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Project Based Learning Model Assisted by Mind Mapping Media: Student Creativity in IPAS Lessons at Public Islamic Elementary

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ABSTRACT

This study seeks to evaluate the impact of the Project Based Learning (PjBL) model, facilitated by mind mapping media, on enhancing students' creativity in science education. This research employs a quasi-experimental approach utilizing a nonequivalent control group design. This research was carried out in fourth grade at State Elementary Madrasah 2 in Bandar Lampung. Data acquisition via assessments, interviews, and observations. The analysis of data involves quantitative assessment utilizing the independent samples t-test. The study's results demonstrate a substantial and favorable impact of the Project Based Learning (PjBL) model, facilitated by mind mapping media, on students' creativity in science subjects. The findings stem from the independent sample t-test, revealing a significance value of 0.000, which is less than the significance threshold of 0.05. Moreover, the creativity of students engaged in the mind mapping-assisted project-based learning model was quantitatively superior to that of students involved in conventional learning. The substantial disparity in the average posttest scores between the experimental group (mean = 16.82) and the control group (mean = 12.18) is apparent. The efficacy of the Mind Mapping-assisted PjBL model in fostering creativity derives from the synergy between the student-centered learning paradigm and the application of visual cognitive tools. Project-based learning fosters a genuine and demanding educational atmosphere, motivating students to engage in exploration, collaboration, and problem-solving. Mind mapping is an effective tool for promoting non-linear thinking, visually organizing complex ideas, and integrating the brain's logical and creative functions.

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1. INTRODUCTION

Education is crucial to improving human resources. Science and technology advance rapidly, so schools must keep up (Fangestu & Syahrizal, 2023). We develop and advance education to improve it and produce quality workers. This initiative encourages everyone to follow education developments. Education is a conscious, organized, and systematic effort by those charged with influencing people to adopt educational values

(Purwaningsih et al., 2022). Education can occur in schools, outside of school, or in daily life. Through education, people gain insight, critical thinking, and social skills to adapt to society. Education boosts quality of life, job creation, and national progress (Sanga & Wangdra, 2023). Curriculum, teaching methods, teacher roles, and learning environments greatly impact education effectiveness. Technology and innovation in education improve access and quality (Makinde et al., 2024). Effective education helps people become independent and productive and contribute to society and global development.

Education is a top priority in life, so excellent education leads to excellent knowledge (Shavkidinova et al., 2023). Quality education can provide students the skills, knowledge, and character to face future challenges. Quality education develops character, skills, and potential and prepares students for challenges. One method that makes education the center of student learning improves education quality (Burganova et al., 2018).

Various stakeholders can help improve education and teacher competence in a region. Student-centered learning achieves this. Student-centered learning promotes equality, inclusion, and diversity (Kladder, 2019). This learning environment empowers students. Student-centered learning emphasizes student participation (Tholibon et al., 2022). Through teacher facilitation, students explore, think critically, and discover their understanding. This method customizes learning for each student's interests, needs, and style. More profound understanding requires interaction, collaboration, and reflection. This method encourages independence, motivation, and meaningful learning. Today, student-centered learning is advised (Kerimbayev et al., 2023). Teachers must actively participate in teaching so students can create creative learning projects. Therefore, student-centered learning requires many learning methods, including learning models.

Project-based learning (PjBL) uses projects or activities as a medium to focus on students and positions the teacher as a motivator and facilitator, allowing students to explore the learning material on their own (Zhang & Ma, 2023). Students focus on one learning point in project-based learning, which can improve memory and creativity in teacher-facilitated projects. Project-based learning challenges students and enhances their ability to learn in this context. PjBL is a student-centered learning model that uses real-world projects to solve problems (Sucilestari et al., 2023; Maros, 2023). In-depth exploration and research promote critical thinking, collaboration, and creativity in this model. This method helps students apply knowledge in real life by learning actively, independently, and contextually. The dynamic project-based learning model teaches students through project organization, design, and presentation (Torrijo et al., 2021). The project is the main learning focus. Project-based learning has a beneficial way of making learning meaningful for students. We need supportive learning collaboration with media that uses the project learning model (Masruri et al., 2024).

