Multidisciplinary Reviews

REVIEW ARTICLE
Published Online: November 27, 2025
https://doi.org/10.31893/multirev.2026286

The implementation of project based learning in empowering student's higher-order thinking skills: A systematic literature review

Sofyan Susanto[a] | **Insih Wilujeng**[a] | **Haryanto**[a] | **Muh Khairul Wajedi Imami**[b] ✉ | **Riyan Hidayat**[c] | **Uslan**[d]

[a]Universitas Negeri Yogyakarta, Yogyakarta, Indonesia.
[b]Sultan Idris Education University, Tanjong Malim, Malaysia.
[c]Universiti Putra Malaysia, Serdang, Malaysia.
[d]Universitas Muhammadiyah Kupang, Kupang, East Nusa Tenggara, Indonesia.

Abstract High Order Thinking Skills (HOTS), encompassing critical, creative, and analytical thinking, are fundamental to preparing students for the challenges of the 21st century. In this context, project-based learning (PjBL) has been widely recognized as a pedagogical approach with the potential to strengthen these skills by engaging learners in meaningful, inquiry-driven, and collaborative tasks. This study systematically reviews existing literature to investigate the extent to which PjBL contributes to enhancing students' HOTS. Following the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) guidelines and employing the rigorous 10-step procedure outlined by Joklitschke et al. (2021), the review ensures methodological validity and reliability. Searches were conducted in reputable databases including ERIC, Scopus, and ProQuest, yielding 48 relevant articles for in-depth analysis. The findings demonstrate that the majority of studies employed quantitative research methods, with a particular emphasis on science education. Within these studies, HOTS were frequently assessed through indicators such as creative thinking, critical thinking, and problem-solving abilities. The analysis highlights a consistently positive impact of PjBL on enhancing students' HOTS, with STEM-based projects identified as the most common and effective implementations across the reviewed literature. These results suggest that PjBL not only fosters academic achievement but also supports the holistic development of learners by cultivating essential cognitive and metacognitive skills. The implications of this study are twofold. First, it underscores the importance of integrating PjBL into various subject areas beyond science to maximize its potential in nurturing HOTS. Second, it provides educators and policymakers with evidence-based insights to design instructional practices that more effectively promote students' critical, creative, and analytical abilities. Overall, this systematic review affirms the significant role of PjBL in advancing HOTS and emphasizes the need for broader and more diverse applications in educational practice.

Keywords: cognitive development, PRISMA, instructional innovation, 21st century competencies, thinking style

1. Introduction

HOTs, or Higher Order Thinking Skills, are an essential tool, requirement, and objective in the educational process of the 21st century (Billah et al., 2019). The ability to think at a high level is essential for people living in the 21st century, as it enables them to adapt and excel in the various disciplines in which they are involved in their day-to-day lives (Eliyasni et al., 2019). HOTs encompasses not only the application, analysis, and evaluation of abilities but also the capacity for creation, namely, the ability to generate a product as a practical manifestation of acquired knowledge (Baharin et al., 2018). Academics stress the importance of explicitly teaching and cultivating higher-order thinking skills in pupils through careful planning and specific teaching methods (Agostino, 2023). Teachers must determine the most effective means of cultivating this skill. Due to the fact that educators are expected to foster the development of competencies beyond the rudimentary ones within their classrooms (Lewis & Smith, 1993), it is thought that it cannot be presumed that kids will automatically become competent thinkers, it is vital to actively educate them on how to think. As a result, educators are supposed to encourage students to engage in higher-order thinking (Wijnen et al., 2021).

Recent research has revealed that the project-based learning (PjBL) approach is suitable for enhancing higher-order thinking skills. Researchers are of the opinion that these models are appropriate for enhancing the cognitive capacities and skills of students (Suherman et al., 2020). The objective of this learning approach is to encourage active involvement and cooperation among students, resulting in the production of tangible outcomes that are applicable in real-life scenarios. Students are afforded the chance to engage in genuine problem-solving and knowledge-building activities in true professional settings (Guo et al., 2020). This method has the ability to provide significant learning (Kokotsaki et al., 2016). Additionally, it

can motivate students, allow them to participate in problem solving; apply ergonomic, hygienic, precise, fast, ecosystem, and metacognitive principles to media and materials for art and technology creations; and produce life-ready works (Zulyusri et al., 2023). Ngadinem and Sulisworo (2020) conducted an experimental study using a pretest-post-test design to investigate the impact of implementing project-based learning in a STEM education setting on the improvement of students' higher-order thinking skills. The findings indicate a beneficial influence of PjBL on the students' cognitive abilities at a relatively higher level of thinking.

Studies examining the current literature on the relation of project-based learning (PBL) to high-order thinking skills (HOTS) through a systematic literature review are as follows: in their systematic literature, Tafakur et al. (2023) focus on reviewing the impact of project-based learning on students critical thinking skills. They conclude that project-based learning encourages students critical thinking skills; however, it is not significantly better than other learning methods in shaping their critical thinking. Loyens et al. (2023), in their systematic literature review research uncover the conceptualization of critical thinking (CR) and HOTS in students center learning environments, namely, project-based learning, and reveal the impact of project-based learning on students critical thinking and high-order thinking skills. The results indicate that critical thinking was used as the disposition and process throughout the project-based learning implementation. In the research, HOTS has a similar conception of critical thinking with a wider scope and more reflected in the Bloom taxonomy. In terms of the impact of project-based learning on critical thinking and HOTS, the research concludes that project-based learning positively affects students critical thinking and HOTS.

Nevertheless, a noticeable gap endures within the academic literature regarding thorough analyses that embrace a broader spectrum of subjects and disciplines. Building upon this observation, scholars contend that existing reviews of project-based learning in high-order thinking research concentrate solely on assessing the direct influence of project-based learning on HOTS, overlooking the intricacies of how the incorporation of project-based learning is managed within HOTS development. Consequently, the present literature review has emerged several pertinent research inquiries:

1. What contexts were used?
2. What research approach was used?
3. What are the types of HOTS targets areas?
4. Is PBL's impact on HOTS?
5. What type of project was implemented?

2. Methods

The present study constitutes a systematic literature review (SLR) aimed at addressing a specific research inquiry. SLR are recognized for their thorough examination of existing knowledge identifying patterns, knowledge gaps, and areas warranting further investigation (Ren et al., 2019). In this instance, a systematic literature review serves as a structured approach to scrutinizing and exploring contemporary literature (Hidayat & Wardat, 2023). Consequently, this research endeavors to investigate the utilization of project-based learning in the context of nurturing students' high-order thinking skills (HOTS). Through this methodical examination, the study seeks to shed light on the potential outcomes associated with integrating project-based learning into the development of HOTS among students.

A thorough literature review serves multiple purposes, including validating current practices, reconciling discrepancies, identifying emerging trends, suggesting future research directions, investigating conflicting findings, and offering recommendations to enhance decision-making (Munn et al., 2018). Employing the SLR method meticulously evaluates the existing database, thus allowing for the targeted investigation of the gap addressed in the current research. This SLR focuses on examining the impact of project-based learning on students' higher-order thinking skills, collecting relevant research literature from reputable databases such as Scopus, ProQuest, and ERIC. These databases were selected for their distinct advantages: Scopus provides extensive coverage of journals and is widely utilized for bibliographic analysis (Singh et al., 2021), ProQuest offers a comprehensive collection of full-text journals across various disciplines, and ERIC is renowned as the most extensively published educational research article database globally (Wright & Pullen, 2007). To gather pertinent journal articles, keywords were generated using terms and phrases relevant to the research topic. These keywords were then combined with Boolean operators offered by the databases, as outlined in Table 1.

Table 1 Participants information.

Keywords	The string and combination of the keywords
Project based learning Higher order thinking skill	TITLE-ABS-KEY ((“PjBL" OR "Project-based-Learning") AND (“Higher-Order-Thinking-Skill” OR “High-Order Thinking-Skill” OR “HOTS”))

In this study, we adhere to the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) criteria. Abelha et al. (2020) point out that systematic literature review research often lacks rigor in methodology. In this context, PRISMA serves as a methodological standard, providing a checklist of guidelines to ensure the empirical validity of the data.

Liberati et al. (2009) characterize PRISMA as a methodological approach that enhances transparency and accuracy while reducing the risk of errors in systematic reviews. PRISMA encompasses four key stages: identification, screening, eligibility, and inclusion. The PRISMA-based flow chart outlining these stages is depicted in Figure 1.

To ensure validity and reliability, the current research adopts the PRISMA SLR method. The systematic literature review was conducted in a robust and well-known database journal, namely, Eric, Scopus, and ProQuest. Based on the 48 eligible articles the finding indicated that most of the research utilized science material in quantitative procedures, covering several typical HOTS, namely, creative thinking, critical thinking, and problem solving. Other than that, the 48 eligible articles proved the significant impact of PjBl on students HOTS, with the most typical project implemented being the Science, Technology, Engineering, and Mathematics (STEM)-based project.

