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META-ANALYSIS: THE EFFECT OF THE PROJECT-BASED LEARNING MODEL ON STUDENTS' MATHEMATICAL CREATIVE THINKING ABILITIES IN INDONESIA 2021-2025

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Abstract

This study aims to comprehensively analyze the effect of the Project Based Learning model on students' mathematical creative thinking abilities in Indonesia in 2021-2025. This study used a meta-analysis method with PRISMA guidelines and obtained 13 primary studies for analysis. Primary studies that met the inclusion criteria were analyzed using Comprehensive Meta-Analysis (CMA) software version 4.0. The results of the calculation of the overall effect size obtained a Hedges'g value of 1.063 with a Z value of 7.990 and a p value <0.05, which means that the application of the Project Based Learning model has a significant effect on students' mathematical creative thinking abilities. Based on the results of the moderator variable analysis, a very large effect size was obtained at the high school level with a Hedges'g value of 1.487 and in studies with a small sample size (≤30 participants) with a Hedges'g value of 1.121. However, the heterogeneity test between groups obtained a p value>0.05 for both moderator variables, so that the differences between groups were not statistically significant and did not provide sufficient evidence that education level or sample size moderated the intervention effect.

Keywords: Project Based Learning; Mathematical Creative Thinking; Meta-Analysis.

INTRODUCTION

Creative thinking is a form of divergent thinking that allows for the emergence of various alternative solutions to a problem. In mathematics learning, this ability is a crucial focus because mathematics not only emphasizes concepts and procedures but also encourages innovation and diverse problem-solving. However, the reality on the ground shows that students' mathematical creative thinking skills are still relatively low (Nurhanifah, 2022; Rozi & Afriansyah, 2022). The results of the 2022 PISA also confirmed the low creative thinking abilities of Indonesian students. In fact, student performance on mathematics tests has also decreased compared to 2018 (OECD, 2023). This situation requires schools to create a learning environment that supports the exploration of new ideas, provides challenges that stimulate critical and creative thinking, and builds students' confidence in trying unconventional solutions. Project-Based Learning (PjBL) is one of several learning models that can be used to improve mathematical creative thinking skills (Yunita et al., 2021). This model emphasizes learning through completing real-life projects that require active student involvement. The teacher acts as a facilitator, while students are more active in the learning process (Hamidah & Citra, 2021). The implementation of PjBL can stimulate students' mathematical creative thinking skills by encouraging the exploration of problem-solving strategies, finding innovative solutions, and developing original ideas in the application of mathematical concepts.

Previous research has shown that the use of the PjBL model influences students' mathematical creative thinking abilities. For example, research by Firdaus (2023), Gunawan et al. (2024), and Safitri & Abadi (2025) found that PjBL significantly influences and can improve mathematical creative thinking abilities. However, other studies have yielded different findings. Saragih (2022) and Wiyanti & Hadi (2023) reported that PjBL implementation had no significant effect. These differences in findings indicate variations in the effects of PjBL influenced by study characteristics, so a meta-analysis approach is needed to obtain a more stable and comprehensive estimate of the effect. In Indonesia, meta-analytic studies have been conducted on the effects of PjBL on mathematical creative thinking abilities (Susilowaty, 2023; Yunita et al., 2021). However, the literature reviewed is limited to the period from 2014 to 2021. This indicates that the research does not include the latest developments, such as innovations in learning methods, curriculum changes, or technological advances that could influence the research results. To date, there has been no meta-analysis of the effect of PjBL on students' mathematical creative thinking skills in Indonesia between 2021 and 2025. This study aims to complement and expand previous studies by analyzing the magnitude of the effect of PjBL on various study characteristics, such as educational level and sample size. This emphasizes the importance of meta-analysis research regarding the effect of PjBL on students' mathematical creative thinking skills in Indonesia.

