EDUCARE Journal of Primary Education
ISSN 2716-1021 (p) 2716-1013 (e)
OPEN ACCESS
https://educare.uinkhas.ac.id/index.php/jie
DOI: 10.35719/educare.v7i1.414
Vol 7, No 1, 2026, pp. 81-98

Core educational benefits of project-based learning: A systematic literature review

Moh. Abdul Qohar[1*], Muhammad Hasan Asnawi[2], Nawal Ika Susanti[3], Siti Nur Azizah[4], Ahmad Sofiyullah[5]

[1,2,3,4,5] Universitas KH. Mukhtar Syafaat, Banyuwangi, East Java, Indonesia

Article Information:

Received 2026-04-03
Revised 2026-06-23
Published 2026-07-31

Keywords:
Project-Based Learning; Educational Benefits; Student Outcomes; Systematic Literature Review.

ABSTRACT

Project-Based Learning (PBL) has gained increasing attention as an instructional approach that promotes active, contextual, and learner-centered education. Although previous studies have reported diverse educational outcomes of PjBL, existing evidence remains fragmented across specific outcomes, limiting understanding of how these benefits are interconnected. This study aims to systematically review and synthesize the core educational benefits of PjBL based on recent empirical evidence. A systematic review and thematic synthesis were conducted following the PRISMA 2020 framework. The literature search was performed in the Scopus database for publications from January 2020 to August 2026. Studies were included if they reported original empirical findings on PjBL implementation in formal educational settings. Of 16 identified records, four empirical studies met the eligibility criteria and were included in the thematic synthesis. Five interconnected dimensions of PjBL benefits were identified: cognitive competence and critical thinking; creativity and innovation; learning engagement, autonomy, and self-regulation; collaboration and communication; and conceptual mastery, contextual application, and academic performance. Evidence was relatively more consistent for cognitive development, student engagement, collaboration, conceptual understanding, and academic outcomes, whereas creativity and communication showed more context-dependent patterns. These variations suggest that specific outcomes may depend on project design, student autonomy, instructional scaffolding, implementation duration, and assessment conditions. This review offers a process-oriented understanding of PjBL by conceptualizing its benefits as interconnected outcomes that emerge through engagement, inquiry, self-regulation, collaboration, and knowledge application. However, given the limited number and contextual diversity of included studies, the findings should be interpreted as recurring patterns within the eligible evidence rather than universal effects of PjBL.

Copyright: © The author (s) 2026
This work is licensed under a Attribution-ShareAlike 4.0 International (CC BY-SA 4.0).

To cite this article (APA Style):
Qohar, M. A., Asnawi, M. H., Susanti, N. I., Azizah, S. N., & Sofiyullah, A. (2026). Core educational benefits of project-based learning: A systematic literature review. *EDUCARE Journal of Primary Education, 7(1)*, 81–98. https://doi.org/10.35719/educare.v7i1.414

[*]**Corresponding Author**: Moh. Abdul Qohar, Mathematics Education Study Program, Faculty of Tarbiyah and Teacher Training, Universitas KH. Mukhtar Syafaat, Banyuwangi, East Java, Indonesia, email: mohabdulqohar@iaida.ac.id

INTRODUCTION

Contemporary education faces the challenge of preparing students not only to master disciplinary knowledge but also to think critically, collaborate effectively, communicate clearly, and manage their learning independently amid increasing academic, professional, and social complexities (Petrychenko et al., 2023; Hmelo-Silver, 2004). In response to these demands, Project-Based Learning (PjBL) has emerged as an approach that positions students as active participants by engaging them in authentic problem inquiry, decision-making, collaboration, and the production of meaningful outcomes over an extended period (Guo et al., 2020; Hussein, 2021; Novalia et al., 2025). The theoretical foundations of PjBL are rooted in constructivism, which views knowledge as constructed through social interaction and experience, and in experiential learning, which emphasizes the development of meaningful learning through the application of knowledge and reflection on decisions made (Wiyono et al., 2025; Zhang et al., 2022). By integrating these principles, PjBL provides a structured learning environment that connects conceptual knowledge with practical application through inquiry, collaboration, and reflection (Fleming, 2000; Kean & Kwe, 2014).

A review of the existing literature reveals three major trends in PjBL research. First, PjBL positively affects academic achievement, higher-order thinking skills, and creativity, although its effects vary according to educational level, subject area, instructional design, and the technology employed (Putri et al., 2024; Hasibuan et al., 2025; Chen & Yang, 2019). Second, context-specific studies tend to focus on particular outcomes or settings, such as creativity, higher-order thinking skills, STEM education, secondary education, and science learning, resulting in limited synthesis across multiple dimensions (Cao et al., 2025; Fauzi et al., 2025; Suyono et al., 2025; Susanto et al., 2025). Third, multidimensional syntheses have identified a wide range of PjBL benefits; however, the quality and consistency of the evidence vary, highlighting the need for an integrative understanding of recurring benefits, the interrelationships among outcomes, and the conditions influencing them (Farshad & Fortin, 2026; Zhang & Ma, 2023; De Los Reyes & Kazdin, 2008). Thus, previous studies have tended to examine the benefits of PjBL separately according to specific outcomes or contexts, while the relationships among these benefits and the mechanisms linking PjBL implementation to broader educational outcomes remain insufficiently understood.

These limitations are important because the benefits of PjBL do not necessarily emerge uniformly and are influenced by project design, learning processes, and implementation contexts. Overly structured projects may constrain creativity, while group work does not necessarily foster communication unless discussion, feedback, negotiation, and presentation activities are explicitly incorporated into the learning design. Therefore, understanding the benefits of PjBL requires consideration not only of its outcomes but also of the learning processes that connect project-based experiences with educational outcomes. Within this framework, engagement, inquiry, self-regulation, collaboration, and knowledge application may serve as mechanisms linking PjBL to cognitive, affective, behavioral, social, and academic development. In response to the identified gap, this study employs the concept of core educational benefits to identify recurring and conceptually relevant benefits without claiming their universality. It also distinguishes relatively consistent benefits from those that are sensitive to instructional design, educational level, subject area, technology use, and learning context.

Accordingly, this study aims to conduct a systematic review and thematic synthesis of the core educational benefits of Project-Based Learning (PBL) reported in recent primary empirical studies. It is guided by the following research question: What core educational benefits of PjBL are reported in primary empirical studies, and how are these benefits interconnected within the learning process? This study makes three main contributions. First, it provides a structured synthesis of PjBL outcomes across cognitive, affective, behavioral, social, and academic domains. Second, it examines engagement, inquiry, self-regulation, collaboration, and knowledge application as interconnected learning processes that link project-based experiences

to broader educational outcomes. Third, it distinguishes relatively consistent benefits from context-sensitive outcomes, thereby providing a more comprehensive understanding of the conditions that support the effectiveness of PjBL.

