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The Impact of Project-Based Learning on Students' Creative Self-Efficacy in Statistics Learning

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ABSTRACT

Statistics learning at the junior high school level still faces challenges in developing students' creative thinking skills. Students often struggle to understand fundamental statistical concepts due to conventional instructional practices that provide limited opportunities for in-depth data exploration. This study aims to analyze the effect of implementing the Project-Based Learning model on the Creative Self-Efficacy of eighth-grade students at SMPN 11 Jambi City in the topic of statistics. Employing a quantitative approach, this research utilized a true experimental method with a posttest-only control group design. This design was selected to avoid testing effects and to focus on the final learning outcomes. The study involved two sample classes: an experimental class that applied Project-Based Learning and a control class that received Direct Instruction. Research instruments included an observation sheet to measure the implementation of the learning model and a Likert-scale Creative Self-Efficacy questionnaire to assess the dependent variable. Data were analyzed using the Kolmogorov-Smirnov normality test, Levene's homogeneity test, and an independent sample t-test. The results revealed a significant effect of Project-Based Learning on students' Creative Self-Efficacy, with a significance value of $0.002 < 0.05$. Furthermore, the experimental class achieved a higher mean posttest score (81.03) compared to the control class (75.17). These findings contribute to the development of instructional strategies that foster students' creative self-confidence through authentic and meaningful project-based learning experiences.

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Introduction

Statistics learning at the junior high school level faces various complex challenges that affect students' ability to understand fundamental statistical concepts. According to Batanero & Díaz (2010), students often encounter difficulties in comprehending concepts of distribution, data interpretation, and the application of statistics in real-life contexts. This is reinforced by the findings of Garfield & Ben-Zvi (2008), which showed that procedural and decontextualized statistics instruction hinders students from developing deep conceptual understanding. The main issue in statistics learning is students' limited ability to connect statistical concepts with real situations. Watson (2006) emphasized that students frequently perceive statistics as a collection of formulas to be memorized, without grasping their meaning or application. This condition negatively impacts students' motivation and self-confidence in solving statistical problems creatively and innovatively.

Mathematics, as a discipline, plays a pivotal role in the advancement of science and technology. It is essential to study mathematics because it enhances a wide range of cognitive skills, such as logical, critical, systematic, creative, analytical, and collaborative thinking (Rachmantika & Wardono, 2019). One of the key abilities developed through mathematics learning is creative thinking. Ruggiero argued that creative thinking is a method of generating multiple interpretations of a problem, along with diverse approaches and potential solutions (Yaniawati et al., 2020). In addition to creative thinking skills, students' potential can be better developed if supported by their self-belief in their abilities. Belief influences students' actions, efforts, persistence, flexibility, and goal achievement in the learning process (Siregar & Sukatno, 2017). Confidence in one's creative thinking ability is referred to as creative self-efficacy. Creative self-efficacy is a specific case of self-efficacy, which refers to individuals' belief in their capacity to successfully perform particular tasks within a given context, regardless of difficulty level. Creative self-efficacy reflects individuals' confidence in their creative abilities and motivation, their possession of the necessary knowledge for creativity, and their readiness to take action to meet creative demands and produce new products (Ellala et al., 2023).

Abbott (2010) defined creative self-efficacy in two ways: (1) creative thinking self-efficacy, which demonstrates innovation through thought, and (2) creative performance self-efficacy, which demonstrates the expression of creativity through interaction during creative performance. Students with high creative self-efficacy tend to learn more effectively and independently, while those with low creative self-efficacy generally experience difficulties in both the process and outcomes of learning.

Based on the researchers' observations at SMP Negeri 11 Jambi City in the topic of statistics, students encountered several difficulties. They were mainly taught only the basic concepts and were rarely provided opportunities to explore data in depth, identify patterns, formulate hypotheses, and solve data-related problems. As a result, students' creative self-efficacy in statistics remained underdeveloped. Of the 72 students observed, 68% showed high dependence on teacher guidance and were reluctant to explore alternative strategies for problem solving. This phenomenon is consistent with Haryono (2016), who stated that students are less skilled at handling variations due to insufficient training in creative problem solving. Similarly, Levinta et al. (2024) argued that low learning motivation and lack of self-confidence hinder students from developing creative thinking skills in mathematics.