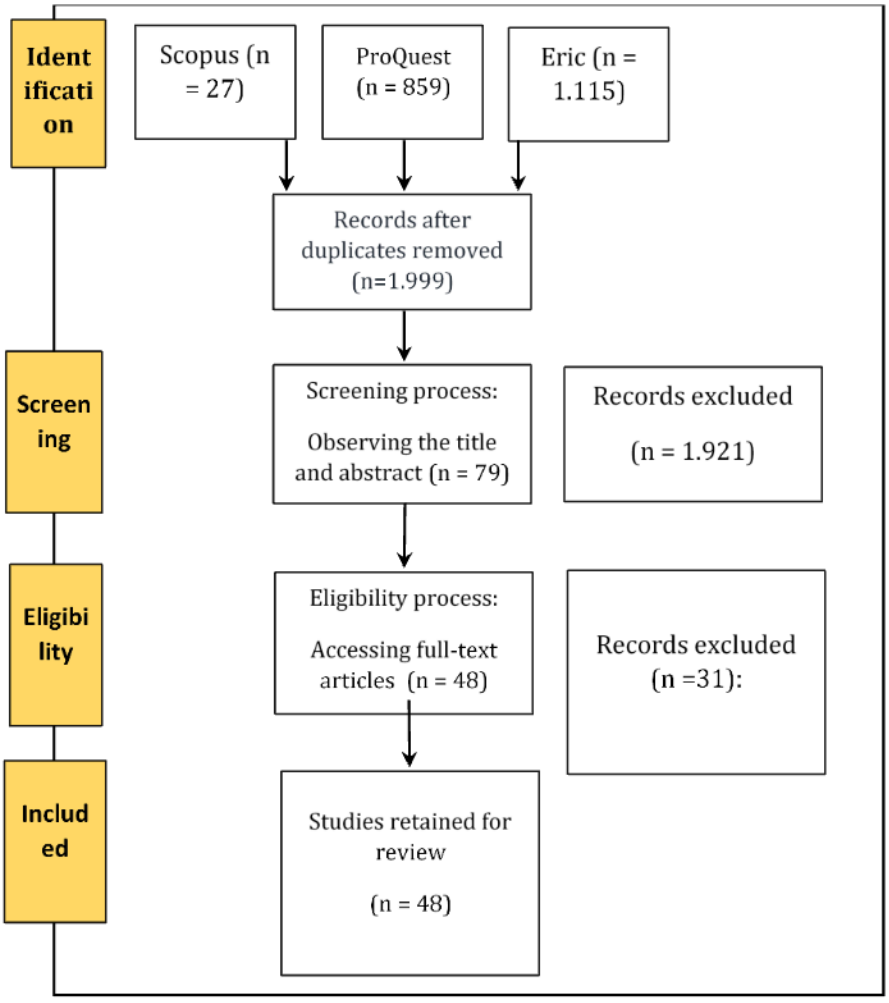

Figure 1 PRISMA flow chart of the study selection process.

2.1. Identification

The Scopus, ProQuest, and ERIC database were employed to conduct a search for pertinent articles. The keywords listed in Table 1 were inputted into the databases to carry out a systematic literature review focusing on project-based learning using the search term (“PjBL" OR "Project-Based-Learning") AND ("Higher-Order-Thinking-Skill" OR "High-Order Thinking-Skill" OR "HOTS"). During the initial search, only these specified terms were considered. Additionally, the search was restricted to full-text publications, articles written in English, and those published between 2014 and 2024. To ensure relevance, the search engines were configured to target the terms within the titles and abstracts of the articles. The search yielded 27 articles from Scopus, 1,115 from ERIC, and 859 from ProQuest, totaling 2,001 articles.

2.2. Screening

The subsequent phase involves screening to identify and eliminate duplicate articles. Among the 2,001 articles gathered during the identification stages, two duplicates were identified and removed following the PRISMA protocol procedure (Figure 1). The remaining articles will undergo assessment, and any articles that do not meet the precise criteria outlined in Table 2 regarding article title, publication year, document type, language, and accessibility will be excluded. Specifically, articles must

have titles relating to project-based learning and students' high-order thinking skills; those that deviate from this topic were eliminated. The selected papers were published between 2014 and 2024 to ensure their timeliness and relevance. Regarding document type, only original research published in scientific journals was considered. Additionally, the articles were required to be in English, given its status as the global language of scholarly communication, allowing for the inclusion of articles from diverse geographical regions. Moreover, only full-text, open-access papers were included to facilitate the analysis process. Consequently, 1,921 items were removed during this screening stage based on the specified criteria.

2.3. Eligibility

Following the elimination of 1,921 items during the screening stages, 79 articles progressed to the eligibility phases. During this stage, researchers meticulously reviewed each article to ensure they met the specified criteria. The examination involved a thorough analysis of the entire text, with articles being excluded if they lacked relevance to the application of project-based learning in students' high-order thinking skills. Given the aim of investigating the implementation of project-based learning within the context of high-order thinking skills, various factors were considered, including teaching practices, research methods, types of high-order thinking skills, the impact of project-based learning, and the form of project-based learning employed. Criteria for selecting suitable articles were established, requiring titles to be related to the subject, articles to discuss the impact of project-based learning on students' high-order thinking skills, and articles to be relevant to predetermined keywords. However, during this stage, numerous articles failed to meet the set standards, either due to unrelated titles, discussions on topics other than the identified keywords, or a lack of focus on the influence of project-based learning on students' high-order thinking skills. Consequently, 31 articles were excluded from the analysis. Despite their focus on project-based learning and high-order thinking skills, these articles did not align with the predefined criteria. For instance, some publications presented modules without testing the influence of project-based learning on students' high-order thinking skills, while others compared project-based learning to low-order thinking skills. As a result, only 48 articles progressed to the inclusion stages.

2.4. Inclusion

The review process serves to ascertain the validity and credibility of the selected papers. In this instance, researchers strictly adhere to the guidelines outlined in the PRISMA protocol to enahnce the validity and reliability of the articles while minimizing the potential for bias. The PRISMA protocol is employed in this study as an evaluative method to analyze previous research on the impact of project-based learning on students' high-order thinking skills. According to the stages delineated in the PRISMA protocol, 48 articles there were included in the reporting phase.

Table 2 Summary of inclusion and exclusion criteria.

Criteria	Inclusion	Exclusion
Article title and content	Appropriate title and fulfil the study`s requirements.	Irrelevant and did not match the study`s requirement
Year of publication	Published from 2014 to 2024	Aside from the given ranged
Type of publication	Only original studies and journal are accepted	Excluding the non-empirical studies, reviews and editorials
Language	English	Others
Field of article study	PjBL and HOTS	Aside from Flipped based learning and critical thinking skill
Accessibility	Full-text articles	Preview and fee are required

2.5. Data analysis

Concluding the literature review, the data obtained from the current research aimed to address the researcher's inquiry. This review consolidates and links various studies pertaining to the subjects covered in earlier research endeavors, utilizing them to explore avenues for advancing prior studies. The validity of this systematic literature review was confirmed through the analysis of reviewed papers using inter-rater agreement for meticulous coding. Before data analysis, thematic analysis was employed to identify, analyze, and interpret patterns of meaning or themes within qualitative data (Clarke & Braun, 2017). The data under examination consisted of articles collected via the PRISMA methodology, as outlined in the methodology section. Following the PRISMA procedure, 48 articles were identified for analysis, resulting in the scrutiny of 48 papers to report the findings. With the intention to further investigate the implementation of project-based learning on students' high-order thinking skills, various perspectives regarding project-based learning practices were explored. Several aspects were taken into consideration, including teaching practices and elements, research methodologies, types of high-order thinking skills, the impact of project-based learning on students' HOTS, and the forms of project-based learning employed. Through the

examination of these elements, researchers aim to offer comprehensive insights into the practice of project-based learning on student high-order thinking skills via this systematic literature review.

3. Results

After the screening and eligibility process, a total of 48 articles were chosen for the systematic literature review. The current research used five research questions to guide a comprehensive understanding of the impact of the PjBL learning method on students HOTS. First, what is the material taught on the implementation of PjBL for students, HOTS? Second, what is the research method used in the paper published related to the implementation of PjBL on HOTS? Third, what type of HOTS is focused on? Fourth, what is the impact of PjBL on students HOTS? Fifth, what form of project or PjBL is the implemented focusing on students HOTS?. In this case, all the results of the research questions were summarized and compared in Table 3.

3.1. Context

The first research question was concerned with the material used in the research. This research question aims to examine what type and what is the most used material in the research related to the impact of PjBL on students HOTS. The result indicated that the material used varied from the social science, science, business, language, and research methodological courses. Most of the materials used in the research were science materials (n = 29), such as math (n = 6), physics (n = 6), biology (n = 7), chemistry (n = 1), general science (n = 4), and STEM (n = 5). Followed by language (n = 5), such as general language material (n = 1), public speaking (n = 1), and English (n = 3). Followed by pedagogical knowledge (n = 3), such as learning management (n = 1), learning media (n = 1), and the learning community (n = 1). Followed by business topics (n = 2), engineering (n = 1), research methodology courses (n = 1), technology (n = 1), and social science, namely, geography (n = 1). The total were 43 article mentioned the material used, and 5 article did not mention the material.