RESEARCH METHODS

This study employed a systematic review combined with thematic synthesis to identify the core educational benefits of Project-Based Learning (PBL). The review process followed the PRISMA 2020 reporting framework to ensure transparency and traceability throughout study identification, screening, eligibility assessment, and inclusion (van den Akker et al., 2023). In this study, *core educational benefits* are learning outcomes that recur across empirical studies that meet the inclusion criteria and play a conceptually significant role in explaining how PjBL supports the learning process.

The literature search was conducted in the Scopus database and covered publications issued between January 2020 and May 2026. The search strategy combined terms related to PjBL and educational outcomes using the following query: TITLE-ABS-KEY ("project-based learning" OR "project based learning" OR PjBL) AND ("critical thinking" OR "cognitive skill" OR creativ OR motivation OR engagement OR "self-regulation" OR collaboration OR communication OR "conceptual mastery" OR "academic performance" OR "learning outcome"). This strategy was designed to identify empirical studies examining a broad range of learning outcomes associated with PjBL implementation, encompassing cognitive, affective, behavioral, social, and academic domains.

Studies were included if they reported original empirical research on the implementation of PjBL in formal education, examined at least one cognitive, affective, behavioral, social, or academic outcome, were indexed in Scopus, provided full-text access, and were published in English or Indonesian. Studies were excluded if they were published outside the January 2020–May 2026 period; constituted systematic reviews, traditional literature reviews, meta-analyses, umbrella reviews, bibliometric analyses, conceptual articles, or non-empirical book chapters; were duplicate records; or did not report relevant empirical findings.

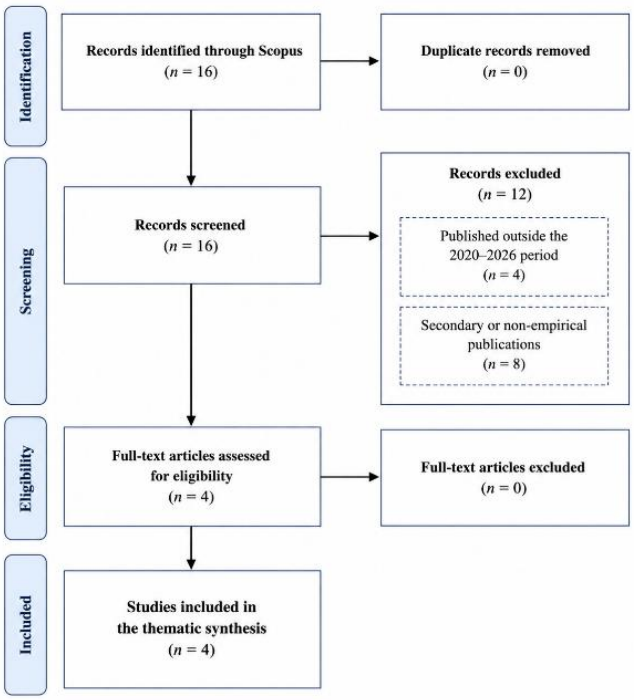
The Scopus search identified 16 unique records. Titles, abstracts, publication years, and document types were screened against the predetermined criteria. This initial screening excluded 12 records: four were published outside the specified period, while eight were classified as secondary or non-empirical publications. The four remaining articles were subsequently retrieved and assessed in full to determine their eligibility. All four articles satisfied the inclusion criteria and were therefore retained as primary empirical studies for the thematic synthesis. The complete selection procedure, including identification, screening, eligibility assessment, and final inclusion, is presented transparently in the PRISMA 2020 flow diagram (Figure 1 below).

Table 1
PRISMA 2020 Study-Selection Process

PRISMA stage	Number of records
Records identified through Scopus	16
Duplicate records removed	0
Records screened	16
Records excluded	12
├─ Published outside the January 2020–August 2026 period	4
└─ Secondary or non-empirical publications	8
Full-text articles assessed for eligibility	4
Full-text articles excluded	0
Studies included in the thematic synthesis	**4**

Source: Author's analysis (2026)

Figure 1
PRISMA 2020 Flow Diagram of the Study-Selection Process



Data were extracted using a standardized matrix covering the research context, participant characteristics, study design, features of the PjBL intervention, research instruments, measured outcomes, key findings, contradictory findings, and methodological limitations. This procedure ensured consistent identification of the principal characteristics and findings of each study that met the inclusion criteria. The methodological quality of each study was assessed using the Mixed Methods Appraisal Tool (MMAT), as the evidence base comprised quantitative and mixed-methods studies. Quality appraisal was used to inform the interpretation of each study's methodological strengths and limitations rather than to generate a single overall numerical score. This approach enabled the weighting of evidence from different research designs proportionately during the synthesis.

The findings were analyzed using thematic synthesis adapted from the approach developed by Thomas and Harden (Thomas & Harden, 2008; Sánchez-García & Angosto, 2026). The analysis involved several stages: repeated reading of all included studies, initial coding of relevant findings, grouping similar codes into descriptive themes, and developing higher-order analytical themes. A cross-study comparison was subsequently conducted to identify recurring patterns, context-dependent variations, non-significant results, and contradictory evidence. An outcome was classified as a *core educational benefit* when it was supported by empirical evidence from at least two studies and demonstrated conceptual relevance to the learning processes underlying PjBL. Conversely, findings reported in only one study were classified as *context-specific benefits*.

The credibility and dependability of the synthesis were strengthened by applying predefined eligibility criteria, standardized data-extraction procedures, documenting exclusion decisions, maintaining a coding audit trail, and repeatedly verifying the alignment between the generated themes and each study's original findings. Divergent or contradictory evidence was retained throughout the synthesis to minimize selective interpretation. Moreover, the methodological quality of each study was considered when determining the interpretive weight assigned to its findings. Given the relatively small number of studies meeting the inclusion criteria, the synthesis results were interpreted as emerging patterns within the eligible evidence base rather than as a statistical representation of the entire international literature on PjBL.

RESULTS AND DISCUSSION

Results

Characteristics of the included studies

The four studies that met the inclusion criteria were published between 2021 and 2026 and involved a total of 768 participants. Two studies were conducted in higher education, while the other two focused on secondary or vocational education across Saudi Arabia, Indonesia, and Ecuador. Methodologically, two studies employed quantitative survey designs with Structural Equation Modeling (SEM), whereas the remaining two used quasi-experimental designs, one of which incorporated mixed methods. Three studies integrated digital or mobile technologies into PjBL, while one combined PjBL with STEM in a vocational education context. Thus, the evidence included in this review predominantly represents technology-enhanced and STEM-oriented PjBL implemented in vocational and higher education settings. Consequently, the range of PjBL contexts represented in the current evidence base remains limited.