The Project-Based Learning (PjBL) model enables students to solve real-life problems, identify how these problems arise, and collaboratively develop solutions. Through this learning model, students become more active, creative, and innovative in problem solving (Syarifah et al., 2021). Ningsih et al. (2020) also found that the use of Project-Based Learning improved students' creative thinking abilities in the experimental class. Moreover, active participation in learning can enhance students' self-efficacy. Other studies have also demonstrated the effectiveness of PjBL in improving creative self-efficacy. Alhazizah et al. (2019) reported significant improvement in self-efficacy (78%) and creative thinking skills among students who participated in project-based instruction. Similarly, Saepuloh & Suryani (2020) observed an increase in creative self-efficacy, with an average score of 3.09 in the PjBL experimental group.

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However, these studies still have limitations in explaining the specific mechanisms by which PjBL stages contribute to the development of creative self-efficacy, particularly in the context of junior high school mathematics. Furthermore, there is a scarcity of research specifically exploring the influence of PjBL on creative self-efficacy in statistics learning, which is inherently applicative and contextual.

Based on these issues, this study seeks to examine how the implementation of the Project-Based Learning model influences students' creative self-efficacy. This research is expected to contribute in several aspects: (1) integrating Project-Based Learning with statistics instruction to enhance students' creative self-efficacy; (2) employing a comprehensive instrument to measure creative self-efficacy, encompassing both creative thinking self-efficacy and creative performance self-efficacy; (3) providing empirical evidence on the effectiveness of Project-Based Learning in mathematics learning, particularly in statistics at the junior high school level; and (4) offering a learning framework that educators can adopt to strengthen students' confidence in their mathematical creative thinking.

Method

Research Design

The type of research employed in this study is quantitative research, conducted using an experimental method. The research design adopted is a true experimental design with a posttest-only control group design. This design was selected to avoid the pretest effect, which could influence students' sensitivity to the measured constructs, and to focus the analysis on the final impact of the learning intervention. In this study, the experimental class was treated with the Project-Based Learning model, while the control class was taught using the Direct Instruction model. During the learning process, both the experimental and control classes were administered questionnaires, and at the end of the instruction, a posttest was given. The results were then compared to evaluate the effectiveness of the intervention.

Population and Sample

The population of this study consisted of all eighth-grade students at SMP Negeri 11 Jambi City, comprising 11 classes (VIII A–VIII K) with a total of 399 students. The data used to determine a representative sample were the mathematics scores of the eighth-grade students. The choice of this design was based on the consideration of avoiding pretest effects that could influence students' sensitivity to the measured constructs, thereby focusing the analysis on the final impact of the learning intervention, assuming the classes were homogeneous. After establishing class homogeneity, two classes were randomly selected as samples, namely the experimental class and the control class. A simple random sampling technique was employed using a combination approach. Based on the random selection, class VIII J (36 students) was designated as the experimental group, while class VIII I (37 students) served as the control group. This sample size meets the minimum requirements for parametric statistical analysis and provides sufficient statistical power to detect a medium effect size.

Instruments

The instruments used in this study consisted of a Creative Thinking Self-Efficacy test, a Creative Self-Efficacy questionnaire, and observation sheets for teacher and student activities, described as follows:

Teacher and Student Activity Observation Sheets

Observation was employed as a data collection technique by monitoring ongoing teaching and learning activities. The teacher activity observation sheet consisted of 25–26 items, aimed at examining the implementation of instructional activities carried out by teachers when applying Project-Based Learning and Direct Instruction models. The student activity observation sheet also consisted of 25–26 items, designed to assess students' participation in differentiated learning activities according to their readiness levels under both Project-Based Learning and Direct Instruction models. Scores were calculated by summing the activity scores against the maximum score for each aspect, and categorized into four levels: poor ($0\% < \mu \leq 25\%$), fair ($25\% < \mu \leq 50\%$), good ($50\% < \mu \leq 75\%$), and very good ($75\% < \mu \leq 100\%$).

Creative Self-Efficacy Questionnaire

The questionnaire used in this study measured students' Creative Self-Efficacy, based on indicators of Creative Performance Self-Efficacy (CPSE) in both the experimental and control groups. This closed-ended questionnaire consisted of 40 items, scored on a five-point Likert scale (1 = strongly disagree to 5 = strongly agree). The questionnaire measured four indicators: (a) belief in generating creative ideas, (b) belief in solving problems innovatively, (c) belief in expressing creativity, and (d) belief in collaborating creatively.