3.2. Research method

The second research question concerned the type of research method used. This research question aims to reveal the research methods commonly used to examine the impact of PjBL on students HOTS: qualitative, quantitative, mixed, and research and development method. The result indicate that most of the research related to the impact of PjBL on students HOTS was quantitative (n= 33) (e.g., Chen & Chang, 2021; Hsu & Wu, 2023; Jewpanich & Piriyasurawong, 2015; Mursid et al., 2021; Muzana et al., 2021; Nor and Jumaat, 2023; Siew & Ambo, 2020; You, 2020). Followed by qualitative methods (n = 5). (e.g., Aránguiz et al., 2020; Haniah & Setyaningsih, 2021; Lukitasari et al., 2018; Puspitasari, 2020; Ummah et al., 2019;). Research and development (n = 4) (e.g., Pramasdyahsari et al., 2023; Saputra & Wagiran, 2019; Sofiyan et al., 2020; Rahayu et al., 2021), the mix method (n = 6) (e.g., Faozi et al., 2020; Budiarti et al., 2021; Puangpunsi, 2021; Holmes & Hwang, 2016; Amorati & Hajek, 2021; Holmes & Hwang, 2016). Based on the basis of these findings, the quantitative research method is the most commonly used method in the research related to the impact of PjBL on students HOTS, followed by the mixed method, qualitative research, and research and development methods.

3.3. Type of HOTS

The third research question was concerned the type of HOTS used or focused on in the research. This research aims to examine what type of HOTS becomes the main focus to be examined or impacted by the PjBL. In this research question, the researcher does not analyze the quantity of the typical HOTS evolved in each article. It is because the type of HOTS might appear in two or more articles.

The finding indicated that several types of HOTS are focused on in the article related to the impact of PjBL on HOTS. For example, problem solving was mentioned or used in 15 articles (n=15) (e.g., Hsu and Wu, 2023; Nor and Jumaat, 2023; Chen & Chang, 2021; Jewpanich & Piriyasurawong, 2015; Haniah & Setyaningsih, 2021; Muzana et al., 2021; Kartini et al., 2021). Critical thinking was mentioned or used in 19 articles (n=19) (e.g., Hsu and Wu, 2023; Holmes & Hwang, 2016; Holmes & Hwang, 2016; Puspitasari, 2020; Haniah & Setyaningsih, 2021, etc). creativity used in 23 articles (n=23) (e.g., Hsu and Wu, 2023; You, 2020; Amorati & Hajek, 2021; Chen & Chang, 2021; Puspitasari, 2020; Ummah et al., 2019; Siew & Ambo, 2020; Mursid et al., 2021; Haniah & Setyaningsih, 2021, etc.). Evaluate used in 2 articles (n=2) (e.g., Wahyudi et al., 2023; Lukitasari et al., 2018), create used in one article (Lukitasari et al., 2018), innovation used in one article (Plailek et al., 2023), and Inventive thinking used in one article (e.g., Husin et al., 2016). According to the findings, the most typical HOTS used in the research related to PjBL were creativity, critical thinking, and problem solving.

3.4. The impact of PjBL on students HOTS

The third research question in the current research concerns the impact of the PjBL on students HOTS. This research question aim to reveal the impact of the use of PjBL on students HOTS and whether PjBL impacts students HOTS or not. The result indicate that all articles, including the quantitative articles, qualitative articles and mix method articles, show the positive impact of the PjBL on students HOTS. For example, Issa and Khataibeh (2021) reported the significant statistical difference (a=

0.05) attributed between the conventional method and the project-based learning strategy. It was shown that PBL model affected on the students' critical thinking ability in science. Aránguiz et al. (2020), in their qualitative research, conclude that the project-based learning using a real-life scenario helped students reflect on their critical thinking and the challenges that our societies face for a transition to sustainability, and Budiarti et al. (2021), in their mix method research, reported that the global PjBL in extracurricular activities as a promising approach to incorporating the 4Cs in an authentic and sustainable manner.

3.5. Type of project implemented

The fifth research question concerns the form of the project implemented in the PjBL teaching and learning practice related to student HOTS. This research question aims to explore and reveal the common project used in the research related to the impact of PjBL on students HOTS.

According to the findings, the projects implemented varied, but one typical project that was used in several articles was based on STEM, such as Nor and Jumaat, (2023) Bitara STEM project, Muzana et al. (2021) E-STEM project-based learning, and Husin et al. (2016) BITARA STEM. Other projects varied. For example, Hsu and Wu (2023) used the business simulation games; Sofiyan et al. (2020) used the geometry of space project; Lukitasari et al. (2018) used portfolio project; You (2020) used team project-based learning (TPjBL); Amorati & Hajek (2021) used writing project; Mursid et al. (2021) engineering drawing project; Haniah & Setyaningsih (2021) used speech video project; Muzana et al. (2021) E-STEM project-based learning; Kartini et al. (2021) Students design and assemble the prototype through a hands-on activity. Rais et al. (2021) are developing a paper about various seaweed product diversifications. Rahayu et al. (2021) project on developing fruit salad recipes, Budiarti et al. (2021) Cultural Exchange Project; Aránguiz et al. (2020) Action Research Project with the Agroecological Market (AM); Saputra & Wagiran (2019) Jobsheet and Lesson Plan; Suherman et al. (2020b) Geogebra Suwarno et al. (2020) Science Worksheet on Applied Waste Management, Kemaloğlu-Er (2022): Research report, translation, creative outcome, interactive report, oral presentation, and self-evaluation report. Karan & Brown (2022) Wood frame project, Tuaputty et al. (2023) Laboratory project, Pramasdyahsari et al. (2023) Hypothetical learning trajectory (HTL), Wahyudi et al. (2023) Ethno-PjBL (Ethnoscience), Faozi et al. (2020) Shoe manufacture, Efendi et al. (2020) Making posters, pamphlets, videos, and interactive media. Based on findings, the most used project in the research on the impact of PjBL on students HOTS were projects based on the STEM approach.

Table 3 Descriptive analysis.

No	Authors	Context	Research method	Type of HOTS	Impact of PjbL on students HOTS	Types of PjBl
1	Hsu and Wu (2023)	Business	Quantitative	Problem solving, critical thinking, creativity	The result of ANCOVA indicated there were significant differences in problem-solving, critical thinking, and creativity between the two study groups.	Business simulation games
2	Sofiyan et al. (2020)	Mathematic	Research and development	(General HOTS)	PjBL-based teaching materials could increase students' HOTS	geometry of space project
3	Lukitasari et al. (2018)	Physic	Qualitative	evaluate, create	E-portfolio using Project Base Learning (PjBL) model can improve the ability of higher-level thinking.	E-portfolio
4	(You, 2020)	Not mentioned	Quantitative	Team creativity	The correlations of team efficacy, psycho- logical safety, and team interaction with team creativity were all found to be positively significant in the PjBL context.	Team project-based learning
5	(Holmes & Hwang, 2016)	Mathematics	Mixed-method	Critical thinking	PjBL students were more intrinsically motivated, showed significantly higher critical thinking skills.	Not mentioned
6	(Amorati & Hajek, 2021)	Language	Mixed-method	Creativity	The project had a positive impact on participants intrinsic motivation and also helped them develop their creative skills.	Writing project
7	(Nor and Jumaat 2023)	STEM	Quantitative	(problem solving)	The application of POPBL in STEM education programs could help	BITARA STEM program

					students to enhance their 21st century skills by learning how to solve real world problems based on authentic and real life experiences through project work	
8	(Chen & Chang, 2021)	Pedagogy (Learning management)	Quantitative	Creativity and problem-solving ability	Students' creative problem-solving ability had been effectively enhanced by the intervention of PjBL.	Not mentioned
9	(Holmes & Hwang, 2016)	Mathematic	Mixed method	Critical thinking skills	PjBL students were more intrinsically motivated, showed significantly higher critical thinking skills, and appreciated peer learning.	Not mentioned
10	(Puspitasari, 2020)	Not mentioned	Qualitative	Creativity and critical thinking	Based on the students' viewpoints, project-based assessment, group classroom activities, teachers being a facilitator, and students' centeredness were successfully trained their ability on creativity, critical thinking, collaboration, and communication.	Not mentioned
11	(Ummah et al., 2019)	Pedagogy (learning media)	Qualitative	Student's creativity	There was an improvement of the students' creativity in the PjBL implementation.	Not mentioned
12	(Siew & Ambo, 2020)	STEM	quantitative	scientific creativity	The result of independent samples t-test established the significant positive effects of the PjBL-STEM on all trait dimensions of scientific creativ- ity. These findings showed that PjBL-STEM provides a reliable, valid, appropriate and effective teaching and learning module to foster the scientific creativity of Fifth Graders.	Not mentioned
13	(Jewpanich & Piriyasurawong, 2015)	Not mentioned	Quantitative	problem solving	HOTS Model developed based on PjBL is rated as most appropriate in terms of quality to enhance students HOTS.	Not mentioned
14	(Mursid et al., 2021)	Engineering	Quantitative	creative thinking ability	The creative thinking ability outcomes of the students taught with PjBL model were higher than those of the group II students who used the ordinary blended learning model	Engineering drawing project works
15	(Haniah & Setyaningsih, 2021)	Language (Public Speaking)	Qualitative	Problem solving, Creativity and critical thinking	Online PjBL helps students to master creativity and innovation skills, communication skills, critical thinking skills, and collaboration skills.	Speech video
16	(Muzana et al., 2021)	STEM (science)	Quantitative	Problem solving	The implementation of E-STEM project-based learning model and	E-STEM project-based