Table 2
Characteristics of the included studies

Code	Study	Country and context	Design and participants	PjBL characteristics	Main outcomes	Principal findings
S1	Al-Abdullatif and Gameil (2021)	Saudi Arabia; higher education	Quantitative survey and SEM; 185 female undergraduate education students	Fourteen-week digitally supported PjBL course integrating animations, augmented reality, social media, mobile applications, Blackboard, and other digital tools	Learning engagement; academic performance	Digitally supported PjBL was positively associated with learning engagement and academic performance. Learning engagement was also positively associated with academic performance.
S2	Fatimah and Sarbaini (2022)	Indonesia; vocational secondary education	Quantitative quasi-experiment; 60 Grade XI students	PjBL supported by mobile learning in crafts and entrepreneurship instruction	Cognitive skills; creativity	The experimental group showed greater descriptive gains in cognitive skills and creativity than the control group; however, inferential evidence for between-group differences was limited.
S3	Yusuf et al. (2023)	Indonesia; vocational education in software engineering	Quantitative survey and SEM; 283 students selected from a population of 1,043	Integration of STEM and PjBL	Critical thinking and problem-solving; creativity; collaboration; communication	STEM-integrated PjBL was positively associated with critical thinking and problem-solving, creativity, collaboration,

						and communication, although communication was the least strongly developed competency.
S4	Pomboza Floril et al. (2026)	Ecuador; four higher education programs	Mixed methods with a quasi-experimental pretest-posttest design; 240 students (120 experimental; 120 control)	Hybrid PjBL supported by Google Sites, Canva, Genially, virtual classrooms, and audiovisual applications	Conceptual mastery; contextual application; digital competence; teamwork; self-regulation; creativity and innovation	Significant posttest advantages favored PjBL in conceptual mastery, contextual application, digital technology use, and teamwork. Creativity and innovation did not differ significantly between groups.

Source: Author's analysis (2026).

Findings from the individual studies

Al-Abdullatif and Gameil (2021) examined 185 female undergraduate education students in a 14-week, digitally supported PjBL course integrating animations, augmented reality, social media, mobile applications, Blackboard, and other digital tools. SEM results indicated positive associations between PjBL and learning engagement and academic performance, while learning engagement was also positively associated with academic performance. However, the survey-based design does not permit causal conclusions.

Fatimah and Sarbaini (2022) employed a quasi-experimental design involving 60 vocational secondary students. The mean cognitive score in the experimental group increased from 44.50 to 78.17, corresponding to an N-Gain of 60.7%, compared with 40.0% in the control group. Creativity scores increased from 33.00 to 60.21 in the experimental group and from 42.48 to 53.58 in the control group, with N-Gain values of 40.8% and 26.3%, respectively. These descriptive gains indicate greater improvements in the PjBL group across both cognitive skills and creativity; however, the limited reporting of inferential statistics precludes firm conclusions regarding the statistical significance and precision of between-group differences.

Yusuf et al. (2023) surveyed 283 vocational software engineering students and used SEM to examine STEM-integrated PjBL. The findings indicated positive associations with critical thinking and problem-solving, creativity, collaboration, and communication. However, communication was the least effectively developed competency, suggesting that collaborative project participation does not necessarily produce equally strong development across all competencies.

Pomboza Floril et al. (2026) compared 120 students receiving hybrid, digitally mediated PjBL with 120 students receiving conventional instruction. Posttest results significantly favored PjBL in conceptual mastery, contextual application, digital technology use, and teamwork, with small-to-moderate effect sizes ranging from $r = 0.198$ for teamwork to $r = 0.271$ for digital technology use. Self-regulation was also identified as an outcome associated with the intervention, whereas creativity and innovation did not differ significantly between groups ($p = 0.082$).

Overall, the four studies indicate that PjBL is associated with diverse educational outcomes, including engagement, academic performance, cognitive skills, creativity, critical thinking, problem-solving, collaboration, communication, conceptual mastery, contextual application, digital competence, teamwork, and self-regulation. However, the evidence is not uniformly positive, with methodological differences and non-significant findings, particularly for creativity and innovation. These variations were retained in the thematic synthesis to distinguish recurrent educational benefits from context-dependent outcomes.

Methodological quality appraisal

The assessment using the Mixed Methods Appraisal Tool (MMAT) revealed variation in the methodological rigor and reporting completeness of the four studies. All studies had clearly defined research objectives and relevant data; however, they differed in participant selection, measurement quality, control of confounding variables, appropriateness of the analyses, and completeness of reporting. As no numerical MMAT scores were assigned, the appraisal findings were used to determine the level of interpretive confidence applied during the synthesis.

Pomboza Floril et al. (2026) provided the most comprehensive methodological reporting through a mixed-methods quasi-experimental design. The study demonstrated baseline comparability, employed validated instruments, applied appropriate quantitative and qualitative analyses, reported effect sizes, triangulated the data, and addressed divergent findings. However, the use of intact groups precluded random allocation. This study was therefore assigned moderate-to-high interpretive confidence.

Al-Abdullatif and Gameil (2021) provided relatively comprehensive information on sample characteristics, constructs, instrument reliability and validity, response rate, the structural model, and model-fit indices. The use of SEM was appropriate for the research objectives. However, the cross-sectional design and reliance on self-reported data limited causal inference, while the inclusion of only female students enrolled in a single course within an education program restricted the generalisability of the findings. This study was assigned moderate-to-high interpretive confidence.

Yusuf et al. (2023) employed a quantitative survey design using SEM, appropriate for the analytical objectives, involving 283 vocational education students. However, the reporting of the sampling procedures, non-response, and instrument validation could not be fully verified. Given its associational design, the findings were interpreted as relationships among variables rather than as evidence of causal effects. The study was therefore assigned moderate but provisional interpretive confidence.

Fatimah and Sarbaini (2022) employed a quasi-experimental design with pretest–posttest data, enabling comparisons between groups. However, inconsistencies were identified in the reporting of the educational context and study location. Information concerning group allocation and instrument validity was limited, and inferential statistics required to assess the precision of between-group differences were not reported comprehensively. Consequently, this study was assigned low-to-moderate interpretive confidence.