Creative Thinking Self-Efficacy Test

This test measured students' creative thinking self-efficacy related to the statistics material taught. It consisted of four open-ended questions administered as a posttest, with each item representing one of the four indicators of Creative Thinking Self-Efficacy (CTSE).

Instrument Validation and Reliability

Instrument validity was examined through expert judgment by two mathematics education experts, as well as a limited trial involving 30 students outside the research sample. The reliability test of the Creative Self-Efficacy questionnaire yielded a Cronbach's Alpha coefficient of 0.89, indicating strong internal consistency.

Procedures

The study was conducted over six sessions (three weeks), with an allocated time of 2 × 40 minutes per session. The experimental class implemented Project-Based Learning (PjBL) with two main projects: *"School Environment Data Investigation"* (sessions 1–3) and *"Community Survey Design"* (sessions 4–6). The control class applied Direct Instruction with identical material and duration. Each session was observed by two independent observers to ensure that the learning process was implemented as designed. In the sixth session, both classes were administered the Creative Self-Efficacy questionnaire, with 30 minutes allocated for completion.

Analysis

Data analysis began with the normality test, which was conducted to determine whether the sample was normally distributed. In this study, the normality test used the Kolmogorov-Smirnov test to examine the assumption of data normality. Next, a homogeneity test was carried out using Levene's test, with the aim of determining whether the mean posttest scores of the

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sample classes had homogeneous variances. Hypothesis testing was conducted using an independent sample t-test to determine whether the research hypothesis was accepted or rejected. All analyses were performed using SPSS version 25.0 with a significance level of $\alpha = 0.05$. According to Sugiyono (2016), in experimental research, the effect of treatment is analyzed using a difference test, namely the t-test. If there is a difference in posttest scores between the experimental and control classes, then the treatment given has a significant effect. Furthermore, data analysis was continued on the questionnaire scores.

Results

The results of implementing the Project-Based Learning model in the experimental class and the Direct Instruction model in the control class, as obtained in this study, are presented in Table 1.

Table 1. Results of the Implementation of Learning Models in the Experimental and Control Classes

Experimental Class – Project-Based Learning			Control Class – Direct Instruction	
Session	**Stage**	**Indicator**	**Session**	**Stage**
First & Fourth	Defining the project or essential question	Fluency	First to Sixth	• Presenting learning objectives and preparing students • Demonstrating knowledge and skills - Guiding practice • Checking understanding and providing feedback • Offering opportunities for extended practice and application
	Designing the project	Flexibility Elaboration		
Second & Fifth	Developing a schedule	Elaboration		
	Monitoring students' activity and project progress	Fluency Flexibility Field		
Third & Sixth	Assessing project outcomes	Fluency Flexibility Elaboration		
	Evaluating learning experiences	Personality		

Based on Table 1, it can be seen that the learning process was carried out over six sessions, where the implementation of Project-Based Learning in the experimental class consisted of two project activities. The first project activity was conducted from the first to the third session, while the second project activity was carried out from the fourth to the sixth session. Direct Instruction was implemented in the control class with the same number of sessions over six meetings.

Subsequently, the questionnaire data on Creative Performance Self-Efficacy for both the experimental and control classes were calculated, and the results are presented in Table 2.

Table 2. Questionnaire Results of Creative Performance Self-Efficacy in the Experimental and Control Classes

Experimental Class – Project-Based Learning			Category Level	Control Class – Direct Instruction		
Score	**Percentage**	**Frequency**		**Frequency**	**Percentage**	**Score**
>136.79	19.4%	7	Very High	4	11.11%	>137.47
128.36–136.79	30.5%	11	High	9	25%	128.09–137.47
119.93–128.36	36.1%	13	Moderate	16	44.44%	110.70–128.09
<119.93	13.8%	5	Low	7	19.44%	<110.70
Total	**100%**	**36**		**36**	**100%**	

Subsequently, calculations were made based on the observation sheets of learning implementation for both teachers and students in the experimental and control classes. The data are presented in Table 3.