					problem solving in teaching science has significant impact in increasing ICT literacy and problem solving	
17	(Kartini et al., 2021)	STEM (Science)	Quantitative	Problem solving	The implementation of STEM Project-Based Learning can develop students' Problem-Solving Skills. The N-gain result suggests a substantial improvement between the pre-test and the post-test treatment can be verified.	Students designing and assemble the prototype by a hands-on activity
18	(Puangpunsi, 2021)	Language (Engglish)	Mix-method	critical thinking and creativity, problem solving	PjBL played the role in the enhancement of English skills improvement and the 21st century skills acquisition.	Not mentioned
19	(Rais et al., 2021)	General science	Quantitative	critical thinking and creativity	This study indicates that the implementation of PjBL brings a better effect compared to the implementation of PBL in fostering 21st-century learning skill.	Develop a paper about various seaweed product diversifications.
20	(Rahayu et al., 2021)	Math	Research and development	critical thinking in problem-solving, creativity)	PjBL through PMRI with the context of fruit salad recipes and the LSLC system, students can learn collaboratively. The learning helps them solve problems by using average material, social arithmetic, and data presentation in developing fruit salad recipes	develop fruit salad recipes
21	(Budiarti et al., 2021)	Not mentioned	Mix method	Critical Thinking, and Creativity	Global Project-Based Learning (Global PBL) in extracurricular activities (ECA) as a promising approach to incorporating the 4Cs in an authentic and sustainable manner.	Cultural Exchange Project
22	(Aránguiz et al., 2020)	Research Methodologies (RM) course	Qualitative	critical thinking	Project-based learning using a real-life scenario helped students reflect on their critical thinking and the challenges that our societies face for a transition to sustainability	Action research project with the Agroecological Market (AM)
23	(Saputra & Wagiran, 2019)	Technology	Research and development	Creative thinking	The learning effectiveness using the developed learning model on knowledge, skill, and creative thinking aspects was considered good.	Jobsheet and Lesson Plan
24	(Sari et al., 2019)	Not mentioned	Quantitative	Critical thinking skills	PjBL improve positively and significantly the critical thinking skills.	Not mentioned
25	(Issa & Khataibeh, 2021)	Science	Quantitative	critical thinking	There is a significant statistical different (a= 0.05) attributed between the conventional method and the PjBL strategy. It	Not mentioned

					was shown that PjBL model affected on the students' critical thinking ability in science.	
26	(Santyasa & Agustini, 2021)	Chemist	Quantitative	Critical thinking skills	There were differences in critical thinking skills and student achievement between students who studied with those models, in which the students who studied with the PjBeL model showed a better result.	Not mentioned
27	Suherman et al. (2020b)	Mathematics	Quantitative	Not mentioned (general HOTS)	The results of one-way ANOVA on HOTS test shows that there is an effect on the improvement of students' HOTS using the Project-Based Learning (PjBL) model assisted by Geogebra.	Geogebra
28	Suwarno et al. (2020)	Biology	Quantitative	Creativity	PjBl assisted in worksheet has positive impact on student`s creativity	Science Worksheet on Applied waste management
29	Kemaloğlu-Er (2022)	Language (English)	Quantitative	Creativity	The PjBL enhance student`s creativity in writing and creativity in visual/audiovisual	Research report, translation, creative outcome, interactive report, oral presentation, and self-evaluation report.
30	Karan & Brown (2022)	Business	Quantitative	Problem solving	Students who learn with PjBL performed better compared to students in convenient class.	Wood frame project
31	Tuaputty et al. (2023)	Biology	Quantitative	Critical thinking	There is strong correlation between the PjBL using laboratory approach to students critical thinking skill in understanding marine biology concept	Laboratory project
32	Plailek et al. (2023)	Language (English)	Quantitative	Problem solving, innovation.	Students have highest skill in creating innovation followed by applying in the PjBL context.	Not mentioned
33	Nurmaliah et al. (2020)	Biology	Quantitative	Creativity	Students creativity in the implementation of the PjBL in the biodiversity material in good category	Not mentioned
34	Husin et al. (2016)	STEM	Quantitative	Inventive thinking	The mean score of the students inventive thinking increased from pre test to post test	BITARA STEM
35	Pramasdyahsari et al. (2023)	Science (DAM for flood controlling)	Research and development	Critical thinking	The use of digital book based on STEM-PjBL could improve students mathematical critical thinking	Hypothetical learning trajectory (HTL)
36	Wahyudi et al. (2023)	Physic	Quantitative	Critical thinking and evaluation	Integrated hybrid E-PjBL with assistive virtual technology enhance student`s critical thinking skill in physic course	Ethno-PjBL (Ethnoscience)

37	Fadhil et al. (2021)	Biology (Vibration and wave)	Quantitative	Creative thinking	The application of PjBL can improve students critical thinking skill	Not mentioned
38	Parno et al. (2022)	Physic (Static fluid)	Quantitative	Critical thinking and problem solving	The implementation of STEM approach with formative assessment has a positive impact on increasing students critical thinking skill.	Not mentioned
39	Nukak et al. (2021)	Biology; classification of living thing	Quantitative	Creativity	Students creativity in the use of PjBL combined with realia media have higher score compare to students use conventional media	Not mentioned
40	Mariyam et al. (2017)	Biology (waste recycle)	Quantitative	Creativity	PjBL model with shared and integrated type of integration is effective in improving the students creativity on the waste recycle material	Not mentioned
41	Faozi et al. (2020)	Pedagogy (Learning with community)	Mix method	Problem solving	Learning community based on PjBL had influence the students ability in problem solving	Shoe manufacture
42	Rahim et al. (2019)	Physic (Momentum and impulse)	Quantitative	Critical thinking skill	There was increase in students critical thinking skill after given project based learning based on process skill approach	Not mentioned
43	Efendi et al. (2020)	Geography	Quantitative	Critical thinking skill	The PjBL plus 4Cs learning model applied to the experimental group empirically is proven to be able to improve critical thinking skill	Making poster, pamphlets, videos and interactive media
44	Setyarini et al. (2020)	Mathematic (Statistic and probability)	Quantitative	Creative thinking	The PjBL assisted with PANGTUS model can effectively improve students creative thinking abilities in higher education	Not mentioned
45	Nurmaliah et al. (2021)	Biology (Immune system)	Quantitative	Problem solving	The STEM approach integrated with PjBL model could improve the abilities of students to solve problem	STEM based project
46	Mukaromah and Wusqo (2020)	General Science (Global warming)	Quantitative	Creative thinking	The experimental class where students taught with PjBL, the students have higher creative thinking compare to the students in control class	STEM based project
47	Anindya and Wusqo (2020)	Physic (Optical instrument topic)	Quantitative	Problem solving	The PjBL STEAM affected the students problem solving	STEAM based project
48	Viana et al. (2019)	Physic (Impulse and momentum)	Quantitative	Creative thinking	There are significant demonstrated creative thinking skill after the use of PjBL-based learning model with process skill approach.	Not mentioned

Source: Authors' compilation based on 48 selected articles (2014–2024) from Scopus, ERIC, and ProQuest

4. Discussion

The current systematic literature review examines the implementation of project-based learning on students' high-order thinking skills. Five aspects were considered: the context or subject used in the implementation, the research method

employed, the type of HOTS used, the impact of PjBL on HOTS, and the form of the project implemented. Regarding the context or subject used, the current research reveals that mathematics, physics, biology, chemistry, general science, and STEM were the most used contexts in research related to the implementation of PjBL on HOTS. It could be explained in the literature that the settings considered has similar characteristics to HOTS; according to Agussuryani et al. (2020), the context of HOTS is the ability to implement and generate new ideas, just as the science material related to adaptation and the use of something in different conditions requires creativity and critical thinking. Zulfiani et al. (2020) stated that science knowledge is typically used to solve daily problems because science corresponds with the daily activities of creatures and problems found in daily life situations. In this case, to solve problems, the procedure and conception of HOTS can be used. That is why, generally, people link science material with HOTS, including in education, such as in the context of the utilization of HOTS conception in science textbooks, the integration of science conception as HOTS teaching material, and the utilization of science material or knowledge on enhancing students HOTS.