Table 3
Summary of the methodological quality appraisal

Study	Research question and data relevance	Participant selection	Measurement quality	Appropriateness of analysis	Main methodological concern	Interpretive confidence
Al-Abdullatif and	Yes	Appropriate for the institutional context	Adequately reported	Appropriate SEM and model-fit assessment	Single institution, all-female sample, and self-	Moderate to high

Gameil (2021)					reported outcomes	
Fatimah and Sarbaini (2022)	Yes	Some concerns	Cannot be fully determined	Some concerns	Inconsistent context reporting and incomplete inferential information	Low to moderate
Yusuf et al. (2023)	Yes	Cannot be fully determined	Cannot be fully determined	SEM was appropriate for the stated objective	Association-based design and incomplete reporting of several appraisal domains	Moderate, but provisional
Pomboza Floril et al. (2026)	Yes	Appropriate, with nonrandom group allocation acknowledged	Adequately reported and validated	Appropriate quantitative and qualitative analyses	Use of intact groups limited randomization	Moderate to high

Note. Interpretive confidence *is* a researcher-derived judgment and does not represent an official MMAT score or category.

Overall, the appraisal indicated that all four studies provided relevant evidence, although they varied in methodological rigour and reporting completeness. Findings from studies with greater methodological or reporting limitations, particularly Fatimah and Sarbaini (2022), were interpreted more cautiously. Conversely, findings supported by studies with more comprehensive methodological reporting, especially Pomboza Floril et al. (2026) and Al-Abdullatif and Gameil (2021), were assigned greater interpretive weight. Nevertheless, no study was excluded solely on the basis of the appraisal results, as all studies met the predefined inclusion criteria. The quality assessment findings were subsequently used to determine the relative weight of the evidence during the thematic synthesis.

Development of the thematic framework

The thematic synthesis generated five interconnected analytical dimensions from the extracted evidence: **(**1) cognitive competence and critical thinking; (2) creativity and innovation; (3) learning engagement, autonomy, and self-regulation; (4) collaboration and communication; and (5) conceptual mastery, contextual application, and academic performance**.** These dimensions were developed iteratively by moving from initial coding of relevant findings to the construction of descriptive themes and, subsequently, higher-order analytical themes. The synthesis also retained divergent and non-significant findings to distinguish consistently supported benefits from outcomes that appeared to be context-sensitive.

Table 4
Development of themes from the extracted evidence

Examples of initial codes	Descriptive theme	Analytical theme
Analyzing problems, selecting information, evaluating alternatives, applying reasoning, improving cognitive scores	Cognitive development and problem-solving	Cognitive competence and critical thinking
Generating ideas, producing original solutions, developing creative products, insignificant creativity difference	Creative development with variable effects	Creativity and innovation as a context-sensitive benefit
Active participation, enthusiasm, task responsibility, time management, independent use of technology	Behavioral and self-directed participation	Learning engagement, autonomy, and self-regulation

Sharing responsibilities, coordinating tasks, exchanging ideas, teamwork, weaker communication performance	Social interaction during project work	Collaboration and communication
Improving test scores, conceptual understanding, theory-practice transfer, contextual application, academic performance	Learning achievement and transfer	Conceptual mastery, contextual application, and academic performance

Source: Author's analysis (2026).

Study-to-Theme Contribution

The five analytical themes were not equally represented across the four included studies. Cognitive competence and critical thinking were supported by three studies, although the outcome was not directly examined in Al-Abdullatif and Gameil (2021). Creativity and innovation were examined in three studies but yielded mixed evidence, including a non-significant between-group difference reported by Pomboza Floril et al. (2026). Learning engagement, autonomy, and self-regulation were directly or indirectly supported by three studies, while collaboration and communication were supported by three studies but showed weaker communication outcomes in Yusuf et al. (2023). Conceptual mastery, contextual application, and academic performance received support from three studies, although it was not directly examined by Yusuf et al. (2023). These variations were considered when determining which outcomes represented recurrent *core educational benefits* and which were better interpreted as context-sensitive benefits.

Table 5
Contribution of the Included Studies to the Thematic Findings

Study	Cognitive competence and critical thinking	Creativity and innovation	Engagement, autonomy, and self-regulation	Collaboration and communication	Conceptual and academic outcomes
Al-Abdullatif and Gameil (2021)	Not directly examined	Not examined	Strong support	Indirectly represented through digitally supported PjBL	Strong support
Fatimah and Sarbaini (2022)	Support	Support, with reporting limitations	Supporting student-response evidence	Not directly measured	Support
Yusuf et al. (2023)	Support	Support	Not directly examined	Support, but communication was weaker	Not directly examined
Pomboza Floril et al. (2026)	Strong support	No significant between-group difference	Strong support	Strong support	Strong support

Source: Author's analysis (2026).

Theme 1: Cognitive competence and critical thinking

The first core educational benefit concerns the development of cognitive competence, critical thinking, and problem-solving skills, as supported by three studies. Fatimah and Sarbaini reported that students participating in technology-enhanced Project-Based Learning (PjBL) demonstrated greater improvements in cognitive competence than those in the control group. The experimental group's mean score increased by 33.67 points, from 44.50 to 78.17, and its N-gain score was also higher than that of the control group.

Yusuf et al. identified associations between STEM-integrated PjBL and critical-thinking and problem-solving skills among vocational education students. Meanwhile, Pomboza Floril et al. found significant posttest differences in conceptual mastery and the contextual application of knowledge. Their qualitative analysis also indicated that critical thinking was the most

frequently identified component, accounting for 68 of the 480 coded units of meaning. It was particularly evident in activities involving information analysis, comparison of alternative solutions, and critical consideration of decisions.

Overall, the three studies revealed a similar pattern involving engagement with authentic problems, the identification and selection of relevant information, and the application of knowledge to develop solutions. Thus, the cognitive benefits of PjBL extend beyond knowledge acquisition to include the abilities to analyse information, evaluate alternatives, make informed decisions, and solve problems contextually.

Theme 2: Creativity and innovation as a context-sensitive benefit

Creativity emerged as a learning outcome in three studies, although the findings were not entirely consistent. Fatimah and Sarbaini reported greater improvement in creativity among students in the PjBL group than in the control group. The experimental group's mean score increased from 33.00 to 60.21, whereas the control group's mean score increased from 42.48 to 53.58, with N-gain values of 40.8% and 26.3%, respectively.

Yusuf et al. also identified a positive association between STEM-integrated PjBL and creativity. This relationship was attributed to the interdisciplinary and project-based nature of the learning process, which enabled students to generate diverse solutions and engage in creative problem-solving. In contrast, Pomboza Floril et al. found no significant difference in creativity and innovation between the experimental and control groups ($p = .082$). The comparison of gain scores was also non-significant ($p = .675$). Although the experimental group achieved a higher posttest rank, the evidence was insufficient to demonstrate a conclusive difference.