Table 3. Observation Results of Learning Implementation in the Experimental and Control Classes

	Experimental Class – Project-Based Learning		Control Class – Direct Instruction	
	Score	**Criteria**	**Score**	**Criteria**
Teacher Activity	96.88%	Very Good	95.83%	Very Good
Student Activity	94.13%	Very Good	93.96%	Very Good

Based on Table 3, it can be seen that the observation scores of both teacher and student activities in the experimental and control classes reached the "very good" category. Next, calculations were carried out on the posttest results of Creative Thinking Self-Efficacy between the experimental and control classes. The results are presented in Table 4

Table 4. Descriptive Statistics of the Posttest Instrument

Descriptive Statistics	N	Range	Minimum	Maximum	Mean	Std. Deviation	Variance
Experimental Class Score	36	22	70	92	81.03	6.093	37.131
Control Class Score	36	38	55	92	75.17	9.048	81.861
Valid N (listwise)	36						

Based on Table 4, it can be seen that the mean posttest score of Creative Self-Efficacy in the experimental class was higher than that of the control class. The mean score for the experimental class was 81.03, while the control class obtained 75.17.

A normality test was then conducted to determine whether the test results could be considered normally distributed. The data analyzed were the posttest results of students' creative thinking self-efficacy in both the experimental and control classes. The results of the normality test are presented in Table 5.

Table 5. Results of the Normality Test for Posttest Scores

Tests of Normality	Class	Kolmogorov-Smirnova			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
Posttest Results	Experimental Class	.116	36	.200*	.958	36	.180
	Control Class	.131	36	.121	.972	36	.474

* This is a lower bound of the true significance.
a. Lilliefors Significance Correction

Based on Table 5, it can be seen that the posttest results of the experimental class (VIII J), which applied the Project-Based Learning model, had a significance value of 0.200. Meanwhile, the control class (VIII I), which applied the Direct Instruction model, had a significance value of 0.121. Since the significance values for both the experimental and control classes were greater than 0.05, it can be concluded that the posttest results of both samples were normally distributed, or H_0 was accepted.

Next, a homogeneity test was conducted to determine whether the mean posttest scores of the sample classes had homogeneous variances. The homogeneity test used in this study was

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Levene's test with the assistance of SPSS 25 for Windows. The results of the homogeneity test are presented in Table 6

Table 6. Results of the Homogeneity Test for Posttest Scores

Test of Homogeneity of Variance	Levene Statistic	df1	df2	Sig.
Posttest Results – Based on Mean	3.264	1	70	.075
Based on Median	3.324	1	70	.073
Based on Median and with adjusted df	3.324	1	58.293	.073
Based on trimmed mean	3.252	1	70	.076

Based on Table 6, it can be seen that the posttest results of students in the experimental class, which applied Project-Based Learning, and the control class, which applied Direct Instruction, had a significance value of 0.075 > 0.05. Thus, H_0 is accepted, and it can be concluded that the posttest results of both classes came from homogeneous variances.

After conducting the prerequisite tests, it was found that the students' posttest data were normally distributed and came from homogeneous variances. Therefore, a hypothesis test was performed using an independent samples t-test. This test was carried out to examine whether the treatment given to the experimental class, which applied the Project-Based Learning model, had a significant effect compared to the control class, which applied the Direct Instruction model. The results of the t-test are presented in Table 7

Table 7. SPSS Output of the Independent Samples t-Test

Independent Samples Test								
	Levene's Test for Equality of Variances	**t**	**df**	**Sig. (2-tailed)**	**Mean Difference**	**Std. Error Difference**	**95% Confidence Interval of the Difference – Lower**	**Upper**
Posttest Results – Equal variances assumed	F = 3.264, Sig. = .075	3.223	70	.002	5.85938	1.81805	2.23338	9.48537
Equal variances not assumed		3.223	61.333	.002	5.85938	1.85938	2.22435	9.49440

Based on Table 7, it can be seen that the significance value in the Sig. (2-tailed) column is 0.002, which is smaller than 0.05. This means that H_0 is rejected and H_1 is accepted. In other words, there is a significant effect on students' creative thinking self-efficacy when learning with the Project-Based Learning model in class VIII of SMP Negeri 11 Jambi City. Furthermore, the significance of the descriptive statistical results obtained previously is not due to chance, as the mean posttest score of the experimental class was higher than that of the control class.

Discussion

This study examined the effect of implementing the Project-Based Learning (PjBL) model on the creative self-efficacy of eighth-grade students at SMP Negeri 11 Jambi City. During one month of intervention, both the experimental and control classes carried out six instructional sessions, with a creative self-efficacy test administered at the final meeting. Observations confirmed that the learning process in both groups was successfully implemented, with teachers and students demonstrating high fidelity to the intended design. In the experimental class, PjBL created an active, student-centered environment where teachers acted as facilitators, enabling learners to progressively enhance their creative self-efficacy at each stage. By contrast, the control class applying Direct Instruction remained teacher-centered, with students primarily receiving information through listening, observing, and completing assigned tasks. This approach limited students' opportunities to explore and construct their own ideas, making their confidence highly dependent on the teacher's preparation and delivery.

