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# UNVEILING THE EFFECTIVENESS OF PROJECT-BASED LEARNING MODELS ON CREATIVE THINKING SKILLS: META-ANALYSIS PERSPECTIVE

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**Abstract**

This research conducted a meta-analysis to identify whether project-based learning approaches can enhance creative thinking skills. The search spanned from 2018 to 2024. Through a rigorous selection process, a total of 15 articles were identified as relevant primary data meeting the criteria for analysis concerning creative thinking skills. The selected articles constituted experimental studies utilizing quasi-experimental design methods. The results of the meta-analysis revealed that project-based learning significantly enhances creative thinking skills, with an overall effect size of ES=0.909. With a significance value for heterogeneity of $p < 0.001$, it is concluded that the effect distribution in this meta-analysis is heterogeneous. This outcome indicates a "High Effect" size. The findings suggest that project-based learning models are more effective in fostering students' creative thinking skills compared to conventional learning models.

**Keywords:** Project-Based Learning, Creative Thinking Skills, Meta-Analysis, Quasi-Experimental Design, Effectiveness.

## 1. INTRODUCTION

Current education faces increasingly complex challenges in an era where static knowledge is no longer sufficient to prepare future generations for global dynamics. In addressing the need for 21st-century skills such as critical thinking, creativity, and problem-solving [1] [2] [3], educators must seek effective learning approaches to develop higher-order thinking skills in students. Various learning models have emerged since the discovery of multiple learning theories, marking one of the developments in education. Project-Based Learning (PjBL) has emerged as a promising approach to achieve 21st-century learning objectives. PjBL emphasizes learning integrated with real-life experiences, where students gain hands-on experience in facing relevant and complex challenges [4]. In this context, PjBL not only facilitates the acquisition of knowledge but also stimulates the development of critical skills such as analysis, evaluation, and synthesis. Project-Based Learning is a learning approach that emphasizes investigation, focusing on the concepts and principles of a subject. In this approach, diverse resources are used, and learning activities are carried out continuously in the real world. The goal is to produce a complete project work that can solve various interconnected problems within a specific timeframe [5]. Project-Based Learning involves students in complex tasks, decision-making, and investigation [6]. PjBL focuses on knowledge construction through hands-on practice and involves learners in decision-making and social discussions [7]. PjBL emphasizes the building of knowledge through active student engagement. Constructivist learning allows learners to make decisions and discuss problems collaboratively [8]. Project-

Based Learning has been shown to significantly enhance students' capacity for critical thinking, communication, collaboration, and creativity, collectively known as the 4Cs, as outlined in the 21st-century framework. Studies have demonstrated that PjBL pedagogy is more effective than traditional methods in improving students' 4C abilities [9] [10]. Additionally, the implementation of PjBL activities has been found to increase students' interest in learning, develop their abilities, and produce rich outcomes in project-based learning [11].Furthermore, the stages of PBL have been proven to enhance 21st-century 4C skills, including critical thinking, problem-solving, creativity, communication, and collaboration. These findings collectively support the idea that PBL is a valuable approach for fostering deeper student engagement and participation in developing essential 21st-century skills.Several studies have demonstrated that project-based learning models are effective in enhancing students' creative thinking skills [12] [13] [14].Project-Based Learning (PjBL) is widely recognized for its benefits in promoting the 4Cs—critical thinking, communication, collaboration, and creativity—identified by the 21st-century framework. This framework is designed to foster deeper levels of student engagement [15] [16]. Moreover, the implementation of PjBL necessitates the use of the 4Cs, aiding students in solving real and meaningful problems through structured projects [17]. This underscores that innovative learning approaches such as PjBL can not only develop students' creative thinking skills but also require these skills for effective application.

Other research indicates that Project-Based Learning (PjBL) offers students a deep and comprehensive learning experience. Through PjBL, students not only acquire conceptual knowledge but also have the opportunity to apply this knowledge in real-world contexts by developing engaging and meaningful projects. PjBL has been recognized as one of the most effective methods for stimulating students' creative thinking skills [18] [19]. By facing challenges in designing and completing projects, students not only practice solving concrete problems but also have the opportunity to hone their creativity in finding innovative solutions. PjBL emphasizes not only the final project outcome but also the learning process that occurs throughout the project journey. This process not only enhances students' understanding of the subject matter [20] but also strengthens their creative thinking abilities [21].