METHOD

This research uses a *systematic review method* with a quantitative approach technique, namely meta-analysis. Meta-analysis is a research method carried out by analyzing, reviewing, summarizing, and combining quantitative results from several previous studies to draw a more accurate conclusion. The general stages in meta-analysis research include: (1) Formulating or explaining the problem to be studied; (2) Establishing inclusion criteria to select studies worthy of analysis; (3) Tracing and collecting literature or empirical data from previous research; (4) Reviewing and converting statistical data contained in articles and then coding primary studies; (5) Calculating effect sizes and average values from the collected data; (6) Applying statistical techniques to analyze the relationship between variables and evaluate the impact or influence found in these studies (Paloloang, 2021; Tamur & Juandi, 2020) . The population in this meta-analysis study includes all primary studies that discuss the influence of the *Project Based Learning model* on students' mathematical creative thinking abilities, while the sample consists of studies that meet the predetermined inclusion criteria.

Inclusion Criteria

Establishing inclusion criteria aims to ensure that only articles that are relevant, valid, and aligned with the research focus are included in the meta-analysis. The following are the inclusion criteria for this study:

1. The study examined the influence of *the Project Based Learning* (PjBL) model on students' mathematical creative thinking abilities.
2. The research was conducted on students at elementary, junior high/Islamic junior high, and senior high/vocational high schools/Islamic senior high schools in Indonesia based on the large islands in Indonesia, namely Sumatra, Java, Kalimantan, Sulawesi, and Papua.
3. The study included sufficient quantitative data to calculate *the effect size* , such as sample size, *mean value* , standard deviation, combination of sample size with statistical test value (t and p).
4. The studies analyzed were experimental or quasi-experimental studies with two comparison classes (experimental class and control class), not a one-group design.
5. The studies were published over a five-year period, from 2021 to 2025.
6. The studies included in this synthesis come from national journals indexed by SINTA, *Scopus, Google Scholar* , and final assignment scientific works (thesis, dissertation).

Data collection

The primary study search was conducted using the *Publish or Perish application that accesses the Google Scholar, Crossref, and Scopus* databases , and supplemented with additional searches through GARUDA and several university repositories. The primary study search used several keywords, namely, " *project-based learning* , mathematical creative thinking", "project-based learning, mathematical creative thinking", " *project-based learning* , *mathematical creative thinking skills* ", and "project-based learning, *mathematical creative thinking skills* ". A total of 99 relevant studies were obtained, published in 2021-2025. The obtained primary studies were then processed according to the PRISMA *(Preferred Reporting Items for Systematic Reviews and Meta-Analyses) flow* to ensure transparency and quality in the data search, selection, and analysis process. The data selection flow using the PRISMA protocol is: 1) identification, 2) screening, 3) eligibility, and 4) inclusion (Auliya et al., 2024) .

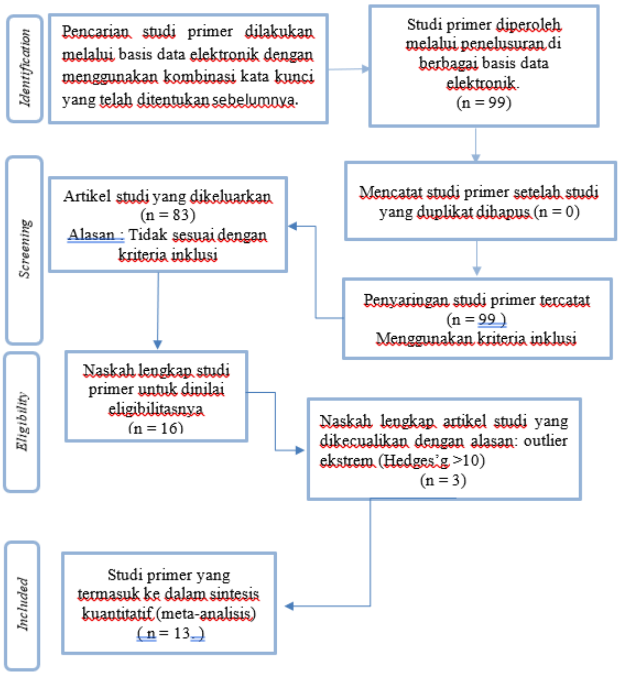

Figure 1PRISMA flow

Based on this diagram, 13 primary studies were found suitable for analysis. The following is a list of the primary studies analyzed in this study.