Media transmits messages. Educational media conveys learning messages. Coordination of learning activities requires media (Daryanes et al., 2023). Media is adaptable to all learning levels and activities. Learning media can also help students take some responsibility for their learning and think long-term (Fülöp et al., 2023). Mind mapping, which is a type of project-based learning media, helps students connect different concepts and material. Mind mapping helps remember previously learned material (Davies, 2011; Li et al., 2021). As explained above, learning media improves understanding, clarifies concepts, and motivates students. Media should match learning objectives, learner characteristics, and content context. Learning media also promotes teacher-student interaction (Lubis et al., 2023). E-learning, simulations, and augmented reality are becoming more popular as technology advances. Use of appropriate media improves learning quality and effectiveness. Effective learning requires media use. Mind mapping helps students develop critical and collaborative thinking and creativity in project-based learning (Goebert, 2023; Fortuna & Aeni, 2024).

Creative people discover and create new things, methods, and models for themselves and society (Henriksen et al., 2017). The elements may already exist, but people discover new combinations and constructs with unique qualities. These novelties are innovative by nature. Human life and development depend on creativity. Creativity is driven by intelligence, talent, and learning outcomes, while affective and psychomotor factors also contribute (Zhan et al., 2022). Students' creativity levels are measured to improve learning creativity (Kusmanto et al., 2021). Creative measures include 1) curiosity, which is actively seeking new things and ideas. 2) Fluency, which is answering questions and expressing ideas readily. 3) Flexibility, the ability to identify alternative solutions to goals. 4) Originality—creating new ideas and products. This skill can be learned through practice, openness to new ideas, and risk-taking. Creativity allows people to make unique contributions and improve life.

The independent curriculum in Indonesian schools changes the previous curriculum. Natural Sciences and Social Sciences become Natural and Social Sciences (IPAS) with the independent curriculum. Teachers must integrate the two topics. Education also values Natural Sciences, which studies the universe and its contents and events, developed by experts using scientific methods (Suprapmanto & Zakiyah, 2024). Therefore, elementary school students learn Natural Sciences. Students should understand the natural world so they can apply their knowledge. The elementary school independent curriculum includes Natural and Social Sciences (IPAS), which combines natural and social science (Andreani & Gunansyah, 2023). Science and social studies in this curriculum aim to spark curiosity, encourage active participation, develop research skills, help students understand themselves and the world, and learn scientific concepts. The independent learning curriculum incorporates natural and social sciences to create a holistic, multidisciplinary, and contextual education.

IPAS uses natural and social sciences to study human-environment relations (Marwa et al., 2023). Science learning develops scientific understanding and systematic thinking through experiments, observations, and data analysis. This topic also emphasizes environmental balance and resource sustainability. IPAS's interdisciplinary approach helps students understand how natural and social sciences affect daily life (Zakarina et al., 2024). Science and natural sciences (IPAS) expects students to understand the material and apply it to real-world problems through projects or works.

According to pre-research at state elementary madrasah 2 Bandar Lampung on project-based learning among fourth-graders, 58.2% (64 out of 110 students) were "Less Creative" (scores 5–9). Of Zaenab's students, 41 (37.3%) were "Quite Creative" (scores 10–14) and 5 (4.5%) were "Very Creative" (scores 15–20). Fluency, flexibility, originality, elaboration, and evaluation are measures of creativity. An observation sheet was used on November 18–20, 2024, with assessments reduced from eight to five indicators for consistency with the primary research. Several main factors reduce creativity. Traditional learning methods like lectures reduce student activity. Second, learning media are limited to printed books without mind mapping, making concepts challenging to grasp. Third, teachers' inexperience with innovative models like PjBL hinders creativity. Therefore, PjBL with mind mapping is suggested to boost science student creativity. The lack of interactive and visual learning media like mind mapping worsens this situation by preventing students from organizing and creating ideas. Students can visualize concepts with mind mapping, improving fluency and flexibility. However, observations indicate that State Elementary Madrasah 2 Bandar Lampung still uses printed textbooks without variety, making it difficult for students to visualize concepts or generate original ideas. Homeroom teachers also lacked experience implementing Project-Based Learning (PjBL), which boosts creativity through real-life exploration and collaboration. Due to their inexperience, teachers often use conventional methods that don't challenge students to think critically or innovate in science.

To develop fluency, flexibility, originality, and elaboration, we need a learning environment that encourages exploration and free expression. The low scores on these aspects at State Elementary Madrasah 2 Bandar Lampung reflect the current learning environment, where teacher-student interactions are one-way and students have little space to develop ideas independently. This research will address these limitations by integrating Project-Based Learning (PjBL), which emphasizes real-world project-based learning, and mind mapping, which helps organize ideas visually. This method will boost student creativity and enrich science learning by contextualizing scientific and social concepts, making students more active, innovative, and motivated.