Recent studies have predominantly employed quantitative methods when investigating the influence of project-based learning (PjBL) on students' high-order thinking skills (HOTS). This prevalence can be attributed to the nature of the research theme, which often centers on examining the relationship or impact of PjBL implementation on students' HOTS. The objective is to ascertain whether the integration and adoption of PjBL in educational settings yield significant enhancement students' high-order thinking abilities, necessitating the use of quantitative procedures for validation. As highlighted by Vrbin (2022), one prevalent form of quantitative analysis is parametric statistics, which assesses fundamental assumptions such as comparing means between variables, establishing significant differences between data groups, and examining the relationship between data sets. In the context of this research, the variables under scrutiny are PjBL and HOTS. Studies within this domain explore the effects of PjBL on HOTS (Martawijaya et al., 2023) and assess the efficacy of PjBL in enhancing HOTS (Hsu & Wu, 2023). Through quantitative analyses, these studies aim to provide empirical evidence regarding the impact of PjBL on students' high-order thinking skills, contributing to a deeper understanding of the effectiveness of project-based learning approaches in educational contexts.

The current research found that the most typical HOTS were creativity, critical thinking, and problem solving. Because it might be because these kinds of higher-order thinking are the suitable thinking ability that correlate and suit the PjBL syntax. Other than that, the teachers who implement PjBL in the classroom more familiar with these kinds of thinking skill. In the literature, creativity is a holistic and multi-dimensional concept (Hernández-Torrano & Ibrayeva, 2020). It is defined as the ability to generate innovative and effective ideas, artifacts, and solutions (Henriksen et al., 2020). Critical thinking is related to the cognitive process, where Yin et al. (2023) defined critical thinking as the cognitive skills and dispositions that involve taking responsibility for one's own thinking and improving it. According to Alsaleh (2020), critical thinking involves investigating a situation, phenomenon, topic, or problem to develop a hypothesis or conclusion that incorporates all available information and is convincingly supported. According to Dunbar, K. (2017), problem solving is defined as the process of searching in a problem space that requires performing action such as physical, mental, and cognitive actions. In this case, Van Gog et al. (2020) stated that solving problems involves both procedural and conceptual knowledge, including knowing what actions to take and why. Based on the definition given, creativity, critical thinking, and problem solving involve the cognitive procedure of high-order thinking. That is why the concepts of creativity, critical thinking, and problem solving were considered HOTS (Nurhalis et al., 2024). Therefore, the adaptation of creativity, critical thinking, and problem solving in research related to HOTS is appropriate (Rahmatika et al., 2024).

The finding also revealed that of the 48 articles included in the current systematic literature review, all of them demonstrated the positive impact of PjBL on students HOTS. For example, Suwarno et al. (2020) proved the significant impact of the use of PjBL integrated in the worksheet on students HOTS, namely, creativity; Setyarini et al. (2020) proved the significant impact of the implementation of PjBL utilizing PANGTUS on students HOTS, namely, creative thinking; and Handhika et al. (2018) proved the significant impact of PjBL on the increase of students HOTS, namely, critical thinking. Keleman (2021) explains that the integration of PjBL in the classroom gives students space to think and utilizes their cognitive abilities in analyzing, evaluating, and solving issues or topics. The PjBL learning approach uses projects as a learning medium. Students examine, appraise, interpret, and synthesize knowledge to attain learning objectives. The learning model focuses on problem-solving as the initial step in acquiring and integrating new knowledge through experience. It analyzes solutions to complicated problems throughout investigations (Hujjatusnaini et al., 2022). It is why the use of PjBL in the classroom could influence the students HOTS.

The findings reveal that the most typical project used was a science, technology, engineering, and mathematics (STEM)-based project. STEM is a scientific-related field that uses math to process data and applies technology and engineering to science (Qudratuddarsi et al., 2022). According to Sudarmin et al. (2019), integrating STEM approaches with project-based learning can address current challenges and solve the problem. The integration of STEM with project-based learning alters several domains to foster critical, creative, inventive, and collaborative thinking. It explains why the research related to the implementation of PjBL on students HOTS because the use of STEM is also integrated with typical skills of HOTS, such as creativity, critical thinking, and invention. Sumarni and Kadarwati (2020) conclude in their research that the integration of STEM in PjBL might provide a good teaching practice to improve the students' creative and critical thinking skills. Santhosh et

al. (2023) stated that inculcating a STEM-based approach in the learning process, such as PjBL, might stimulate the students to use their cognitive abilities to explore, create, and re-construct solutions for challenging problems.

5. Conclusion

The current study is a comprehensive literature analysis on the use of Project-Based Learning (PjBL) to equip students with High Order Thinking Skill (HOTS). The current study examined the current literature on project-based learning research in the context of student HOTS. Based on the 48 eligible articles, the findings revealed that the majority of research used science material in a quantitative approach to cover various typical HOTS, including creative thinking, critical thinking, and problem solving. Aside from that, the 48 eligible publications demonstrated the strong impact of PjBl on students' HOTS, with the most common project implemented being the Science Technology Engineering and Mathematics (STEM)-based project.

The information gathered in this systematic literature review would be beneficial for the teacher as the one who control the classroom learning. The teachers could imitate several kind of project based learning founded in the current research where these kind of PjBL project have already proved to be significant to enhance the HOTS students on the based of research procedure. Other than that, the current research would be beneficial for the policy maker. It is because, many important aspect of PjBL related to students HOTS information was revealed in the current research, such as in what learning context the PjBL is beneficial to improve students HOTS. It could be the references for the policy maker to suit and match the learning context with the learning method.

Ethical Considerations

Not applicable.

Conflict of Interest

All authors have no conflict of interest.

Funding

This research was supported by the Beasiswa Pendidikan Indonesia (BPI) program of the Lembaga Pengelola Dana Pendidikan (LPDP) through the Program Penelitian dan Pengembangan Akademik dan Teknologi Pendidikan (PPATP), Kementerian Pendidikan, Kebudayaan, Riset, dan Teknologi (KEMDIKTISAINTEK), Indonesia.

References

Abelha, M., Fernandes, S., Mesquita, D., Seabra, F., & Ferreira-Oliveira, A. T. (2020). Graduate employability and competence development in higher education—A systematic literature review using PRISMA. *Sustainability, 12*(15), 5900. https://doi.org/10.3390/su12155900

Agostino, T. J. D. (2023). Examination reform for higher order thinking: A case study of assessment-driven reform in Uganda. *International Journal of Educational Development, 103*, 102918. https://doi.org/10.1016/j.ijedudev.2023.102918

Agussuryani, Q., Sudarmin, S., Sumarni, W., Subali, B., & Saptono, S. (2020). Implementation of STEM integrated ethnoscience-based vocational science learning in fostering students' higher order thinking skills (HOTs). *International Journal of Active Learning, 5*(2), 53–61. https://doi.org/10.15294/ijal.v5i2.27498

Alsaleh, N. J. (2020). Teaching critical thinking skills: Literature review. *TOJET: The Turkish Online Journal of Educational Technology, 19*(1), 21–39. http://files.eric.ed.gov/fulltext/EJ1239945.pdf

Amorati, R., & Hajek, J. (2021). Fostering motivation and creativity through self-publishing as project-based learning in the Italian L2 classroom. *Foreign Language Annals, 54*(4), 1003–1026. https://doi.org/10.1111/flan.12568

Anindya, F. a. U., & Wusqo, I. U. (2020). The influence of PjBL-STEAM model toward students' problem-solving skills on light and optical instruments topic. *Journal of Physics: Conference Series, 1567*(4), 042054. https://doi.org/10.1088/1742-6596/1567/4/042054

Aránguiz, P., Palau-Salvador, G., Belda, A. M., & Peris, J. (2020). Critical thinking using project-based learning: The case of the agroecological market at the "Universitat Politècnica de València." *Sustainability, 12*(9), 3553. https://doi.org/10.3390/su12093553

Baharin, N., Kamarudin, N., & Manaf, U. K. A. (2018). Integrating STEM education approach in enhancing higher order thinking skills. *International Journal of Academic Research in Business and Social Sciences, 8*(7), 810–821. https://doi.org/10.6007/ijarbss/v8-i7/4421

Billah, A., Khasanah, U., & Widoretno, S. (2019). Empowering higher-order thinking through project-based learning: A conceptual framework. *AIP Conference Proceedings*. https://doi.org/10.1063/1.5139743

Budiarti, M., Macqueen, S., Reynolds, R., & Ferguson-Patrick, K. (2021). Global project-based learning as an approach to teaching the 4Cs in schools. *Journal of International Social Studies, 11*(1), 33–62. https://iajiss.org/index.php/iajiss/article/download/609/431

Chen, P., & Chan, Y. (2021). Enhancing creative problem solving in postgraduate courses of education management using project-based learning. *International Journal of Higher Education, 10*(6), 11. https://doi.org/10.5430/ijhe.v10n6p11

Clarke, V., & Braun, V. (2017). Thematic analysis. *The Journal of Positive Psychology, 12*(3), 297–298. https://doi.org/10.1080/17439760.2016.1262613