Table 1List of Analyzed Studies

No	Citation	Journal Name
1	Afifah, et al. 2025	SCIENCE (Journal of Innovation in Mathematics and Science Education)
2	Alamsyah and Wulandari, 2024	Journal of Education for All (EduFA), Ar-Rahman Nahdlatul Wathan Foundation
3	Amelia, et al. 2025	Cendekia Journal (Journal of Mathematics Education), Pahlawan Tuanku Tambusai University
4	Gunawan, et al. 2024	JouME (Journal of Mathematics Education), Mandiri University, Subang
5	Islamiati and Irfan, 2022	Proximal (Journal of Mathematics Research and Mathematics Education), Cokroaminoto University, Palopo
6	Kumaralalita, et al. 2025	THEMATIC (Journal of Mathematics Education Content), Zainul Hasan Genggong Islamic University
7	Lavli and Efendi, 2024	JIP (Journal of Educational Sciences), Kusuma Negara Teacher Training College
8	Luthfiyah, et al. 2024	Tambusai Journal of Education, Pahlawan Tuanku Tambusai University
9	Khoirun Nisa and Waluyo, 2024	Journal of Mathematics Education, IKIP Veteran Semarang
10	Pangalila, et al. 2024	SOSCIED, Saint Paul Catholic Polytechnic Sorong
11	Rahmawati and Yuliardi, 2024	IMEIJ (Indo-MathEdu Intellectuals Journal), STKIP Muhammadiyah Kuningan
12	Wijaya, et al. 2025	Cognitive (HOTS Research Journal of Mathematics Education), Education and Talent Development Center Indonesia (ETDC Indonesia)
13	Wiyanti and Hadi, 2023	Prisma Sains (Journal of Mathematics and Science Studies and Learning), IKIP Mataram

Of the 13 primary studies analyzed, the distribution based on education level and sample size is presented in Table 4.2 below.

Table 2Distribution of Moderator Variables

No	Moderator Variables	Group	Frequency
1	Educational level	Elementary School	1
		JUNIOR HIGH SCHOOL	9
		SENIOR HIGH SCHOOL	3
2	Sample Size	≤ 30	8
		> 30	5

"The distribution of sample sizes in primary studies was analyzed to understand the role of sample size as a moderating variable. Sample sizes were categorized into ≤30 and >30 based on the Central *Limit Theorem* , which states that the distribution of sample means will become closer to normal as the sample size increases.

Subhaktiyasa (2024) added that the larger the sample size, the higher the level of confidence and precision of the research results. However, Susanti et al., (2020) found that in small samples (≤30 students), the value of the trial effect tends to be higher than in large samples. Therefore, this division is relevant for assessing the stability of estimates and potential bias in meta-analyses, and is consistent with common practice in the statistical literature, where n > 30 is often considered a practical limit to distinguish small samples from large samples (Aziz et al., 2025; Islam, 2018) .

Data Extraction

Articles meeting the inclusion criteria were analyzed using a coding sheet validated by two validators, one of whom was a meta-analysis expert. The coding sheet included citations, statistical data, research area, educational level, sample size, publication year and year of study implementation, publication type and source, indexing level, and journal information and article links. Data coding was performed independently by two coders. The level of inter-coder agreement on the coding results was tested using the Cohen's kappa coefficient using SPSS version 26 software.

Data analysis

Data analysis using *software Comprehensive Meta Analysis* (CMA) version 4.0. The statistical analysis in this study refers to the procedures of Borenstein et al., (2009) , namely (a) calculating the effect size in each primary study, (b) testing heterogeneity and determining the estimation model, (c) evaluating the potential for publication bias, and (d) calculating the p-value for testing the research hypothesis.

To test the hypothesis, this study used *effect size* (ES) as the primary indicator of influence in the meta-analysis. The effect size used to analyze the magnitude of influence in this meta-analysis is the Hedges' g formula . *Interpretation* of *effect size values* will use the classification created by Thalheimer & Cook, 2002 , *as described in* (Nurhasanah, 2024) , as below.