This situation shows the need for contextual learning that actively engages students. PjBL encourages critical thinking, collaboration, and creativity by giving students real-world projects to learn from. Mind mapping will help students understand concepts, organize information visually, and improve memory and creativity. The Project-Based Learning (PjBL) model and mind mapping media are expected to make science learning meaningful and foster creativity indicators like curiosity, originality, risk-taking, and problem-solving. Based on the problem formulation above, this study examines how the Project-Based Learning (PjBL) model with mind mapping improves fourth-grade science student creativity at State Elementary Madrasah 2 Bandar Lampung.

2. METHOD

This study employed a quasi-experimental design utilizing a Nonequivalent Control Group to evaluate the efficacy of Project Based Learning (PjBL) augmented by mind mapping in enhancing the creativity of fourth-grade students in science education at State Elementary Madrasah 2 Bandar Lampung. Two classes were chosen: the experimental group engaged in project-based learning (PjBL), creating models of animal life cycles through mind mapping, whereas the control group utilized traditional instructional methods, specifically lectures and printed materials. Due to the pre-established classes, complete randomization was not feasible; however, initial characteristics such as student count, age, and academic level were standardized to preserve validity. The design of this study can be outlined schematically as follows in Table 1.

Table 1. Nonequivalent Control Group Design

Group	Pretest	Treatment	Posttest
Experimental Group	O_1	PjBL + Mind Mapping (X)	O_2
Control Group	O_3	Copperative Learning Model	O_4

Description:
O_1 and O_3: Creativity pretest results for the experimental and control groups.
X: PjBL treatment with mind mapping.
O_2 and O_4: Creativity posttest results for the experimental and control groups.

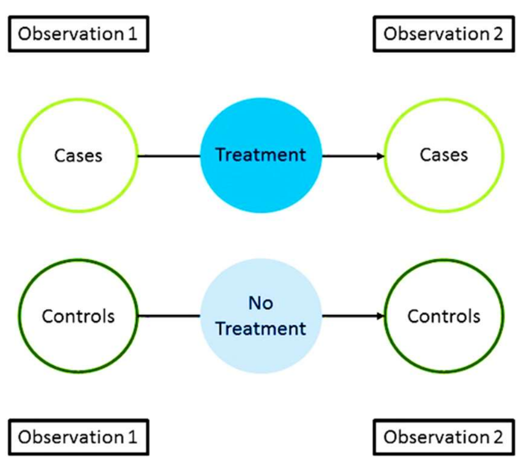

Figure 1. Flowchart Nonequivalent Control Group Design

Data was collected through in-depth interviews. Data is collected through interviews with research participants. Interviews involve face-to-face meetings and direct question-and-answer sessions between the researcher and the informant. The researcher asks respondents questions during interviews. Face-to-face interviews are possible. It presents researchers more detailed, exploratory, and flexible data than other methods.

Teacher interviews were used to learn about their teaching and learning process, student creativity challenges, and their views on innovative learning models like Project-Based Learning (PBL) supported by mind mapping. A fourth-grade science teacher at State Elementary Madrasah 2 Bandar Lampung was interviewed. The pre-research interview was held at State Elementary Madrasah 2 Bandar Lampung before the intervention. A semi-structured interview guide guided in-person interviews. The researcher recorded the interviewee's responses and analyzed key points to create an action plan.

Data analysis will compare pretest and posttest scores in each group (gain scores) and between groups using statistical tests like the independent t-test or Mann-Whitney test, depending on the data distribution. This study uses a quasi-experimental design to test the hypothesis that mind-mapping-assisted PjBL can significantly increase student creativity compared to conventional methods while maintaining validity and reliability. In this study, 109 fourth graders at State Elementary Madrasah 2 Bandar Lampung participated.

Students' creativity was assessed using performance-based tests. Following Project-Based Learning (PjBL), students were asked to investigate a problem, design a solution, create a work, and present it for this test. This test is relevant because it better represents students' creativity than written tests. The rubric assessed creativity indicators like fluency, flexibility, originality, elaboration, and evaluation. Student performance was objectively assessed using rubric and converted into creativity level categories for quantitative analysis.