One research technique capable of synthesizing diverse research findings on a relevant topic through a quantitative approach is meta-analysis. Meta-analysis is a research method that systematically integrates various relevant primary studies using a quantitative approach to summarize, estimate, and evaluate information into a unified framework regarding the strength of average effects, correlations, and relationships among variables, utilizing effect sizes as measurement tools [22]. Meta-analysis offers several advantages such as greater transparency, detection and reduction of bias, improved estimation of population parameters, the ability to assess outcomes across various fields, providing strong evidence for significant refutation, and offering rigorous methodology in the synthesis process [23]. Consequently, these benefits enhance the quality of meta-analytical research. The primary objective of this meta-analysis research is to provide accurate and clear information to policymakers in the field of education. This study will address the impact of implementing project-based learning on enhancing students' creative thinking skills, a topic that currently generates inconsistent research reports. Therefore, this meta-analysis aims to estimate, evaluate, and summarize the effects of PBL implementation on creative thinking skills. Additionally, this research will investigate the characteristics of studies such as field of study, year of publication, and sample size, which may contribute to the heterogeneity of effect size data.

## 2. METHODOLOGY

Meta-analysis is a quantitative analysis method that gathers and organizes findings from various experimental or quasi-experimental studies examining the same research question [24]. This method then produces average effect sizes by weighting sample sizes, average standard deviations, and other data from existing research findings to obtain the final results. Meta-analysis has been widely used in the field of education. This study compares and combines literature on the same research topic but with different outcomes, extracting data such as pre- and post-test means, sample sizes, and standardized mean differences from relevant literature. Additionally, this method utilizes standard deviation to correct bias in small samples, serving as an effective value to indicate the level of project-based learning implementation on creative thinking skills. In the context of this research, meta-analysis utilizes secondary data derived from learning outcomes in experimental and control classes from a study on Project-Based Learning.

Meta-analysis involves a series of steps, beginning with framing the subject, designing the study as a whole, identifying research samples, collecting data, and analyzing data [25]. A systematic literature search was conducted using electronic databases, including Google Scholar, Scopus, PubMed and ERIC, covering the period from 2018 to 2024. Search terms included combinations of “project-based learning,” “creative thinking skills,” “meta-analysis,” and related terms. Studies were included if they met the following criteria: (1) used an experimental design, (2) used project-based learning as an intervention, (3) measured creative thinking skills as an outcome, and (4) provided sufficient data for effect size calculations. Studies using quasi-experimental designs were also considered due to the nature of educational research. The next step involves evaluating the Cohen's Effect Size values from the gathered articles. This calculation aims to categorize the values according to the classification table established. This classification is utilized to assess the effectiveness of implementing the blended learning model in enhancing learning achievement. Below is the table listing the classification of Cohen's Effect Size based on Rosenthal & Rubin [26].

**Table 1: Cohen's Effect Size Classification**

| Effect Size | Category |
|---|---|
| 0 ≤ES≤ 0,2 | Low Effect |
| 0,2 ≤ ES≤ 0,8 | Medium Effect |
| ES ≥ 0,8 | High Effect |

The data analysis for this study utilized the JSP software. The conducted tests included heterogeneity testing and meta-analysis testing. Heterogeneity testing was performed to determine the type of effect model used, whether it's a fixed-effect model or a random-effect model. Meta-analysis was conducted by calculating the effect size, standardizing mean differences with bias correction (Hedges' g), computing the standard error of the effect size, calculating the standard difference in means, determining the summary effect, computing the standard error of the summary effect, establishing lower and upper limits, calculating the Z-value and hypothesis testing, as well as interpreting the Summary Effect, describing the forest plot, and conducting publication bias correction through the funnel plot diagram.