Table 3. Effect Size Hedges'g

Hedges'(g)	Interpretation
$g < 0,15$	Ignored
$0.15 \leq g < 0.40$	Low
$0.40 \leq g < 0.75$	Currently
$0.75 \leq g < 1.10$	Tall
$1.10 \leq g < 1.45$	Very high
$1.45 \leq g$	Perfect

The heterogeneity test aims to select an appropriate effect size model (Manaf & Natsir, 2022) . The heterogeneity test is performed using the Q statistic and p-value. If the p-value is <0.05, the null hypothesis stating homogeneity between studies is rejected, and the random-effects model is selected. Conversely, if the p-value is >0.05, the null hypothesis is accepted, and the *fixed-effects model* can be used. Moderator variable analysis is only performed after confirming the heterogeneity of the data and selecting the *random-effects model.* Publication bias analysis is performed to avoid inaccurate presentation of findings. Published studies tend to be more easily included in meta-analyses than unpublished studies, raising concerns that meta-analyses may overestimate the true effect size. To detect publication bias in meta-analyses, a *funnel plot test is performed. The fill and trim* method detects asymmetry in *the funnel plot,* indicating bias, and then eliminates studies with the most extreme small effect sizes. The effect sizes are then recalculated gradually until the distribution in *the funnel plot* becomes symmetrical. This ensures more accurate results and is free from publication bias, which can lead to overinterpretation of effect sizes.

The robustness of meta-analysis results is measured using the *fail-safe N test* . The greater the FSN value, the stronger and more stable the meta-analysis results are against the possibility of publication bias. FSN calculations can be done using software such as CMA version 4.0, and if the FSN value is obtained using the formula $\frac{N}{5k+10} > 1$, then all primary studies used in the meta-analysis research are resistant to publication bias with k being the number of studies included in the meta-analysis. To test the research hypothesis, *a p-value calculation was performed* (Paloloang, et al. 2020) . If *the p-value* < 0.05, then there is a significant influence of the *Project Based Learning model* on students' mathematical creative thinking abilities from studies synthesized based on *the Effect Size category* .

RESULTS AND DISCUSSION

The first primary objective of this study was to identify the overall influence of the Project-Based Learning (PjBL) model on students' mathematical creative thinking skills. The initial step in the analysis was to calculate the effect size for each primary study. The results of the effect size calculations for all primary studies are presented in Table 4.

Table 4. Results of Effect Size Calculations for Primary Studies

Author	*Effect Size*	Interpretation	Standard error	Variance	Lower limit	Upper limit
Afifah, et al. 2025	0.991	Tall	0.266	0.071	0.469	1,512
Alamsyah and Wulandari, 2024	1,187	Very high	0.375	0.141	0.451	1,922
Amelia, et al. 2024	1,581	Perfect	0.286	0.082	1,020	2,141
Gunawan, et al. 2024	1,075	Tall	0.269	0.072	0.548	1,602
Islamiati and Irfan, 2022	2,388	Perfect	0.341	0.116	1,720	3,057
Kumaralalita, et al. 2025	1,087	Tall	0.250	0.063	0.597	1,578
Lavli and Efendi, 2024	1,043	Tall	0.297	0.088	0.46	1,626
Luthfiyah, et al. 2024	1,180	Very high	0.286	0.082	0.619	1,741
Nisa and Waluyo, 2024	1,005	Tall	0.271	0.073	0.474	1,536
Pangalila, et al. 2024	0.688	Currently	0.341	0.116	0.020	1,355
Rahmawati and Yuliardi, 2024	0.550	Currently	0.260	0.067	0.041	1,059
Wijaya, et al. 2025	1,059	Tall	0.243	0.059	0.583	1,535
Wiyanti and Hadi, 2023	0.269	Low	0.237	0.056	-0.197	0.734

Based on Table 4, the overall effect size range is 0.550 to 2.388, with a 95% confidence level. Referring to the classification, it can be seen that two effect sizes have a perfect positive effect (n=2); two effect sizes have a very high effect (n=2); six effect sizes have a high effect (n=6); two effect sizes have a moderate effect (n=2); and one effect size has a low effect (n=1). Table 4 shows a comparison of the meta-analysis results according to the random effects model. As illustrated in Table 4, it appears that according to the random effects model, the lower limit of the 95% confidence interval is 0.802, and the upper limit is 1.324. The overall effect size of the study is 1.063. This effect size falls within the interpretation of a high effect.