Dunbar, K. (2017). Problem solving. In *Wiley encyclopedia of cognitive science* (pp. 289–298). Wiley. https://doi.org/10.1002/9781405164535.ch20

Efendi, D. R., Sumarmi, S., & Utomo, D. H. (2020). The effect of PjBL plus 4Cs learning model on critical thinking skills. *Journal for the Education of Gifted Young Scientists, 8*(4), 1509–1521. https://doi.org/10.17478/jegys.768134

Eliyasni, R., Kenedi, A. K., & Sayer, I. M. (2019). Blended learning and project-based learning: The method to improve students' higher order thinking skill (HOTS). *Jurnal Iqra': Kajian Ilmu Pendidikan, 4*(2), 231–248. https://doi.org/10.25217/ji.v4i2.549

Fadhil, M., Kasli, E., Halim, A., Evendi, M., & Yusrizal, Y. (2021). Impact of project-based learning on creative thinking skills and student learning outcomes. *Journal of Physics: Conference Series, 1940*(1), 012114. https://doi.org/10.1088/1742-6596/1940/1/012114

Faozi, A. K. A., Hobri, H., Fatekurohman, M., Aini, K., & Yuniar, D. (2020). Student's problem solving abilities in project-based learning (PjBL) based on learning community (LC). *Journal of Physics: Conference Series, 1538*(1), 012070. https://doi.org/10.1088/1742-6596/1538/1/012070

Fisher, D., Kusumah, Y. S., & Dahlan, J. A. (2020). Project-based learning in mathematics: A literature review. *Journal of Physics: Conference Series, 1657*(1), 012032. https://doi.org/10.1088/1742-6596/1657/1/012032

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

Handhika, J., Cari, C., Sunarno, W., Супармі, A., & Kurniadi, E. (2018). The influence of project-based learning on the student conception about kinematics and critical thinking skills. *Journal of Physics: Conference Series, 1013*, 012028. https://doi.org/10.1088/1742-6596/1013/1/012028

Haniah, A. U., Ngadiso, N., & Setyaningsih, E. (2021). Students' perception on the implementation of online project-based learning in teaching 4Cs. *IJELTAL (Indonesian Journal of English Language Teaching and Applied Linguistics, 6*(1), 123. https://doi.org/10.21093/ijeltal.v6i1.895

Hanif, S., Wijaya, A. F. C., & Winarno, N. (2019). Enhancing students' creativity through STEM project-based learning. *Journal of Science Learning, 2*(2), 50. https://doi.org/10.17509/jsl.v2i2.13271

Hartik, S., Utaminingsih, S., & Madjdi, A. H. (2021, March). A need assessment of integrated science teaching material based higher order thinking skills (HOTS). In *Journal of Physics: Conference Series* (Vol. 1823, No. 1, p. 012078). IOP Publishing.

Henriksen, D., Richardson, C., & Shack, K. (2020). Mindfulness and creativity: Implications for thinking and learning. *Thinking Skills and Creativity, 37*, 100689. https://doi.org/10.1016/j.tsc.2020.100689

Herman, Prananda, M. R., Proboningrum, D. I., Pratama, E. R., Laksono, P., & Amiruddin. (2020). Improving higher order thinking skills (HOTS) with project-based learning (PjBL) model assisted by GeoGebra. *Journal of Physics: Conference Series, 1467*(1). https://doi.org/10.1088/1742-6596/1467/1/012027

Hernández-Torrano, D., & Ibrayeva, L. (2020). Creativity and education: A bibliometric mapping of the research literature (1975–2019). *Thinking Skills and Creativity, 35*, 100625. https://doi.org/10.1016/j.tsc.2019.100625

Hidayat, R., & Wardat, Y. (2023). A systematic review of augmented reality in science, technology, engineering and mathematics education. *Education and Information Technologies*. https://doi.org/10.1007/s10639-023-12157-x

Holmes, V., & Hwang, Y. (2016). Exploring the effects of project-based learning in secondary mathematics education. *Journal of Educational Research, 109*(5), 449–463. https://doi.org/10.1080/00220671.2014.979911

Hsu, C., & Wu, T. (2023). Applications of business simulation games in flipped classrooms to facilitate student engagement and higher-order thinking skills for sustainable learning practices. *Sustainability*. https://doi.org/10.20944/preprints202311.0082.v1

Hujjatusnaini, N., Corebima, A. D., Prawiro, S. R., & Gofur, A. (2022). The effect of blended project-based learning integrated with 21st-century skills on pre-service biology teachers' higher-order thinking skills. *Jurnal Pendidikan IPA Indonesia/JPPI: Jurnal Pendidikan IPA Indonesia, 11*(1), 104–118. https://doi.org/10.15294/jpii.v11i1.27148

Husin, W. N. F. W., Arsad, N. M., Othman, O., Halim, L., Rasul, M. S., Osman, K., & Iksan, Z. H. (2016). Fostering students' 21st century skills through project oriented problem based learning (POPBL) in integrated STEM education program. *Asia-Pacific Forum on Science Learning and Teaching, 17*(1). https://eric.ed.gov/?id=EJ1113235

Issa, H. B., & Khataibeh, A. M. (2021). The effect of using project-based learning on improving the critical thinking among upper basic students from teachers' perspectives. *Pegem Journal of Education and Instruction, 11*(2), 52–57. https://doi.org/10.14527/pegegog.2021.06

Jewpanich, C., & Piriyasurawong, P. (2015). Project-based learning using discussion and lesson-learned methods via social media model for enhancing problem solving skills. *International Education Studies, 8*(6). https://doi.org/10.5539/ies.v8n6p24

Joklitschke, J., Rott, B., & Schindler, M. (2021). Notions of creativity in mathematics education research: A systematic literature review. *International Journal of Science and Mathematics Education, 20*(6), 1161–1181. https://doi.org/10.1007/s10763-021-10192-z

Juandi, D. (2021). Heterogeneity of problem-based learning outcomes for improving mathematical competence: A systematic literature review. *Journal of Physics: Conference Series, 1722*(1), 012108. https://doi.org/10.1088/1742-6596/1722/1/012108

Karan, E., & Brown, L. (2022). Enhancing students' problem-solving skills through project-based learning. *Journal of Problem Based Learning in Higher Education, 10*(1), 74–87. https://doi.org/10.54337/ojs.jpblhe.v10i1.6887

Kartini, F. S., Widodo, A., Winarno, N., & Astuti, L. (2021). Promoting students' problem-solving skills through STEM project-based learning in Earth layer and disasters topic. *Journal of Science Learning, 4*(3), 257–266. https://doi.org/10.17509/jsl.v4i3.27555

Keleman, M. (2021). Assessment of higher order thinking skills through STEM integration project-based learning for elementary level. *International Journal of Social Science and Human Research, 4*(4). https://doi.org/10.47191/ijsshr/v4-i4-40

Kemaloğlu-Er, E. (2022). Project-based EFL learning at the tertiary level: Research, translation, creativity and interaction. *Turkish Journal of Education, 11*(3), 162–182. https://doi.org/10.19128/turje.1061653

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

Lewis, A., & Smith, D. (1993). Defining higher order thinking. *Theory Into Practice, 32*(3), 131–137. https://doi.org/10.1080/00405849309543588

Liberati, A., Altman, D. G., Tetzlaff, J., Mulrow, C. D., Gøtzsche, P. C., Ioannidis, J. P. A., Clarke, M., Devereaux, P., Kleijnen, J., & Moher, D. (2009). The PRISMA statement for reporting systematic reviews and meta-analyses of studies that evaluate health care interventions: Explanation and elaboration. *Journal of Clinical Epidemiology, 62*(10), e1–e34. https://doi.org/10.1016/j.jclinepi.2009.06.006

Linnenluecke, M. K., Marrone, M., & Singh, A. K. (2019a). Conducting systematic literature reviews and bibliometric analyses. *Australian Journal of Management, 45*(2), 175–194. https://doi.org/10.1177/0312896219877678

Lo, C. O., & Feng, L. (2020). Teaching higher order thinking skills to gifted students: A meta-analysis. *Gifted Education International, 36*(2), 196–217. https://doi.org/10.1177/0261429420917854

Loyens, S. M. M., Van Meerten, J. E., Schaap, L., & Wijnia, L. (2023). Situating higher-order, critical, and critical-analytic thinking in problem- and project-based learning environments: A systematic review. *Educational Psychology Review, 35*(2). https://doi.org/10.1007/s10648-023-09757-x

Lukitasari, M., Handhika, J., & Murtafiah, W. (2018). Higher order thinking skills: Using e-portfolio in project-based learning. *Journal of Physics: Conference Series, 983*, 012047. https://doi.org/10.1088/1742-6596/983/1/012047

Lukitasari, M., Hasan, R., Sukri, A., & Handhika, J. (2021). Developing students' metacognitive ability in science through project-based learning with e-portfolio. *International Journal of Evaluation and Research in Education, 10*(3), 948. https://doi.org/10.11591/ijere.v10i3.21370