Thus, creativity does not appear to emerge automatically from PjBL implementation but rather constitutes a context-sensitive benefit. Variations across findings may be associated with the degree of project openness, intervention duration, level of student autonomy, opportunities for creative decision-making, and measurement instruments employed. Because creativity was supported by more than one study but yielded inconsistent results, it was retained as a context-sensitive benefit rather than an outcome that consistently occurs across all PjBL implementations.

Theme 3: Learning engagement, autonomy, and self-regulation

The third theme concerns students' active participation and capacity to manage their learning independently. Al-Abdullatif and Gameil identified a strong positive association between digitally supported PjBL and learning engagement ($\beta = .61$, $t = 9.55$). Learning engagement was also positively associated with academic achievement ($\beta = .18$, $t = 2.66$). These findings suggest that learning engagement functions as an intermediate process linking participation in project-based learning to academic outcomes.

Pomboza Floril et al. found significant differences in teamwork and self-regulation for both posttest scores ($p = .002$, $r = .198$) and gain scores ($p = .012$). Their qualitative analysis also identified autonomy and self-regulation in 52 coded units of meaning, as reflected in students' abilities to manage their time, assume responsibility, and continue learning independently beyond the classroom. Fatimah and Sarbaini similarly reported greater enthusiasm, a stronger focus on learning, and more positive responses among students in the experimental group. However, the limited questionnaire evidence was treated as supplementary evidence.

Overall, learning engagement in PjBL encompasses active participation, sustained effort, time management, task responsibility, and the independent use of learning resources. Engagement, autonomy, and self-regulation can therefore be understood as enabling processes that support the development of various other positive outcomes within PjBL.

Theme 4: Collaboration and communication

Collaboration and communication constitute the principal social dimensions identified in the synthesis. Yusuf et al. found positive associations between STEM-integrated PjBL and students' collaboration and communication skills, although communication developed less strongly than critical thinking, creativity, and collaboration. This finding suggests that group activities can strengthen coordination and shared responsibility but do not automatically lead to comparable improvements in communication skills.

Pomboza Floril et al. also reported significant differences in teamwork and found that students shared responsibilities, organised tasks, communicated asynchronously, and used digital tools to coordinate their projects. Structured observations indicated moderate-to-high levels of collaborative performance.

Across the studies, collaboration was reflected in task distribution, coordination, shared responsibility, and collective project completion, whereas communication involved articulating ideas, participating in discussions, exchanging feedback, negotiating, and communicating decisions. The evidence for collaboration was stronger and more consistent than that for communication. Thus, PjBL provides a supportive context for teamwork, whereas the development of communication appears to depend more strongly on explicitly designed opportunities for presentations, feedback exchange, argumentation, and guided interaction.

Theme 5: Conceptual mastery, contextual application, and academic performance

The fifth theme concerns conceptual mastery, knowledge application, and academic performance. Al-Abdullatif and Gameil identified a positive association between digitally supported PjBL and academic performance ($\beta = .30$, $t = 5.11$), with learning engagement serving as a partial mediator. Fatimah and Sarbaini similarly reported greater improvements in cognitive learning outcomes among students in the experimental group than in the control group, although reporting limitations limited confidence in the magnitude of the observed effect.

Pomboza Floril et al. found significant posttest differences in conceptual mastery ($p < .001$, $r = .220$) and the application of knowledge in real-world contexts ($p < .001$, $r = .247$). The experimental group also demonstrated greater improvement in conceptual mastery than the control group ($p = .034$). Qualitative evidence indicated that students were able to connect theoretical content with project requirements and apply their knowledge to address contextual problems.

Overall, the findings indicate two interrelated outcomes: conceptual mastery and academic performance, and the application of knowledge in real-world contexts. As the available evidence directly supports academic outcomes, conceptual mastery, and contextual application but remains insufficient to establish product quality as a distinct outcome, this theme was retained as Conceptual Mastery, Contextual Application, and Academic Performance.

Cross-study convergence and divergence

The synthesis revealed three main areas of convergence. First, all four studies reported at least one positive educational outcome associated with PjBL, with relatively consistent evidence regarding cognitive competence or conceptual mastery, learning engagement, teamwork, and academic performance. Second, the integration of digital technology facilitated access to information, task organisation, asynchronous collaboration, product development, and continuity between classroom-based and independent learning. However, the contribution of technology depended on its ease of use, pedagogical relevance, connectivity, and students' ability to use it strategically. Third, the benefits of PjBL were interconnected: engagement and self-regulation supported sustained participation, while collaboration facilitated knowledge exchange and task completion. Together, these processes contributed to conceptual mastery and academic performance.

Conversely, two main areas of divergence were identified. First, the findings regarding creativity were inconsistent: two studies reported positive results, whereas a quasi-experimental study with relatively greater methodological rigour found no significant difference. Second, communication developed less strongly than collaboration and the other 4C competencies in the study of STEM-integrated PjBL. Thus, the five themes were not supported by equally consistent evidence. Cognitive competence, engagement, collaboration, and academic performance demonstrated stronger convergence, whereas creativity and communication appeared more sensitive to learning conditions and the contexts in which PjBL was implemented.

Integrated thematic synthesis

The analytical synthesis generated a process-oriented framework comprising three interconnected layers. The first layer represents the instructional structure of Project-Based Learning (PjBL), encompassing authentic problems, sustained projects, collaborative responsibility, tangible outputs or products, and, in three studies, the integration of digital technology. The second layer comprises enabling learning processes, including active engagement, autonomy, self-regulation, inquiry, information analysis, collaboration, communication, and the integration of theory and practice. The third layer encompasses educational outcomes, including cognitive competence, critical thinking, conceptual mastery, contextual application, creativity, teamwork, and academic performance.

The relationship among these layers can be expressed as follows:

Figure 2

Process-Oriented Framework of PjBL Educational Benefits



Note: Project activities establish the learning conditions that activate enabling processes, which subsequently contribute to cognitive, social, and academic outcomes.

This framework indicates that the benefits of PjBL emerge through learning processes that link project structures to diverse educational outcomes. Digital technology functions as an enabling condition rather than an outcome in itself and can enhance access to information, coordination, learning flexibility, and product development. Meanwhile, creativity and communication appear to be more sensitive to learning conditions. Creativity may require open-ended projects, student autonomy, and sufficient time to develop original ideas, whereas communication requires explicitly designed opportunities for discussion, presentation, feedback exchange, and negotiation.

Thus, the synthesis suggests that PjBL does not produce educational benefits directly or uniformly but operates through a series of interconnected learning processes. Authentic and collaborative project structures create conditions that foster engagement, inquiry, self-regulation, and collaboration, thereby supporting the development of cognitive, social, and academic competencies. The less consistent findings, particularly regarding creativity and communication, indicate that these benefits depend on how the project-based learning environment is designed and facilitated.