This study observed students' creativity indicators during learning. Science and social studies were observed in a fourth-grade classroom at State Elementary Madrasah 2 Bandar Lampung. PjBL learning cycle observations were done during the treatment (dates adjusted to the research schedule). A creativity indicator-based observation sheet was used to conduct systematic observations. The sheet listed creativity as fluency, flexibility, originality, elaboration, and evaluation. As students participated in group discussions and project presentations, researchers recorded their indicators. Converting observation scores into creativity levels allowed further analysis. The hypothesis test in this study examines whether the Project Based Learning (PjBL) model and mind mapping affect fourth-grade science student creativity. Two independent samples were tested with a t-test. This inferential statistical test compares two unrelated groups' averages:

a. The experimental group receiving treatment using the PjBL model assisted by mind mapping.
b. The control group undergoing conventional learning.

This test aimed to ascertain if the mean creativity score of students in the experimental group was significantly greater than that of the control group. This test was employed to validate the alternative hypothesis (H_a) that the PjBL model, augmented by mind mapping, enhances student creativity. Before the T-test, prerequisite assessments were performed, including normality and homogeneity tests:

a. The normality test to ensure that the data from each group was normally distributed.
b. The homogeneity test is used to determine whether the variances of the two groups are equal.

Upon fulfillment of both prerequisites, a two-tailed t-test is conducted. Consequently, as the study aimed to assess the enhancement or superiority of the experimental group, a one-tailed t-test was employed. The t-test results are subsequently compared to the t-table at a specified significance level (e.g., 5%) and degrees of freedom (df) = n1 + n2 - 2. If the t-test statistic exceeds the critical value from the t-table, then the null hypothesis (H_0) is rejected in favor of the alternative hypothesis (H_a), signifying a statistically significant difference between the two groups.

3. RESULTS AND DISCUSSION

Results

The principal data in this study were the creativity scores of students acquired via a performance assessment. The utilized instrument was a creativity assessment rubric intended to evaluate five primary dimensions: fluency, flexibility, originality, elaboration, and evaluation. Data collection occurred in two phases: a pretest prior to the treatment implementation to assess initial capabilities, and a posttest following the treatment period to evaluate the intervention's effects. The data was gathered from two sample groups: an experimental class utilizing the Mind Mapping-assisted PjBL model (N=28) and a control class adhering to conventional learning methods (N=28). The creativity scores produced by this instrument varied from 5 (minimum) to 20 (maximum).

Description of Statistical Data

To obtain a clear initial picture of the data characteristics and changes that occurred in both groups, descriptive statistical analysis was conducted. This analysis includes calculating the mean as a measure of central tendency, the standard deviation as a measure of data variability, and the minimum and maximum values to determine the range of score distribution. A complete summary of the results of the descriptive statistical analysis of student creativity scores is presented in detail in Table 2.

Table 2. Descriptive Statistics of Students' Creativity Scores

Group	Test	N	Average	Standard Deviation	Min.	Maks.
Experimental	Pretest	28	10.54	2.15	6	14
	Posttest	28	16.82	1.58	13	19
Control	Pretest	28	10.46	2.07	7	14
	Posttest	28	12.18	2.25	8	16

Table 2 data suggest several key conclusions. First, in the pretest phase, the experimental group (10.54) and control group (10.46) had similar scores. Pretest standard deviations were also similar (2.15 for experimental and 2.07 for control). This strongly suggests that both groups had similar creativity levels before treatment. In quasi-experimental research designs, a comparable initial condition allows researchers to assume that any differences at the end of the study are due to the treatment rather than group capabilities.

Second, after treatment, posttest scores increased in both groups, indicating that the conventional and intervention learning processes were effective. Differences in increase magnitude were evident. The experimental group's average scores rose 6.28 points from 10.54 to 16.82. However, the control group only increased 1.72 points from 10.46 to 12.18. Initial descriptive findings suggest the mind mapping-assisted PjBL model is more effective due to this sharp improvement.

Third, posttest standard deviation analysis adds insight. The experimental group's standard deviation (1.58) was lower than the pretest and lower than the control group's (2.25). The lower standard deviation suggests that the experimental class's creativity scores after treatment centered around a high average. This suggests that the applied learning model improved the creativity of most students in the class more evenly and consistently, not just a few. The control group's higher standard deviation indicates greater variability in results, where student improvements may not be evenly distributed.