Mariyam, M., Kaniawati, I., & Sriyati, S. (2017). Shared or integrated: Which type of integration is more effective improves students' creativity? *Journal of Physics: Conference Series, 895*, 012154. https://doi.org/10.1088/1742-6596/895/1/012154

Martawijaya, M. A., Rahmadhanningsih, S., Swandi, A., Hasyim, M., & Sujiono, E. H. (2023). The effect of applying the Ethno-STEM-project-based learning model on students' higher-order thinking skill and misconception of physics topics related to Lake Tempe, Indonesia. *Jurnal Pendidikan IPA Indonesia/JPPI: Jurnal Pendidikan IPA Indonesia, 12*(1), 1–13. https://doi.org/10.15294/jpii.v12i1.38703

Miri, B., David, B., & Uri, Z. (2007). Purposely teaching for the promotion of higher-order thinking skills: A case of critical thinking. *Research in Science Education, 37*(4), 353–369. https://doi.org/10.1007/s11165-006-9029-2

Mitani, H. (2021). Test score gaps in higher order thinking skills: Exploring instructional practices to improve the skills and narrow the gaps. *AERA Open, 7*. https://doi.org/10.1177/23328584211016470

Mukaromah, S., & Wusqo, I. U. (2020). The influence of PjBL model with STEM approach on global warming topic to students' creative thinking and communication skills. *Journal of Physics: Conference Series, 1521*(4), 042052. https://doi.org/10.1088/1742-6596/1521/4/042052

Munn, Z., Peters, M. D. J., Stern, C., Tufănaru, C., McArthur, A., & Aromataris, E. (2018). Systematic review or scoping review? Guidance for authors when choosing between a systematic or scoping review approach. *BMC Medical Research Methodology, 18*(1). https://doi.org/10.1186/s12874-018-0611-x

Mursid, R., Saragih, A. H., & Herawati, H. (2021). The effect of the blended project-based learning model and creative thinking ability on engineering students' learning outcomes. *International Journal of Education in Mathematics, Science and Technology, 10*(1), 218–235. https://doi.org/10.46328/ijemst.2244

Muzana, S. R., Jumadi, J., Wilujeng, I., Yanto, B. E., & Mukti, W. A. H. (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. https://doi.org/10.11591/ijere.v10i4.21942

Ngadinem, N., & Sulisworo, D. (2020). The improvement of higher-order thinking skills through project-based learning on STEM education settings. *Proceedings of the International Conference on Community Development (ICCD 2020)*. https://doi.org/10.2991/assehr.k.201017.111

Nor, A. F. M., & Jumaat, S. A. (2023). *Implementing project-oriented problem-based learning (POPBL) in the power system stability chapter* [Online resources]. Penerbit UTHM.

Nowlan, N., Arya, A., Samar, H., & Abdinejad, M. (2023). X reality higher-order thinking skills assessment in 3D virtual learning environments using motifs and expert data. *Computers & Education: X Reality, 2*(November 2022), 100012. https://doi.org/10.1016/j.cexr.2023.100012

Nukak, S. K., Rayer, D. J. J., & Maramis, A. A. (2021). Project-based learning (PjBL) integrated with realia media towards learning outcomes on students' creativity and learning interest in classification of living things at SMA Negeri 3 Tondano. *Journal of Physics: Conference Series, 1968*(1), 012005. https://doi.org/10.1088/1742-6596/1968/1/012005

Nurhalis, F., Nuryanti, S., & Sakung, J. (2024). The influence of the integrated problem-based learning (PBL) model of high order thinking skills (HOTS) on the critical thinking ability and science creativity of high school students. *International Journal of Education, Humaniora, and Social Studies*, 17–22. https://doi.org/10.63895/j30321271.2024.v1.i1.pp17-22

Nurmaliah, C., Azmi, T., Safrida, S., Khairil, & Artika, W. (2021). The impact of implementation of STEM integrating project-based learning on students' problem-solving abilities. *Journal of Physics: Conference Series, 1882*(1), 012162. https://doi.org/10.1088/1742-6596/1882/1/012162

Nurmaliah, C., Syukriah, Abdullah, A., Khairil, Safrida, S., Artika, W., & Huda, I. (2020). Enhancing students' creativity by implementing project-based learning (PjBL) in biodiversity concept. *Journal of Physics: Conference Series, 1460*(1), 012065. https://doi.org/10.1088/1742-6596/1460/1/012065

Parno, P., Nur'Aini, D., Kusairi, S., & Ali, M. B. (2022). Impact of the STEM approach with formative assessment in PjBL on students' critical thinking skills. *Journal of Physics: Conference Series, 2165*(1), 012044. https://doi.org/10.1088/1742-6596/2165/1/012044

Ph, Q. A., Sudarmin, S., Sumarni, W., Subali, B., & Saptono, S. (2020). Implementation of STEM integrated ethnoscience-based vocational science learning in fostering students' higher-order thinking skills (HOTS). *International Journal of Active Learning, 5*(2), 53–61. https://doi.org/10.15294/ijal.v5i2.27498

Plailek, T., Kitjarak, T., & Plailek, W. (2023). Improving creative problem-solving abilities of English students through HyFlex learning management and project-based learning. *Higher Education Studies, 13*(4), 128. https://doi.org/10.5539/hes.v13n4p128

Pramasdyahsari, A. S., Setyawati, R. D., Aini, S. N., Nusuki, U., Arum, J. P., Astutik, I. D., Widodo, W., Zuliah, N., & Salmah, U. (2023). Fostering students' mathematical critical thinking skills on number patterns through digital book STEM PjBL. *Eurasia Journal of Mathematics, Science and Technology Education, 19*(7), em2297. https://doi.org/10.29333/ejmste/13342

Puangpunsi, N. (2021). Learners' perception towards project-based learning in encouraging English skills performance and 21st century skills. *THAITESOL Journal, 34*(1), 1–24. https://files.eric.ed.gov/fulltext/EJ1304647.pdf

Puspitasari, E. (2020). Project-based learning implementation to cultivate preservice English teachers' 21st century skills. *IJELTAL (Indonesian Journal of English Language Teaching and Applied Linguistics, 5*(1), 191. https://doi.org/10.21093/ijeltal.v5i1.638

Qudratuddarsi, H., Hidayat, R., Shah, R. L. Z. B. R. M., Nasir, N., Imami, M. K. W., & Nor, R. B. M. (2022). Rasch validation of instrument measuring Gen-Z science, technology, engineering, and mathematics (STEM) application in teaching during the pandemic. *International Journal of Learning, Teaching and Educational Research, 21*(6), 104–121. https://doi.org/10.26803/ijlter.21.6.7

Rahayu, P., & Putri, R. I. I. (2021). Project-based mathematics learning: Fruit salad recipes in junior high school. *Journal on Mathematics Education, 12*(1), 181–198. https://doi.org/10.22342/jme.12.1.13270.181-198

Rahim, A. C., Jumadi, J., Wilujeng, I., & Kuswanto, H. (2019). The effect of PjBL model based on skill approach process to physics critical thinking ability of high school student. *Journal of Physics: Conference Series, 1233*(1), 012040. https://doi.org/10.1088/1742-6596/1233/1/012040

Rahmatika, N., Hanapi, M. H. B. M., Jendriadi, J., Sariasih, Y., Imami, M. K. W., & Uslan, U. (2024). The impact of flipped learning on students' critical thinking: A systematic literature review. *International Journal of Learning, Teaching and Educational Research, 23*(10), 180–206. https://doi.org/10.26803/ijlter.23.10.9

Rais, M., Yahya, M., Jamaluddin, J., & Purnamawati, P. (2021). Comparing project-based learning and problem-based learning to foster 21st-century learning skills in agricultural seaweed product. *Cypriot Journal of Educational Sciences, 16*(3), 1217–1230. https://doi.org/10.18844/cjes.v16i3.5842

Ren, R., Dong, J., Dong, J., Sun, B., Chen, Y., & Chen, Z. (2019). A systematic literature review of green and sustainable logistics: Bibliometric analysis, research trend and knowledge taxonomy. *International Journal of Environmental Research and Public Health, 17*(1), 261. https://doi.org/10.3390/ijerph17010261

Rozi, A., Khoiri, A., Farida, R. D. M., Sunarsi, D., Jasmani, Paeno, Munawaroh, & Iswadi, U. (2021). The fullness of higher order thinking skills (HOTs) in applied science textbooks of vocational schools. *Journal of Physics: Conference Series, 1764*(1), 012143. https://doi.org/10.1088/1742-6596/1764/1/012143

Santhosh, M., Farooqi, H., Ammar, M., Siby, N., Bhadra, J., Al-Thani, N., Sellami, A., Fatima, N., & Ahmad, Z. (2023). A meta-analysis to gauge the effectiveness of STEM informal project-based learning: Investigating the potential moderator variables. *Journal of Science Education and Technology, 32*(5), 671–685. https://doi.org/10.1007/s10956-023-10063-y