Adequacy and representativeness of the evidence

The four studies comprised all primary empirical publications that met the inclusion criteria based on the documented Scopus search. This evidence base was sufficient to identify recurring themes and develop a thematic interpretation bounded by the characteristics of the available evidence. However, it should not be regarded as statistically representative of the entire international literature on Project-Based Learning (PjBL).

The evidence was concentrated in three countries and derived primarily from vocational secondary and higher education contexts. Three of the four studies examined technology-supported PjBL, while one integrated PjBL with STEM. No included study represented early childhood education, primary education, general secondary education outside vocational settings, or PjBL implementation without substantial technological or STEM integration.

Methodological heterogeneity further limited the generalizability of the findings. Survey-based studies employing Structural Equation Modeling (SEM) can demonstrate associations among variables but cannot establish causal effects. The quasi-experimental studies provided stronger comparative evidence, although one had substantial reporting limitations and the other used intact groups without randomization.

Accordingly, the five themes should be understood as recurring, conceptually salient dimensions within the evidence base that meet the inclusion criteria, rather than as universally applicable benefits across all PjBL implementations. Interpretive confidence was relatively stronger for cognitive competence and conceptual mastery, engagement and self-regulation, collaboration, and academic performance, whereas creativity and communication are more appropriately regarded as promising but context-sensitive benefits.

Discussion

This systematic review and thematic synthesis identified five interconnected dimensions of the educational benefits of Project-Based Learning (PjBL): cognitive competence and critical thinking; creativity and innovation; learning engagement and self-regulation; collaboration and communication; and conceptual mastery and academic performance. The findings indicate that PjBL operates through interconnected pedagogical processes in which authentic project tasks encourage students to participate actively, investigate problems, apply knowledge, manage responsibilities, and interact with peers. However, the consistency of the evidence varied across dimensions. Cognitive competence, learning engagement, collaboration, and academic achievement demonstrated relatively consistent patterns, whereas creativity and communication appeared more sensitive to instructional design and implementation context. Thus, the benefits of PjBL should not be understood as uniform effects but as outcomes shaped by how the project environment is designed, facilitated, and aligned with learning objectives.

These findings are socially relevant to the global educational challenges of the post-pandemic period, in which student engagement and the development of higher-order thinking skills, including critical thinking, have become major concerns across education systems (UNESCO, 2024). In Indonesia, the PISA 2022 results indicated that only 18% of students achieved the minimum proficiency level in mathematics and 34% in science, highlighting persistent challenges in developing more complex academic competencies (OECD, 2023). At the same time, the demands of the twenty-first-century workplace increasingly emphasize the importance of creative thinking, collaboration, communication, and effective interpersonal interaction (World Economic Forum, 2023). In this context, PjBL has the potential to address these needs by integrating conceptual mastery, problem-solving, and the contextual application of knowledge, as demonstrated by Pomboza Floril et al. (2026) and Yusuf et al. (2023) in vocational education contexts. However, the mere inclusion of project activities does not guarantee the development of all targeted competencies; the effectiveness of PjBL remains dependent on the quality of instructional design, activity structure, and pedagogical facilitation.

Theoretically, these findings align with Vygotsky's social constructivist perspective, which conceptualizes learning as a process of knowledge construction through social interaction, experience, meaningful activities, and support from the learning environment. In PjBL, interactions among students and between students and educators enable learners to actively construct knowledge through contextualized tasks and projects (Gómez-del Río & Rodríguez, 2022; Marnewick, 2023). This pattern helps explain why cognitive competence, learning engagement, collaboration, and academic achievement demonstrated relatively consistent findings. Engagement, autonomy, and self-regulation can also be understood as enabling mechanisms that support sustained participation and independent learning management. This interpretation is consistent with self-determination theory, which emphasizes the importance of autonomy, competence, and social relatedness in facilitating motivation and self-regulation (Ryan & Deci, 2000). However, the less consistent findings concerning creativity and communication suggest that project structure alone may be insufficient. Explicit scaffolding, opportunities for revision, guided interaction, and adequate instructional time, as emphasized by Hmelo-Silver (2004), may constitute essential conditions for developing these outcomes.

These findings suggest that the pedagogical effectiveness of PjBL is not inherent in the method itself but depends on the alignment among project design, learning processes, student characteristics, and learning objectives (Chen & Yang, 2019; Guo et al., 2020). Within the evidence base, outcomes embedded directly in the project structure, such as engagement, collaboration, and task management, tended to demonstrate more consistent patterns (Guo et al., 2020; Splichal et al., 2018). In contrast, creativity and communication require more specific learning conditions (Kokotsaki et al., 2016). Creativity develops through opportunities to explore alternatives, experiment, and revise ideas, whereas communication requires opportunities to articulate ideas, exchange feedback, and negotiate (Kokotsaki et al., 2016). Thus, variations across implementations may indicate that different educational outcomes require distinct forms of instructional design and facilitation rather than merely reflecting inconsistencies in the effectiveness of PjBL (Anugraheni et al., 2025; Yusri et al., 2024). Given the heterogeneity in study designs, contexts, and outcome measures, causal claims about the effectiveness of PjBL should be made with caution.

These findings are consistent with the meta-analysis conducted by Chen and Yang (2019), which reported positive effects of PjBL on academic achievement and higher-order thinking skills, although effect sizes varied across contexts ($g = 0.65$ for academic achievement and $g = 0.71$ for thinking skills). This consistency is reflected in the present review through relatively strong evidence regarding cognitive competence, critical thinking, conceptual mastery, and academic performance. In line with Kokotsaki et al. (2016), this review also identified the multidimensional benefits of PjBL. However, unlike previous syntheses that have generally reported broad benefits of PjBL, the present synthesis demonstrates that creativity and communication do not consistently develop across contexts. This finding aligns with Farshad and Fortin (2026), who reported lower confidence in the evidence for creativity than in the evidence for academic achievement. The present review extends current understanding of PjBL by emphasizing the roles of engagement, learner autonomy, collaboration, communication, and reflection within the learning process, while also highlighting the need for more systematic assessment of both learning processes and final project outputs (Guo et al., 2020; Kokotsaki et al., 2016).

The pedagogical implications of these findings suggest that PjBL implementation should begin with clearly defined learning objectives and projects that require students to apply the targeted concepts and competencies, rather than merely produce an artifact or use technology. Projects should be sufficiently complex to stimulate inquiry while remaining manageable through structured stages, including problem identification, planning, evidence collection, solution development, feedback, and revision. Student autonomy should be supported through

scaffolding strategies such as milestones, rubrics, exemplars, and formative feedback. Collaboration and communication should also be assessed as distinct constructs, while creativity should be deliberately fostered through opportunities for exploration, experimentation, and revision. Digital technologies should be selected according to their pedagogical functions in supporting inquiry, collaboration, communication, and production. At the institutional level, teacher professional development should focus on strengthening educators' capacity to design, facilitate, and evaluate PjBL, accompanied by collaborative research to identify the most effective design conditions for achieving specific educational outcomes.