Distribution of Creativity Categories

To deepen the analysis and understand the impact of the treatment more qualitatively, the raw scores of students' creativity was converted into five descriptive categories: "Very Creative," "Creative," "Quite Creative," and "Less Creative." This categorization allows for visualization of changes in the creativity profiles of both groups. The frequency distribution and percentage of students in each category, both in the pretest and posttest, are presented in Table 3.

Table 3. Distribution of Student Creativity Categories

Category	Score Range	Pretest Experiment	Pretest Control	Posttest Experiment	Posttest Control
Very Creative	17–20	0 (0%)	0 (0%)	15 (53.6%)	0 (0%)
Creative	13–16	4 (14.3%)	3 (10.7%)	13 (46.4%)	7 (25%)
Quite Creative	9–12	19 (67.9%)	21 (75%)	0 (0%)	18 (64.3%)
Less Creative	5–8	5 (17.8%)	4 (14.3%)	0 (0%)	3 (10.7%)
Total		28 (100%)	28 (100%)	28 (100%)	28 (100%)

Table 3 visually confirms descriptive statistical analysis results. The pretest profiles of the two groups were similar, with most students in the "Quite Creative" category (67.9% experimental and 75% control). No student was "Very Creative" in either group. After treatment, the experimental group changed drastically. 100% of students placed in "Creative" (46.4%) and "Very Creative" (53.6%) categories. The Mind Mapping-assisted PjBL intervention significantly increased the creativity of all students, emptying the "Quite Creative" and "Less Creative" categories. Control group changes were much smaller. The number of "Creative" students increased from 10.7% to 25%, but 64.3% remained in "Quite Creative". This shows that conventional learning rarely fosters students' creativity.

Prerequisite Analysis Tests

Prerequisite statistical analysis tests are needed before hypothesis testing. These tests verify that data meets parametric statistical assumptions, such as the Independent Sample T-Test. The prerequisite tests include data distribution normality and variance homogeneity.

Normality Test

The hypotheses for this test are:

a. H0: The data are normally distributed.

b. Ha: The data are not normally distributed. The decision criterion is: if the significance value (Sig.) > 0.05, then H0 is rejected, and the data is concluded to be normally distributed.

Table 4. Posttest Data Normality Test Results

Group	Shapiro-Wilk Statistic	df	Sig.	Information
Experiment	0.968	28	0.521	Normal
Control	0.955	28	0.278	Normal

The results of the normality test presented in Table 4 show that the significance value for the posttest data for the experimental group was 0.521, and for the control group it was 0.278. Because both significance values were substantially greater than $\alpha=0.05$, H0 was rejected for both groups. Therefore, it can be concluded that the posttest score data from both research groups were normally distributed, thus meeting the normality assumption for the t-test.

Homogeneity Test

The test used was Levene's Test of Homogeneity of Variances. The hypothesis for this test is:

a. H0: The variance of the data between groups is homogeneous (the same).

b. Ha: The variance of the data between groups is not homogeneous (different). The decision criterion is if the significance value (Sig.) > 0.05, then H0 fails to be rejected, and the variance is concluded to be homogeneous.

Table 5. Results of the Posttest Data Variance Homogeneity Test

Levene Statistic	df1	df2	Sig.	Information
2.457	1	54	0.123	Homogeneous

Table 5 shows a Levene Statistic of 2.457 and a significant value of 0.123 for the homogeneity test. H0 is rejected as the significance value is greater than α=0.05 (0.123 > 0.05). Posttest score variance is homogeneous between experimental and control groups. Parametric statistical analysis, the Independent Sample T-Test, is valid and statistically justified to test the research hypothesis because the two prerequisite tests showed normally distributed and homogeneous data.

Hypothesis Testing

The formulated research hypotheses are as follows:

1. Null Hypothesis (H0): There is no significant difference in average creativity scores between students learning with the Mind Mapping-assisted PjBL model and students learning with the conventional model. (Statistically: $\mu 1=\mu 2$)
2. Alternative Hypothesis (Ha): There is a significant difference in the average creativity scores between students learning with the Mind Mapping-assisted PjBL model and students learning with the conventional model. (Statistically: $\mu 1=\mu 2$).

Hypothesis testing was conducted using an Independent Sample T-Test by comparing the posttest scores of both groups. The significance level (α) was set at 0.05. The decision-making criteria were: if the significance value (Sig. 2-tailed) generated by the statistical test is less than 0.05, then the Null Hypothesis (H0) is rejected and the Alternative Hypothesis (Ha) is accepted. The complete results of the statistical calculations are presented in Table 6.