The second stage is to conduct a heterogeneity test and select an estimation model.

Table 5. Comparison of Results Based on Estimation Models

No	Estimation Model	n	Z	P	Effect Size	Standard Error	95%CL		*Heterogeneity*		
							Lower Limit	Upper Limit	Qb	P-value	I-square
1	Fixed Effects	13	13,246	0,000	1,025	0.006	0.873	1,176	34,850	0,000	65,566
2	Random Effects	13	7,990	0,000	1,063	0.018	0.802	1,324			

Based on Table 5, the Qb value is 34.850 and the p value is 0.000. Thus, the distribution of effect sizes is found to be heterogeneous at $p < 0.05$ (the actual effect size varies from one study to another). The degree of variation in effect sizes between studies is reflected in the I-squared value of 65.566, which indicates that 65% of the variance in observed effect sizes reflects the percentage of variability caused by true heterogeneity (not caused by sampling error). Since the homogeneity test result was rejected, the estimation model used was a random-effects model.

The third step was to examine publication bias in 13 primary studies. A funnel plot of the effect sizes of the twelve studies is presented in Figure 2.

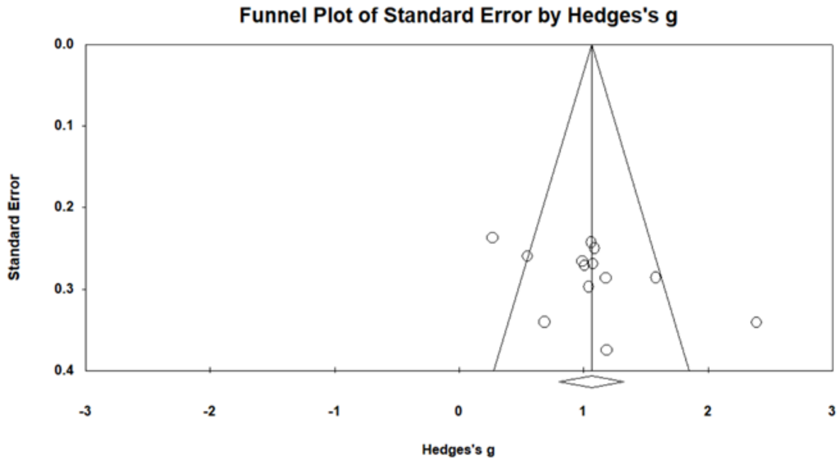

Figure 2. Funnel Plot of 13 Primary Studies

Figure 2 indicates that the distribution of effect sizes does not exhibit perfect symmetry. This raises the possibility that the average effect size from the studies included in this meta-analysis may not fully reflect the true effect size in the population (Borenstein et al., 2009). To statistically confirm this indication of asymmetry, Egger's regression test was performed as a formal approach to detecting publication bias.

Table 6. Egger Regression Test Results

Coefficients						
	Estimate	Standard Error	T	p	95% Confidence	
					Lower	Upper
Intercept	6.45597	3.34218	1.93166	0.07956	-0.90012	13.81206

Based on the results of the Egger regression test in Table 6, the intercept value was 6.45597 with a p-value of 0.07956. This p-value is greater than the 0.05 significance level, so statistically there is insufficient evidence to state the presence of significant publication bias in the analyzed study set. However, given that the distribution of effect sizes in the funnel plot indicated asymmetry, further analysis using the trim-and-fill method and the Fail-Safe N (FSN) calculation was performed to evaluate whether there were signs of publication bias in this study set (Borenstein et al., 2009). Both procedures are useful for detecting and addressing studies suspected of being affected by publication bias. The results of the trim and fill test are presented in Table 6.