CONCLUSION

This systematic review and thematic synthesis identified five interconnected dimensions of the educational benefits of Project-Based Learning (PjBL): cognitive competence and critical thinking; creativity and innovation; learning engagement, autonomy, and self-regulation; collaboration and communication; and conceptual mastery, contextual application, and academic performance. The findings indicate that PjBL benefits do not emerge as isolated outcomes but through interconnected learning processes in which authentic project activities promote inquiry, engagement, self-regulation, collaboration, and knowledge application. Cognitive development, learning engagement, collaboration, conceptual mastery, and academic achievement showed relatively more consistent evidence, whereas creativity and communication appeared more sensitive to instructional design and implementation context. Thus, the educational value of PjBL depends not merely on assigning projects but on aligning authentic project structures with learning objectives, appropriate scaffolding, and meaningful interaction.

The principal contribution of this review is the conceptualization of PjBL as a multidimensional pedagogical process in which enabling learning processes connect project participation with cognitive, social, creative, and academic outcomes. This perspective suggests that different outcomes may require different instructional conditions: creativity requires opportunities for exploration, experimentation, and revision, while communication requires explicit opportunities for dialogue, argumentation, feedback, and negotiation. In practice, teachers should align projects with curriculum objectives, provide structured scaffolding and milestones, distinguish collaboration assessment from communication assessment, and integrate digital technologies according to their pedagogical functions. At the institutional level, professional development should strengthen teachers' capacity to design, facilitate, and evaluate PjBL.

These conclusions should nevertheless be interpreted cautiously because the synthesis included only four empirical studies from a limited range of countries, educational levels, and disciplinary contexts, with substantial representation of vocational, higher education, STEM, and technology-supported settings. Methodological heterogeneity and limited experimental evidence also constrain causal interpretation. Future research should therefore expand across educational levels, disciplines, geographical settings, and implementation conditions while providing clearer information on project duration, task complexity, student autonomy, teacher scaffolding, group organization, assessment, and implementation fidelity. Such evidence is needed to determine not only whether PjBL supports learning, but also which design conditions are most effective for specific educational outcomes.

ACKNOWLEDGEMENT

The authors would like to express their sincere gratitude to their colleagues and friends for their valuable support throughout the preparation of this article. Their willingness to engage in discussions, share constructive insights, and provide thoughtful suggestions contributed significantly to the refinement and completion of this manuscript. The authors also greatly

appreciate the encouragement and support, which motivated them to complete this article for publication.

AUTHOR CONTRIBUTION STATEMENT

Moh. Abdul Qohar: Conceptualization; Data Curation; Formal Analysis; Investigation; Methodology; Writing Original Draft; Writing Review & Editing. **Muhammad Hasan Asnawi:** Formal Analysis; Supervision; Validation; Writing Original Draft; Writing Review & Editing. **Nawal Ika Susanti:** Formal Analysis; Supervision; Validation; Writing Review & Editing. **Siti Nur Azizah:** Supervision; Validation; Writing Review & Editing**. Ahmad Sofiyullah:** Supervision; Validation; Writing Review & Editing.

REFERENCES

Al-Abdullatif, A. M., & Gameil, A. A. (2021). The effect of digital technology integration on students' academic performance through project-based learning in an e-learning environment. *International Journal of Emerging Technologies in Learning, 16*(11), 189–210. https://doi.org/10.3991/ijet.v16i11.19421

Anugraheni, I., Gufron, A., & Purnomo, Y. W. (2025). The impact of realistic problem-based learning on mathematical connection abilities: Evidence from elementary schools in Indonesia. *Cogent Education, 12(1)*, Article 2523078. https://doi.org/10.1080/2331186X.2025.2523078

Cao, X., Lu, H., Wu, Q., & Hsu, Y. (2025). Systematic review and meta-analysis of the impact of STEM education on students' learning outcomes. *Frontiers in Psychology, 16*, 1579474. https://doi.org/10.3389/fpsyg.2025.1579474

Chen, C.-H., & Yang, Y.-C. (2019). Revisiting the effects of project-based learning on students' academic achievement: A meta-analysis investigating moderators. *Educational Research Review, 26*, 71–81. https://doi.org/10.1016/j.edurev.2018.11.001

De Los Reyes, A., & Kazdin, A. E. (2008). When the evidence says, "Yes, no, and maybe so": Attending to and interpreting inconsistent findings among evidence-based interventions. *Current Directions in Psychological Science, 17*(1), 47–51. https://doi.org/10.1111/j.1467-8721.2008.00546.x

Farshad, S., & Fortin, C. (2026). An umbrella review of meta-analyses on project-based learning: Effects on academic achievement, higher-order thinking, and 21st-century skills. *Educational Research Review, 52*, 100809. https://doi.org/10.1016/j.edurev.2026.100809

Fatimah, & Sarbaini. (2022). Using project-based learning coupled with mobile learning technologies to enhance students cognitive skills: How the approach shapes creativity among learners in higher education. *International Journal of Applied Engineering & Technology, 4(2)*, 1–6. https://doi.org/10.5281/zenodo.7404339

Fauzi, W. N. A., Wuryandani, W., & Supartinah. (2025). Creative thinking in global primary education: Pedagogical innovations and learning outcomes through an integrated bibliometric and systematic review. *Social Sciences & Humanities Open, 12*, 102216. https://doi.org/10.1016/j.ssaho.2025.102216

Fleming, D. S. (2000). *A teacher's guide to project-based learning*. Scarecrow Education. https://eric.ed.gov/?id=ED469734

Gómez-del Río, T., & Rodríguez, J. (2022). Design and assessment of a project-based learning in a laboratory for integrating knowledge and improving engineering design skills. *Education for Chemical Engineers, 40*, 17–28. https://doi.org/10.1016/j.ece.2022.04.002

Guo, P., Saab, N., Post, L. S., & Admiraal, W. (2020). A review of project-based learning in higher education: Student outcomes and measures. *International Journal of Educational Research, 102*, 101586. https://doi.org/10.1016/j.ijer.2020.101586

Hasibuan, M. T. D., & Sunarno, W. (2025). Creative thinking enhancement through project-based learning in science: A meta-analytic review. *International Journal of Evaluation and Research in Education, 14*(5), 3994–4005. https://doi.org/10.11591/ijere.v14i5.34521

Hmelo-Silver, C. E. (2004). Problem-based learning: What and how do students learn? *Educational Psychology Review, 16*(3), 235–266. https://doi.org/10.1023/B:EDPR.0000034022.16470.f3

Hussein, B. (2021). Addressing collaboration challenges in project-based learning: The student's perspective. *Education Sciences, 11*(8), 434. https://doi.org/10.3390/educsci11080434

Kean, A. C., & Kwe, N. M. (2014). Meaningful learning in the teaching of culture: The project-based learning approach. *Journal of Education and Training Studies, 2*(2), 189–197.