Table 6. Hypothesis Test Results with Independent Sample T-Test

Variable	t	df	Sig. (2-tailed)	Mean Difference	Conclusion
Creativity (Posttest)	7.854	54	0.000	4.64	H0 is rejected

Table 6 shows a t-value of 7.854 at 54 df. This large t-value qualitatively indicates a large difference between group means. The key statistical decision is value significance. The 2-tailed Sig. is 0.000. According to decision-making criteria, this value is significantly below the significance level of 0.05 (0.000 < 0.05). Thus, H0 is convincingly rejected, and Ha is accepted. This decision statistically proves that experimental and control groups have very different average creativity scores. The experimental group's average creativity score is 4.64 points higher than the control group's after treatment. The Project Based Learning (PjBL) learning model with Mind Mapping media has a significant impact on fourth grade science students' creativity at State Ibtidaiyah Madrasah 2 Bandar Lampung.

Discussion

The quantitative data analysis and hypothesis testing in the previous section show that Project-Based Learning (PjBL) with Mind Mapping improves student creativity. Rejecting the Null Hypothesis (H0) with high significance ($p < 0.001$) and descriptive data indicating a significant difference in creativity scores between experimental and control groups support this finding. The experimental group's average posttest score (16.82) far exceeded the control group's (12.18), proving the intervention's efficacy. This section integrates theoretical foundations, analyzes learning process dynamics, and compares findings with previous relevant research to explain why and how this learning model has this impact.

The PjBL model's success in fostering creativity stems from a shift from teacher-centered, behaviorist to student-centered, constructivist pedagogy. Constructivists view knowledge as actively constructed by students through experience and interaction with their environment. Project-Based Learning (PjBL) embodies this philosophy. In this study, the PjBL model centers on a mind map on "The Life Cycle of Living Things," which provides an authentic, relevant learning anchor with challenging driving questions. Many practice questions are decontextualized and have only one correct answer, which encourages convergent thinking. PjBL projects are open-ended. This open-endedness unlocks creativity. Students must now explore, investigate, synthesize, and present knowledge. PjBL specifically trains each creativity dimension measured in this study:

Enhancing Fluency: Project planning in Project-Based Learning (PjBL) requires brainstorming. Students are encouraged to brainstorm as many topic-related ideas, concepts, and keywords as possible in a group. This unstructured, criticism-free process trains mental muscles to think fluently and productively. Collaboration allows one idea to spark another, creating a snowball effect of ideas that would be impossible in passive, individual learning.

Develop Flexibility: Project work presents many challenges and choices for students. They must decide on information organization, visual approach, task division, and group conflict resolution. They must think critically, consider alternatives, and adapt their approach in this situation. Cognitive flexibility—the ability to change your mind—is essential to creativity. Promoting Originality: Project-Based Learning (PjBL) emphasizes a unique and presentable product, a strength. Each group can express their understanding creatively. Student creativity is encouraged by the requirement to create a unique mind map. Instead of copying examples, they combine text, images, colors, and structures to express their group's identity. This is hands-on creativity practice.

Develop Elaboration Skills: Meaningful projects aren't superficial. Students must do extensive research, reading, and discussion to create a good mind map. They must stretch main ideas into more specific details and add relevant information. Deepening and detailing improve elaboration skills, or the ability to fully develop an idea. Developing Evaluation Skills: Creativity involves both coming up with ideas and choosing the best ones. Students evaluate implicitly and explicitly throughout the project cycle. They evaluate sources, weigh ideas, evaluate visual design, and give peers feedback. Evaluative thinking—analyzing, comparing, and making rational decisions—is the pinnacle of creativity.

Mind mapping helps students navigate and thrive in PjBL's creative ecosystem. Mind mapping, developed by Tony Buzan, is based on brain associative and radial functions. This research uses it as a thinking tool throughout the project, not just a display medium. Mind mapping illustrates thinking. Elementary school students in the concrete operational stage may struggle with abstract concepts. Mind mapping uses keywords, images, colors, and connecting lines to visualize abstract ideas. Complex information becomes easier to comprehend and remember. Strong conceptual understanding increases the ability to create from knowledge (Wu & Chen, 2018).

