 8(3), 434-447.

Septi, R. I., & Susilowati. (2020). The Effect of Model Project-Based Learning Approach on STEM (Science, Technology, Engineering and Mathematics) on Science Learning to Junior High School Students Critical Thinking Skills and Cooperative Skills. *Journal of Science Education Research*, 4(1), 5-10. DOI: 10.21831/jser.v4i2.35717

Sumarni, W., & Kadarwati, S. (2020). Ethno-STEM Project-Based Learning: Its Impact To Critical And Creative Thinking Skills. *Jurnal Pendidikan IPA Indonesia*, 9(1), 11–21. https://doi.org/10.15294/jpii.v9i1.21754

Sylvia, N. W., Yamtinah, S., & Susanti, E. V. (2020). Pengaruh Model Project Based Learning Terintegrasi STEM (PjBL-STEM) Terhadap Kemampuan Berpikir Tingkat Tinggi pada Materi Asam dan Basa Kelas XI Di SMA Negeri 3 Surakarta Tahun Pelajaran 2018/2019. *Jurnal Pendidikan Kimia*, 9(1), 47-53

Tarigan, R. I., Silaban, P. J., Sari H. S, D.W., Abi, A.R., & Pinem, I. (2025). The Effect of the Big Book Media-Based Discovery Learning Model on Class III Students' Learning Outcomes on Theme 7 Technological Development at Agia Sophia Private Elementary School. *Jurnal PAJAR (Pendidikan dan Pengajaran)*, 9(1), 49-67. DOI: http://dx.doi.org/10.33578/pjr.v9i1.10042

Topsakal, İ., Yalçın, S. A., & Çakır, Z. (2022). The Effect Of Problem-Based Stem Education On The Students' Critical Thinking Tendencies And Their Perceptions For Problem Solving Skills. *Science Education International*, 33(2), 136-145. DOI: https://doi.org/10.33828/sei.v33.i2.1

Tulniza, F. & Hidayati, N. (2020). Pengembangan Aplikasi Android Komik Interaktif Berbasis STEM-PjBL Sebagai Media Pembelajaran pada Materi Sistem Pernapasan Pada Manusia. *Prosiding Seminar Nasional IKIP Budi Utomo*, 1(1), 747–753. http://ejurnal.budiutomomalang.ac.id/index.php/prosidinghttps://doi.org/10.33503/prosiding.v1i01.970

Utomo, R. H., Sudiyanto & Supianto. (2025). The Role of STEM-Based Project-Based Learning in Developing Future Competencies: A Systematic Review. *Jurnal TEKNODIKA*. 23(01), 12-26