Kokotsaki, D., Menzies, V., & Wiggins, A. (2016). Project-based learning: A review of the literature. *Improving Schools, 19(3)*, 267–277. https://doi.org/10.1177/1365480216659733

Marnewick, C. (2023). Student experiences of project-based learning in agile project management education. *Project Leadership and Society, 4*, 100096. https://doi.org/10.1016/j.plas.2023.100096

Novalia, R., Marini, A., Bintoro, T., & Muawanah, U. (2025). Project-based learning: For higher education students' learning independence. *Social Sciences & Humanities Open, 11*, 101530. https://doi.org/10.1016/j.ssaho.2025.101530

OECD. (2023). *PISA 2022 results (Volume I and II): Country notes—Indonesia*. OECD Publishing. https://www.oecd.org/en/publications/pisa-2022-results-volume-i-and-ii-country-notes_ed6fbcc5-en/indonesia_c2e1ae0e-en.html?utm

Petrychenko, O., Petrichenko, I., Burmaka, I., & Vynohradova, A. (2023). Changes in modern university: Challenges of today and development trends. *Transport Systems and Technologies*, (41), 74–83. https://doi.org/10.32703/2617-9059-2023-41-6

Pomboza Floril, C. A., Pomboza Floril, M. D. R., Radicelli García, C. D., Cuji Sains, M. A., Morales Fiallos, J. R., & Riera Pomboza, S. A. (2026). Project-based learning with digital technologies and competency development in hybrid higher education. *Frontiers in Education, 11*. https://doi.org/10.3389/feduc.2026.1847905

Putri, J. H., Diva, D. F., Dalimunthe, N. F., Prasiska, M., & Irani, A. R. (2024). Miskonsepsi dalam pembelajaran matematika: Sebuah tinjauan literatur terhadap penelitian-penelitian terbaru. *JagoMIPA: Jurnal Pendidikan Matematika dan IPA, 4*(3), Article 3. https://doi.org/10.53299/jagomipa.v4i3.749

Ryan, R. M., & Deci, E. L. (2000). Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being. *American Psychologist, 55(1)*, 68–78. https://doi.org/10.1037/0003-066X.55.1.68

Sánchez-García, R., & Angosto, S. (2026). Mapping the path to effective project-based learning: A systematic review and analysis of models and practices. *Humanities and Social Sciences Communications*. https://doi.org/10.1057/s41599-026-07870-0

Splichal, J. M., Oshima, J., & Oshima, R. (2018). Regulation of collaboration in project-based learning mediated by CSCL scripting reflection. *Computers & Education, 125*, 132–145. https://doi.org/10.1016/j.compedu.2018.06.003

Susanto, S., Wilujeng, I., Haryanto, Imami, M. K. W., Hidayat, R., & Uslan. (2025). The implementation of project-based learning in empowering students' higher-order thinking skills: A systematic literature review. *Multidisciplinary Reviews, 9(6)*, 2026286. https://doi.org/10.31893/multirev.2026286

Suyono, S., Tukiran, T., & Yuliaturosida, E. (2025). Exploring project-based learning for enhancing creative thinking in high schools: A bibliometric analysis and literature review.

Educational Process: International Journal, 18. https://doi.org/10.22521/edupij.2025.17.480

Thomas, J., & Harden, A. (2008). Methods for the thematic synthesis of qualitative research in systematic reviews. *BMC Medical Research Methodology, 8*(1), 45. https://doi.org/10.1186/1471-2288-8-45

UNESCO. (2024). *Addressing students' learning gaps to ensure quality learning for all children and prevent drop-out in Asia-Pacific*. UNESCO. https://www.unesco.org/en/articles/project-brief-note-addressing-students-learning-gaps-ensure-quality-learning-all-children-and?hub=66925&utm

van den Akker, O. R., Peters, G.-J. Y., Bakker, C. J., Carlsson, R., Coles, N. A., Corker, K. S., Feldman, G., Moreau, D., Nordström, T., Pickering, J. S., Riegelman, A., Topor, M. K., van Veggel, N., Yeung, S. K., Call, M., Mellor, D. T., & Pfeiffer, N. (2023). Increasing the transparency of systematic reviews: Presenting a generalized registration form. *Systematic Reviews, 12*(1), 170. https://doi.org/10.1186/s13643-023-02281-7

Wiyono, B. B., Imron, A., Sumarsono, R. B., Musa, K., & Binti Mohd. Saat, R. (2025). The effect of constructivist learning and project-based learning model on students' entrepreneurial competence in higher education. *Cogent Education, 12(1)*. https://doi.org/10.1080/2331186X.2025.2557606

World Economic Forum. (2023). *The future of jobs report 2023*. World Economic Forum. https://www.weforum.org/publications/the-future-of-jobs-report-2023/?utm

Yusri, R., Yusof, A. M., & Sharina, A. (2024). A systematic literature review of project-based learning: Research trends, methods, elements, and frameworks. *International Journal of Evaluation and Research in Education, 13(5)*, 3345–3359. https://doi.org/10.11591/ijere.v13i5.27875

Yusuf, A. R., Sutadji, E., & Sugandi, M. (2023). Integration of STEM project-based learning into 21st century learning and innovation skills (4Cs) in vocational education using SEM model analysis. *Hacettepe Egitim Dergisi, 38*(4), 454–469. https://doi.org/10.16986/HUJE.2023.499

Zhang, L., & Ma, Y. (2023). A study of the impact of project-based learning on student learning effects: A meta-analysis study. *Frontiers in Psychology, 14*. https://doi.org/10.3389/fpsyg.2023.1202728

Zhang, M. J., Croiset, E., & Ioannidis, M. (2022). Constructivist-based experiential learning: A case study of student-centered and design-centric unit operation distillation laboratory. *Education for Chemical Engineers, 41*, 22–31. https://doi.org/10.1016/j.ece.2022.09.002

Zhou, X., & Tsai, C.-W. (2023). The effects of socially shared regulation of learning on the computational thinking, motivation, and engagement in collaborative learning by teaching. *Education and Information Technologies, 28*(7), 8135–8152. https://doi.org/10.1007/s10639-022-11527-1