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## 3. RESULTS

This section presents the results of the meta-analysis. The meta-analysis in this study combines and interprets findings from various studies to provide a more comprehensive overview. This technique allows researchers to consolidate data from multiple studies, thereby yielding stronger and more reliable conclusions regarding the researched issue. After the selection process, a total of 15 articles were ultimately chosen as primary data for this analysis. The following presents the results of the selection of primary data that meet the criteria for analysis.

**Tabel 2: The result of data extraction**

| Article code | Experiment | | | Control | | | Year |
|---|---|---|---|---|---|---|---|
| | N | M | SD | N | M | SD | |
| A1 | 20 | 70,5 | 10,375 | 20 | 61,5 | 12,042 | 2023 |
| A2 | 40 | 83,3 | 3,674 | 40 | 80 | 3,537 | 2022 |
| A3 | 36 | 90,35 | 11,09 | 36 | 78,83 | 11,09 | 2022 |
| A4 | 29 | 10,172 | 29,163 | 22 | 8,409 | 41,936 | 2021 |
| A5 | 25 | 74,4 | 6,344 | 25 | 65 | 6,614 | 2022 |
| A6 | 25 | 51,8 | 4,536 | 25 | 53,4 | 13,51 | 2022 |
| A7 | 40 | 22,32 | 3,856 | 39 | 20,34 | 3,552 | 2020 |
| A8 | 40 | 41,15 | 3,945 | 39 | 34,54 | 3,215 | 2020 |
| A9 | 24 | 22,29 | 4,41 | 21 | 16,28 | 5,37 | 2019 |
| A10 | 11 | 645,455 | 960,587 | 11 | 664,545 | 107,458 | 2018 |
| A11 | 26 | 78,84 | 4,834 | 26 | 73,31 | 9,104 | 2018 |
| A12 | 44 | 18,11 | 2,498 | 42 | 17,71 | 3,078 | 2019 |
| A13 | 35 | 82,46 | 4,21 | 35 | 74,49 | 5,47 | 2023 |
| A14 | 11 | 87,77 | 3,559 | 11 | 83,5 | 2,511 | 2024 |
| A15 | 24 | 80,92 | 7,436 | 24 | 63,46 | 6,731 | 2023 |

The data extracted from the 15 primary studies have been collected and presented in Table 2. This table provides an overview of the relevant research findings. Meanwhile, the characteristics of each primary study are discussed in detail in Table 3. This table provides information on the Effect Size, Standard Error of the primary data. By considering both tables, a more comprehensive understanding of the researched topic and the results found in the meta-analysis is obtained.

**Tabel 3: The Study Characteristics of Each Primary Study**

| Article code | Effect Size | Standard Error |
|---|---|---|
| A1 | 0,785 | 0,325 |
| A2 | 0,906 | 0,234 |
| A3 | 1,028 | 0,25 |
| A4 | 0,049 | 0,281 |
| A5 | 1,428 | 0,315 |
| A6 | -0,156 | 0,281 |
| A7 | 0,529 | 0,228 |
| A8 | 1,817 | 0,267 |
| A9 | 1,21 | 0,323 |
| A10 | -0,027 | 0,418 |
| A11 | 0,747 | 0,285 |
| A12 | 0,142 | 0,215 |
| A13 | 1,615 | 0,274 |
| A14 | 1,334 | 0,466 |
| A15 | 2,421 | 0,38 |

The data above indicates significant variation in the effect sizes generated by various articles, with effect sizes ranging from -0.156 to 2.421 and standard errors from 0.215 to 0.466.

The majority of articles demonstrate positive effect sizes, suggesting that the intervention or independent variable tends to have a positive impact on the dependent variable. However, two articles show negative effect sizes, namely articles A6 and A10.

Referring to Cohen's Effect Size Classification, two articles fall into the weak effect category, three articles fall into the medium effect category, and eight articles fall into the high effect category.

The meta-analysis results presented here focus on the implementation of the Project-Based Learning model in enhancing creative thinking abilities. To calculate the effect size of this research, the first step is to determine the appropriate meta-analysis model. Beginning with testing the homogeneity of studies using Fixed and Random Effects. The following table presents the homogeneity analysis results and the overall effect size based on Fixed and Random Effects.