Second, mind mapping helps non-linear organization. Unlike linear note-taking, which forces the brain to think sequentially, mind maps' radial structure lets ideas flow without order. This frees the mind, enabling creative leaps and unexpected connections, which boosts fluency and flexibility. Third, mind mapping integrates left and right brain functions. Both hemispheres work together during mind mapping. Selecting keywords, categorizing, and hierarchizing information activates the left brain, which processes logic, analysis, and language. Images, symbols, and spatial layouts stimulate the right brain, which controls imagination, color, space, and holistic thinking. Creative conditions are optimal with whole-brain engagement.

PjBL and mind mapping reinforce each other. PjBL provides authentic, creative problem-solving tasks, while mind mapping organizes the process visually. Students learn about the life cycle and think, organize, and represent it creatively. Intervention results contrast sharply with control group results, proving its superiority. Lectures, structured Q&A sessions, and textbook-based exercises make students passive recipients. The acquisition and reproduction of correct information are the main goals of this model. Creative exploration, discovery, and invention are not given enough space to develop.

The control class encouraged convergent thinking, where students were taught to find one correct answer from the teacher or textbook. Although creativity scores increased slightly, this was likely due to a greater understanding of the material rather than systematic creative thinking stimulation. Though more knowledgeable, students were not necessarily more creative. Lack of opportunities to collaborate, explore independently, and create unique products hindered control class creativity.

The findings of this study complement and expand education research. Hidayati and Restian (2023) found that PjBL boosts elementary school science students' creativity in the Independent Curriculum. This study replicated these findings in a different population and added mind mapping as an integrated learning aid. This study also supports learning theories empirically. These findings are relevant to Vygotsky's Social Constructivism theory, which emphasizes social interaction in knowledge construction (Siregar et al., 2024; Gannar & Kilani, 2025). The Zone of Proximal Development (ZPD) in PjBL groups helps students learn and be creative through peer scaffolding (Jia et al., 2025; Lee & Chen, 2025). Group discussion, meaning negotiation, and feedback promote cognitive and creative development.

These findings support David Ausubel's Meaningful Learning. Learning can be integrated into existing knowledge by working on relevant and contextual projects (Bryce & Blown, 2024; Sexton, 2025). Mind mapping explicitly aids this process by mapping new and old concepts. Meaningful learning fosters deep understanding, which is necessary for flexible and creative knowledge use (Selkrig & Keamy, 2017). Overall, this discussion shows that the mind-mapping-assisted PjBL model's impact is intentional. A fundamentally different learning environment intentionally and systematically activates, trains, and develops all aspects of students' creative potential. This model turns the classroom into a workshop where knowledge and creativity are actively, collaboratively, and meaningfully constructed.

4. CONCLUSION

This study found that Project Based Learning (PjBL) with mind mapping media improves science students' creativity. The hypothesis test using the independent sample t-test shows a significance value of 0.000, below 0.05. This figure statistically proves that the creativity difference between the PjBL model group and the conventional group is real and not due to chance. Students who used the PjBL model with mind mapping were also more creative than those who used conventional learning. The result is shown by the significant difference in posttest scores between the experimental group (16.82) and the control group (12.18). The experimental group's higher scores show that the intervention stimulates and develops students' creativity. Mind mapping-assisted PjBL enhances creativity because the student-centered learning framework and visual cognitive aids work together. Students explore, collaborate, and solve problems in PjBL's authentic and challenging learning environment. Mind mapping helps with nonlinear thinking, visualizing complex ideas, and integrating the brain's logical and creative functions. Additionally, mind mapping-assisted PjBL has been shown to develop numerous creative skills. According to qualitative data from category distribution, all experimental class students were "Creative" and "Very Creative" after the treatment. The evidence shows that this model improves overall scores and stimulates creativity by improving idea generation, perspective-taking, originality, and idea expansion.

As a suggestion, teachers, especially elementary school teachers, should use Project-Based Learning (PjBL) with creative media like mind mapping. This model works well for teaching subject matter and developing 21st-century skills, especially creativity. In PjBL, teachers should facilitate learning, not provide all the information. Classroom projects should be contextual, relevant to students' lives, and include exploratory questions. For further researchers, this study was quasi-experimental. Future researchers should use a true-experimental design with random assignment of experimental and control groups to increase internal validity. In addition, this study examined creativity. Future researchers can examine how the mind mapping-assisted PjBL model affects critical thinking, collaboration, learning motivation, and student learning independence.

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