Santyasa, I. W., Agustini, K., & Pratiwi, N. W. E. (2021). Project-based e-learning and academic procrastination of students in learning chemistry. *International Journal of Instruction, 14*(3), 909–928. https://doi.org/10.29333/iji.2021.14353a

Saputra, T., & Wagiran. (2019). Developing project-based learning model using jobsheet in vocational high school. *Journal of Physics: Conference Series, 1273*(1), 012041. https://doi.org/10.1088/1742-6596/1273/1/012041

Sari, I. K., Kenedi, A. K., Andika, R., Ningsih, Y. Y. W., & Ariani, Y. (2019). Develop a student's critical thinking skills. *Journal of Physics: Conference Series, 1321*(3), 032093. https://doi.org/10.1088/1742-6596/1321/3/032093

Setyarini, T. A., Mustaji, M., & Jannah, M. (2020). The effect of project-based learning assisted PANGTUS on creative thinking ability in higher education. *International Journal of Emerging Technologies in Learning (iJET), 15*(11), 245. https://doi.org/10.3991/ijet.v15i11.12717

Shoimah, R. N., & Fatoni, A. (2023). The implementation of higher order thinking skill (HOTS) oriented learning through project-based learning model (PjBL) in elementary schools. *Deleted Journal, 1*(0), 47. https://doi.org/10.24235/sicee.v1i0.14583

Sidiq, Y., Ishartono, N., Desstya, A., Prayitno, H. J., Anif, S., & Hidayat, M. L. (2021). Improving elementary school students' critical thinking skill in science through HOTS-based science questions: A quasi-experimental study. *Jurnal Pendidikan IPA Indonesia/JPPI: Jurnal Perndidikan IPA Indonesia, 10*(3), 378–386. https://doi.org/10.15294/jpii.v10i3.30891

Siew, N. M., & Ambo, N. (2018). Development and evaluation of an integrated project-based and STEM teaching and learning module on enhancing scientific creativity among fifth graders. *Journal of Baltic Science Education, 17*(6), 1017–1033. https://doi.org/10.33225/jbse/18.17.1017

Siew, N. M., & Ambo, N. (2020). The scientific creativity of fifth graders in a STEM project-based cooperative learning approach. *Problems of Education in the 21st Century, 78*(4), 627–643. https://doi.org/10.33225/pec/20.78.627

Singh, V. K., Singh, P., Karmakar, M., Leta, J., & Mayr, P. (2021). The journal coverage of Web of Science, Scopus and Dimensions: A comparative analysis. *Scientometrics, 126*(6), 5113–5142. https://doi.org/10.1007/s11192-021-03948-5

Sofiyan, S., Amalia, R., & Suwardi, A. B. (2020). Development of mathematical teaching materials based on project-based learning to improve students' HOTS and character. *Journal of Physics: Conference Series, 1460*(1), 012006. https://doi.org/10.1088/1742-6596/1460/1/012006

Suastra, I. W., & Ristiati, N. P. (2019). Developing critical thinking, scientific attitude, and self-efficacy in students through project-based learning and authentic assessment in science teaching at junior high school. *Journal of Physics: Conference Series, 1233*(1), 012087. https://doi.org/10.1088/1742-6596/1233/1/012087

Sudarmin, S., Sumarni, W., Endang, P. R. S., & Susilogati, S. S. (2019). Implementing the model of project-based learning: Integrated with ETHNO-STEM to develop students' entrepreneurial characters. *Journal of Physics: Conference Series, 1317*(1), 012145. https://doi.org/10.1088/1742-6596/1317/1/012145

Suherman, S., Prananda, M. R., Proboningrum, D. I., Pratama, E., Laksono, P. J., & Amiruddin, A. (2020). Improving higher order thinking skills (HOTS) with project-based learning (PjBL) model assisted by GeoGebra. *Journal of Physics: Conference Series, 1467*(1), 012027. https://doi.org/10.1088/1742-6596/1467/1/012027

Sumarni, W., & Kadarwati, S. (2020). Ethno-STEM project-based learning: Its impact to critical and creative thinking skills. *Jurnal Pendidikan IPA Indonesia/JPPI: Jurnal Perndidikan IPA Indonesia, 9*(1), 11–21. https://doi.org/10.15294/jpii.v9i1.21754

Susanto, S., Desrani, A., Ritonga, A. W., & Rubiyantoro, Y. (2022). Improving students' creative thinking in learning Arabic through HOTS-based project-based learning model. *An Nabighoh/An-Nabighoh, 24*(1), 1. https://doi.org/10.32332/an-nabighoh.v24i1.3924

Suwarno, S., Wahidin, W., & Nur, S. (2020). Project-based learning model assisted by worksheet: Its effect on students' creativity and learning outcomes. *Jurnal Pendidikan Biologi Indonesia, 6*(1), 113–122. https://doi.org/10.22219/jpbi.v6i1.10619

Tafakur, T., Retnawati, H., & Shukri, A. A. M. (2023). Effectiveness of project-based learning for enhancing students' critical thinking skills: A meta-analysis. *Jurnal Inovasi Pembelajaran, 9*(2), 191–209. https://doi.org/10.22219/jinop.v9i2.22142

Tuaputty, H., Alimudi, S., Irene, I., Latuperissa, L. N., & Donkor, A. (2023). Project-based learning using a laboratory approach on learning outcomes and critical thinking in marine biology. *Jurnal Pendidikan Biologi Indonesia, 9*(1), 103–114. https://doi.org/10.22219/jpbi.v9i1.24551

Ummah, S. K., In'am, A., & Azmi, R. D. (2019). Creating manipulatives: Improving students' creativity through project-based learning. *Journal on Mathematics Education, 10*(1), 93–102. https://doi.org/10.22342/jme.10.1.5093.93-102

Usmeldi, U., & Amini, R. (2022). Creative project-based learning model to increase creativity of vocational high school students. *International Journal of Evaluation and Research in Education, 11*(4), 2155–2164. https://doi.org/10.11591/ijere.v11i4.21214

Van Gog, T., Hoogerheide, V., & Van Harsel, M. (2020). The role of mental effort in fostering self-regulated learning with problem-solving tasks. *Educational Psychology Review, 32*(4), 1055–1072. https://doi.org/10.1007/s10648-020-09544-y

Viana, R. V., Jumadi, J., Wilujeng, I., & Kuswanto, H. (2019). The influence of project-based learning based on process skills approach to student's creative thinking skill. *Journal of Physics: Conference Series, 1233*(1), 012033. https://doi.org/10.1088/1742-6596/1233/1/012033

Vrbin, C. M. (2022). Parametric or nonparametric statistical tests: Considerations when choosing the most appropriate option for your data. *Cytopathology, 33*(6), 663–667. https://doi.org/10.1111/cyt.13174

Wahyudi, W., Verawati, N. N. S. P., Islahudin, I., & Agustina, S. P. (2023). Hybrid ethno-project based learning integrated with virtual assistive technology to enhance students' critical thinking in fundamental physics course. *TEM Journal*, 2006–2012. https://doi.org/10.18421/tem124-11

Wijnen, F., Van Der Molen, J. W., & Voogt, J. (2021). Measuring primary school teachers' attitudes towards stimulating higher-order thinking (SHOT) in students: Development and validation of the SHOT questionnaire. *Thinking Skills and Creativity, 42*, 100954. https://doi.org/10.1016/j.tsc.2021.100954

Wright, T., & Pullen, S. (2007). Examining the literature. *Journal of Education for Sustainable Development, 1*(1), 77–90. https://doi.org/10.1177/097340820700100114

Yin, X. F., Saad, M. R. B. M., & Halim, H. B. A. (2023). A systematic review of critical thinking instructional pedagogies in EFL writing: What do we know from a decade of research. *Thinking Skills and Creativity, 49*, 101363. https://doi.org/10.1016/j.tsc.2023.101363

You, J. W. (2020). Enhancing creativity in team project-based learning amongst science college students: The moderating role of psychological safety. *Innovations in Education and Teaching International, 58*(2), 135–145. https://doi.org/10.1080/14703297.2020.1711796

Yunita, Y., Juandi, D., Kusumah, Y. S., & Suhendra, S. (2021). The effectiveness of the project-based learning (PjBL) model in students' mathematical ability: A systematic literature review. *Journal of Physics: Conference Series, 1882*(1), 012080. https://doi.org/10.1088/1742-6596/1882/1/012080

Zulfiani, Z., Suwarna, I. P., & Sumantri, M. (2020). Science adaptive assessment tool: Kolb's learning style profile and student's higher order thinking skill level. *Jurnal Pendidikan IPA Indonesia/JPPI: Jurnal Perndidikan IPA Indonesia, 9*(2), 194–207. https://doi.org/10.15294/jpii.v9i2.23840

Zulyusri, Z., Elfira, I., Lufri, L., & Santosa, T. A. (2023). Literature study: Utilization of the PjBL model in science education to improve creativity and critical thinking skills. *Jurnal Penelitian Pendidikan IPA, 9*(1), 133–143. https://doi.org/10.29303/jppipa.v9i1.2555