**Table 4: Results of Heterogeneity Meta-Analysis**

| Fixed and Random Effects | | | |
|---|---|---|---|
| **Omnibus test of Model Coefficients** | **Q** | **df** | **p** |
| Test of Residual Heterogeneity | 23.569 | 1 | < 0,001 |
| | 82.588 | 14 | < 0,001 |

The table above provides an overview of the heterogeneity analysis in the meta-analysis study. The value of $Q = 82.588$ exceeds the expected value of 23.569, with a confidence level of 95%.

This result indicates significant variation among the existing study findings, signifying heterogeneity in the effect distribution. Furthermore, the significance value $p < 0.001$ confirms that the differences among these study results cannot be explained solely by random variation.

Therefore, it can be concluded that the effect distribution in this meta-analysis is heterogeneous, according to the fixed-effect model. In this context, the fixed-effect model reveals that no single effect can be identified under the observed effect size. Instead, the variation in these effects demonstrates the complexity of the studied phenomenon and highlights the importance of considering heterogeneity in interpreting the results of meta-analysis.

Figure 1 displays the Forest Plot depicting the distribution of effect size values from primary studies formed by the random-effects model. This plot provides a clear visualization of the variation in effect sizes among the various studies analyzed in the meta-analysis. Each bar on this plot represents the effect size of one study, with the vertical line indicating the 95% confidence interval.

Through this plot, one can observe the extent of variation in effects among different studies and identify any patterns or trends emerging from the distribution. This assists researchers in interpreting the strength and consistency of effects in the analyzed dataset.

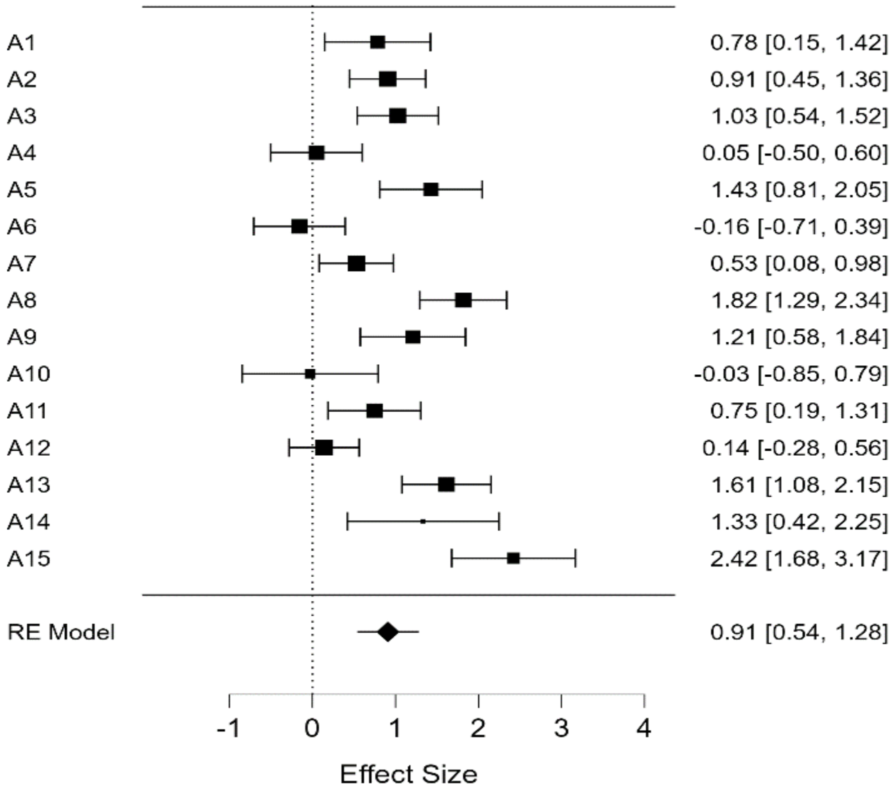


**Figure 1: Forest Plot Displaying the Distribution of Effect Size Values Across Studies**

The squares within the plot indicate the effect size of each study, while the lines on both sides of the squares represent the 95% confidence interval of the effect size range. These squares are consolidated into a main study box reflecting the overall effect size weight. At the bottom, there is a diamond shape representing the overall effect size of all studies.