Table 7. Trim and Fill Test Results

	Studies on *trim*	Hedges'g	Lower Limit	Upper Limit	Q value
Observed values	0	1.06297	0.800221	1.32373	34.84975
Adjusted value		1.06297	0.80221	1.32373	34.84975

Based on Table 6, it appears that the number of excluded studies is zero. These results indicate that the thirteen studies analyzed in this study did not show any indication of publication bias. No studies required exclusion from the analysis due to indications of publication bias. Next, a Fail-Safe N test was conducted to determine the study's resistance to publication bias. The calculation using CMA version 4.0 yielded an N value of 606 from the thirteen analyzed studies. This value was then substituted into the Fail-Safe N formula, $FSN = \frac{N}{(5k+10)} = \frac{606}{(5(13)+10)} = \frac{606}{75} = 7.76$. A value of 7.76 >1 indicates that the analyzed studies are resistant to publication bias. The final step is to calculate the p-value to test the research hypothesis. Table 5 compares the analysis results according to the estimation model. According to the random effects model presented in Table 5, the 95% confidence interval ranges from 0.801 to 1.324, indicating that the average difference can fall anywhere within this range, and the effect size of the thirteen studies is 1.063. This effect size falls within the interpretation of a high effect. The results of the Z-test calculation to determine statistical significance obtained a Z-value of 7.990. This result is said to be statistically significant because the p-value is <0.005. Thus, the application of the PjBL model has a high positive influence on students' mathematical creative thinking abilities compared to the conventional approach. Next, we analyzed the moderator variables from 13 primary studies, namely educational level and sample size. Hedges' g, Z, and p values with 95% confidence intervals were calculated using CMA and presented in Table 7.

Table 8. Analysis Results Based on Moderator Variables

No	Moderator Variables	Group	n	Combined Effect Size (*Hedges'g*)	*Test of null* (3-Tail)		*Heterogeneity*		
					Z	p	*Between Effect* (Qb)	Df (Q)	P
1	Educational level	Elementary School	1	1,187	3,163	0.002	2,162	2	0.339
		JUNIOR HIGH SCHOOL	9	0.920	6,951	0,000			
		SENIOR HIGH SCHOOL	3	1,487	3,796	0,000			
2	Sample Size	≤ 30	8	1,121	6,158	0,000	0.242	1	0.623
		> 30	5	0.984	4,663	0,000			

First, in Table 7, the study characteristics based on education level obtained effect sizes at the Elementary School (SD) level of 1.187 (very high), Junior High School (SMP) of 0.920 (high), and Senior High School of 1.487 (perfect). The PjBL model has a perfect effect when applied to the high school level. The results of the heterogeneity test showed a Q value = 2.162 and p> 0.05. This indicates that there is no statistically significant difference in effect size based on education level. This means that there is no difference in students' mathematical creative thinking abilities through the PjBL model caused by education level. Second, regarding study characteristics based on sample size, an effect size of 1.121 (very high effect) was obtained for sample sizes ≤30 participants. For sample sizes >30 participants, an effect size of 0.984 (high) was obtained. Based on Table 7, the Q value was obtained = 0.242 and p value > 0.05. Although the effect size tended to be higher in studies with small sample sizes, the results of the heterogeneity test between groups showed that the difference was not statistically significant.

The overall effect size calculation of the Project Based Learning (PjBL) model obtained a Hedges'g value of 1.063 with a Z value of 7.990 and a p-value <0.05, which means that the implementation of the Project Based Learning model has a significant effect on students' mathematical creative thinking abilities. This value is included in the interpretation of a high effect. In other words, through these calculation results, it can be seen that the Project Based Learning model is effective in improving students' mathematical creative thinking abilities. This finding is supported by the results of a literature study conducted by Djam'an, et al. (2025) with the conclusion that the Project Based Learning model can effectively develop students' mathematical creative thinking abilities with a STEM approach. In addition, the results of this meta-analysis study are also supported by the findings of a meta-analysis by Yunita, et al. (2021) which shows a positive effect of the Project Based Learning model on mathematical creative thinking abilities with an effect size of 1.063 which is categorized as high.