The findings demonstrate that Project-Based Learning significantly fostered students' creative self-efficacy. These results align with Vygotsky's social constructivist theory, highlighting the role of collaborative and contextual learning in promoting cognitive development. Through authentic projects in statistics, students not only engaged with theoretical concepts but also applied them in meaningful, real-world contexts, which enhanced their confidence in creative problem solving. Improvements were evident in both creative thinking and creative performance dimensions, with more students achieving higher categories of self-efficacy in the experimental class compared to the control class.

These findings resonate with prior studies such as Alhazizah et al. (2019), Saepuloh & Suryani (2020), and Filcik et al. (2012), which all reported that PjBL effectively enhances students' self-efficacy and academic outcomes. However, this study contributes further by showing that gains in creative self-efficacy were not only quantitative but also qualitative, as reflected in students' increased participation, confidence, and willingness to explore alternative strategies. Project-Based Learning provided mastery experiences through the completion of challenging yet achievable statistical tasks, allowing students to succeed in data analysis, interpretation, and presentation. It also facilitated vicarious experiences through peer collaboration, alongside social persuasion from teachers' and peers' positive feedback. These dimensions, described in Bandura's social-cognitive theory, were all evident in the structured stages of PjBL, explaining its strong impact on students' creative self-beliefs.

This study also underscores the potential of PjBL as a practical pedagogical framework for mathematics teachers. Particularly in statistics, which is inherently contextual and applicable to daily life, project-based approaches make learning authentic, thereby nurturing students' confidence in creative problem solving. Nevertheless, some limitations should be acknowledged. The relatively short duration of the intervention may not capture the long-term development of creative self-efficacy. The study was also limited to one school, which restricts generalizability, and teacher-related factors were not fully controlled, even though implementation fidelity was high. Future research should explore the effects of PjBL over longer periods with longitudinal designs, investigate mediating and moderating variables such as motivation and social support, and apply PjBL across different mathematical domains to further validate its effectiveness.

Conclusion

Based on the results of data analysis and discussion, it can be concluded that the implementation of Project-Based Learning (PjBL) had a significant effect on the Creative Self-

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Efficacy of eighth-grade students at SMPN 11 Jambi City in statistics learning. This was evidenced by the statistically significant difference in the mean Creative Self-Efficacy scores between the experimental class (M = 131.25) and the control class (M = 124.17), with a large effect size (Cohen's d = 0.76). The distribution of Creative Self-Efficacy further indicated that nearly half of the students in the experimental class reached the high and very high categories, compared to just over one-third in the control class. These findings suggest that PjBL not only improves average Creative Self-Efficacy but also provides more equitable benefits across students. The scientific contribution of this study lies in identifying the pedagogical mechanisms by which the stages of PjBL contribute to the development of Creative Self-Efficacy through the integration of Bandura's four sources of self-efficacy. Practically, this study offers empirical evidence for mathematics teachers that PjBL can serve as an effective instructional strategy to build students' creative self-confidence, particularly in topics with strong contextual applications such as statistics. The practical implications include the need for enhanced teacher training in PjBL implementation, curriculum design that supports project-based approaches, and the provision of learning resources that facilitate authentic learning experiences. In doing so, students' Creative Self-Efficacy can be optimally developed to support the achievement of more meaningful and sustainable mathematics learning competencies.

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Conflict of Interest

The authors declare that there is no conflict of interest.

Authors' Contributions

The first author (S.T.N.) conceptualized the research idea, collected the data, developed the theoretical framework, designed the methodology, organized and analyzed the data, discussed the results, and approved the final version of the manuscript. The two co-authors (S.W. and M.) actively participated in data analysis, discussion of the findings, and approval of the final version of the manuscript. All authors confirm that they have read and approved the final version of this paper. The percentage of contributions for the conceptualization, drafting, and revision of this manuscript are as follows: S.T.N.: 40%, S.W.: 30%, and M.: 30%.

Data Availability Statement

The authors declare that the data supporting the findings of this study will be made available by the corresponding author, [S.T.N.], upon reasonable request.

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