When assessing the effect size in the study, it was observed that the range of values varied from a minimum of -0.16 to a maximum of 2.42. Out of the 15 studies examined, 13 indicated a positive impact, while only 2 showed a negative impact. This underscores a notable trend across these studies, where the majority favored the PjBL approach.

From the studies reporting positive effects, it was evident that the experimental groups implementing PjBL tended to experience improvements. Conversely, the two studies indicating negative effects suggested that in specific contexts, traditional educational methods might be more effective.

Hence, a careful interpretation of these diverse outcomes allows for a nuanced understanding of the intricate dynamics among different learning methodologies.

The research's effect sizes typically follow a normal distribution, with the confidence interval points positioned around the x=y line. Figure 2 depicts the normal distribution graph of the study's effect sizes, a representation also included in this research.

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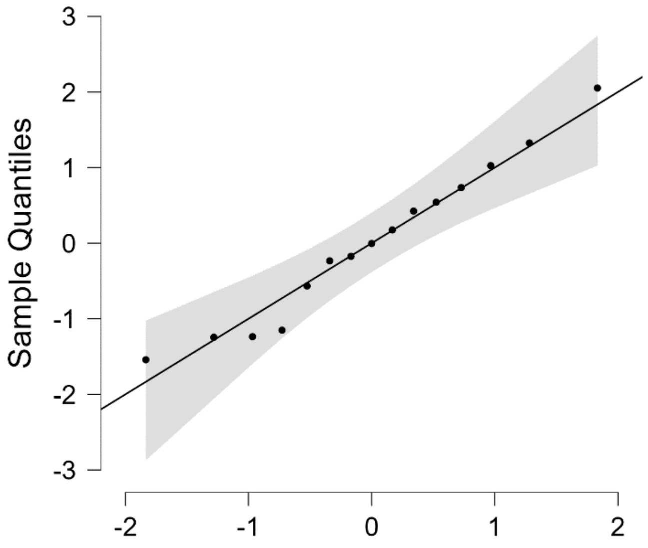


**Figure 2: Effect Size's Normal Quantile Plot**

Upon reviewing the normal quantile plot of the study's effect sizes, it's evident that the plot closely adheres to the normal distribution line without exceeding predetermined bounds. This suggests that the data distribution within the analyzed studies tends to conform to a normal distribution pattern. In simpler terms, the research findings tend to align with the distribution pattern commonly seen in the population, which enhances the validity and interpretation of the research outcomes.

The overall effect size of the project-based learning approach in enhancing Creative Thinking Skills is 0.909 at a high effect level. With a sufficient number of studies, it can be concluded that the analysis results obtained have a high level of reliability and low publication bias. Furthermore, the presence of publication bias can be interpreted using the attached Funnel Plot in Figure 3.