The consistency of these findings is reinforced by a recent meta-analysis showing that the implementation of STEM project-based learning has a significant impact on student creativity, including creative thinking which is part of mathematical creative thinking skills (Kwon & Lee, 2025). Project-based learning also facilitates the development of aspects of fluency, flexibility, originality, and elaboration as the main components of mathematical creative thinking through student involvement in authentic problem solving, collaborative work, and continuous reflection on the learning process and outcomes, as shown in various empirical findings and recent meta-analyses which confirm that Project-Based Learning and STEM Project-Based Learning consistently improve student creativity (Feziyasti et al., 2025; Islamiati & Irfan, 2022). This significant increase in effectiveness aligns with the development of PjBL implementation in 2021-2025, which has significantly integrated technology, ethnomathematics, and adapted to the Independent Curriculum (Islamiati & Irfan, 2022; Safitri & Abadi, 2025).

Therefore, it can be concluded that PjBL implementation is highly effective and has a significant impact compared to conventional learning. Based on educational level, the results of the PjBL implementation effect size analysis appear to vary across educational levels. The effect sizes obtained at the junior high school/Islamic junior high school level ($g = 0.920$; high effect), elementary school ($g = 1.187$; very high effect), and senior high school/Islamic senior high school/vocational high school ($g = 1.487$; perfect effect). However, the results of the heterogeneity test between groups showed Q_between = 2.162 and $p = 0.339$ ($p > 0.05$). Thus, the difference in the average effect sizes of the three levels was not significantly different. This is in line with the findings of Zhang & Ma (2023) who emphasized that the effectiveness of PjBL is determined more by the quality of implementation and project design than by educational level, thus it can be concluded that PjBL has consistent impacts across levels. This finding differs from the meta-analysis by Yunita et al., (2021) which showed that there were significant differences in effect sizes based on educational level. Meanwhile, recent studies from 2021–2025 demonstrate the consistent effectiveness of PjBL across levels, confirming that this model has a positive impact on mathematical creative thinking skills in a relatively uniform manner across various educational levels.

Based on sample size, descriptive analysis showed variations in the effect size of PjBL implementation on mathematical creative thinking skills. Studies with small samples (≤ 30 participants) had an effect size of $g = 1.121$ (very high effect), while studies with large samples (> 30 participants) had an effect size of $g = 0.984$ (high effect). However, the results of the heterogeneity test showed $Qb = 0.242$ and $p = 0.623$ ($p > 0.05$), indicating that the difference in sample size was not statistically significant. This indicates that although there are variations in the descriptive effect size between studies with small and large samples, these differences are not strong enough to affect the consistency of PjBL's effectiveness. This finding is in line with Vygotsky's constructivist theory of the zone of proximal development (ZPD), which emphasizes that the quality of interaction, scaffolding, and teacher support are more important determinants of student creativity development than simply the number of participants in the class (Kouicem, 2020). Thus, the stability of the PjBL effect across educational levels and sample sizes indicates that the effectiveness of this model's implementation is not influenced by educational level or number of participants, but rather by the quality of implementation, such as relevant project planning, discussion facilitation, and reflective feedback. This finding confirms that teachers' primary focus should be on learning strategies that encourage active student engagement.

CONCLUSION

This study analyzed 13 studies published between 2021 and 2025. The results showed that the implementation of the Project-Based Learning model had a significant positive effect on students' mathematical creative thinking skills. Moderator variable analysis showed that neither educational level nor sample size significantly affected the effect size ($p > 0.05$). Thus, the effect of the Project-Based Learning model on mathematical creative thinking skills is stable regardless of educational level or sample size. This study generates several recommendations for future research. Increasing the number of studies in the analysis will make the symmetrical pattern in the funnel plot clearer and increase the likelihood of being free from publication bias. Furthermore, the moderator variables analyzed in this study are still limited. Therefore, future research is recommended to include additional moderator variables such as intervention duration, level of technology integration, ethnomathematics approach, and other contextual factors such as student characteristics and institutional support to provide a more comprehensive picture of the effectiveness of PjBL on the development of mathematical creative thinking. At the policy level, these results can serve as a basis for schools and policymakers to provide structural support in the form of adequate time, access to learning resources, and technology integration, so that PjBL implementation can be optimal and sustainable in enhancing students' mathematical creativity.

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