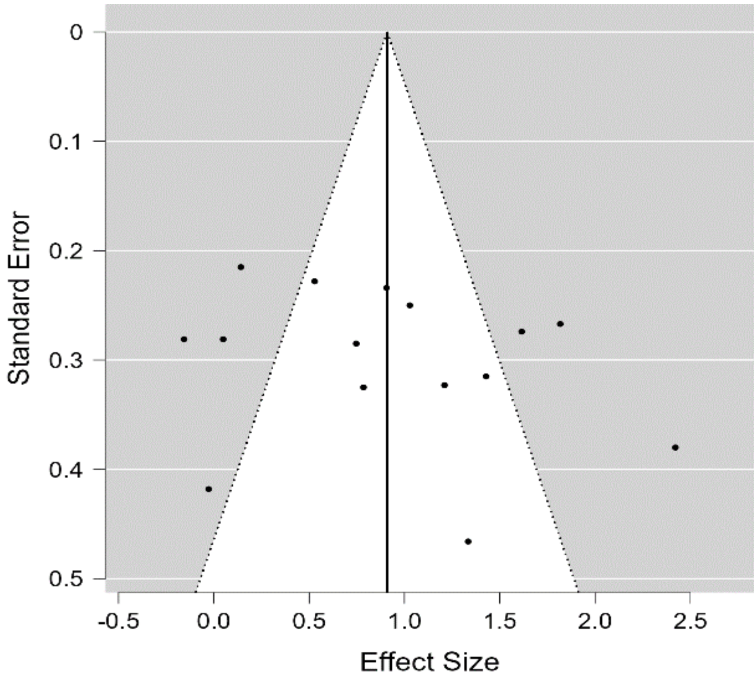


**Figure 3: Effect Size's Funnel Plot**

Interpreting the analysis results using the funnel plot from Figure 3 presents a challenge due to the uncertainty in determining whether the plot is symmetrical or asymmetrical. Hence, conducting the Rosenthal Fail Safe N (FSN) test is necessary to assess potential publication bias. Details regarding the outcomes of the Rosenthal Fail Safe N (FSN) test are available in Table 5.

**Table 5: Rosenthel Fail Safe N Test**

| File Drawer Analysis | | | |
|---|---|---|---|
| Rosenthal | **Fail-safe N** | **Target Significance** | **Observed Significance** |
| | 760.000 | 0.050 | < .001 |

Based on the table provided, the Fail Safe N value is derived (FSN = 760.000), alongside a significance level of 0.050 and p < 0.001. Subsequently, the FSN value is computed using the formula 760 / (5K + 10) = 15.2, indicating FNS > 1, implying the absence of publication bias in the meta-analysis, thus confirming the scientific integrity of the analyzed data. The final step in the analysis entails calculating the summary value or mean effect size from the 15 primary data points examined. The outcomes of this summary analysis or mean effect size are presented in Table 6.

**Table 6: The Outcomes of Studies' Effect Size Based on Fixed and Random Effects**

| | | | | | **95% Confidence Interval** | |
|---|---|---|---|---|---|---|
| Intercept | **Estimate** | **Standard Error** | **z** | **p** | **Lower** | **Upper** |
| | 0.909 | 0.187 | 4.855 | < .001 | 0.542 | 1.276 |

Based on the outcomes derived from the random effect model analysis presented in the table above, it can be inferred that there is significance in advancing our comprehension of the effects associated with project-based learning models. The 95% Confidence Interval signifies a range of values spanning from 0.542 to 1.276, with an overall effect size of 0.909.

According to Cohen, an effect size of this magnitude qualifies as high, confirming that this educational approach carries substantial impact. Furthermore, the Z-test outcome of 4.855 strongly suggests that the project-based learning model significantly enhances students' creative thinking skills when compared to conventional methods. This is reinforced by the statistical significance indicated by a very low p-value, specifically p < 0.001. Hence, it can be deduced that the project-based learning model effectively boosts students' creative thinking abilities.

These results are consistent with several prior findings indicating that the implementation of Project-Based Learning models has been significantly proven to enhance students' creative thinking skills in various studies [27] [28]. Research has underscored the positive influence of PBL models on students' creative thinking skills within social studies, showcasing advancements in students' ability to think creatively and solve problems [29] [30].

Furthermore, experimental studies have highlighted a robust association between project-based learning models and the improvement of creative thinking skills, with notable enhancements observed in metrics such as fluency, flexibility, originality, and elaboration among students [31].

Overall, the evidence suggests that adopting project-based learning models can indeed lead to meaningful enhancements in students' creative thinking abilities, rendering it a valuable approach within educational settings.

## 4. CONCLUSION

This meta-analysis study uncovers several notable findings: firstly, the application of project-based learning (PBL) models significantly enhances creative thinking skills, as demonstrated by the synthesis of 15 relevant primary studies.

Secondly, publication characteristics emerge as a factor influencing the diverse variation in effect sizes. Hence, this research offers educators insights into the effectiveness of project-based learning models in boosting students' creative thinking abilities.

The meta-analysis concludes that project-based learning models exert a positive impact on creative thinking skills, supported by a mean effect size of 0.909, classified as high. The study's results suggest that project-based learning models outperform conventional methods in nurturing students' creative thinking skills.

Overall, this investigation reinforces the assertion that project-based learning represents a highly effective pedagogical approach for cultivating students' creative thinking abilities, presenting compelling evidence for educators to contemplate integrating this model into the educational process.

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