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THE EFFECT OF PEER TUTORING WITH PROJECT-BASED LEARNING MODEL ON EDUCATIONAL STATISTICS COURSE

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ABSTRACT

This study investigates the effect of combining peer tutoring with a project-based learning (PjBL) model on the academic performance of students enrolled in an Educational Statistics course within an elementary teacher education program. A quasi-experimental design was employed with two intact classes (n = 42) from a state university in Indonesia. The experimental group received peer-assisted PjBL instruction, while the control group experienced conventional PjBL without peer tutors. Both groups followed the same syllabus, instructor, and assessment structure. Data were collected through standardized Midterm (UTS) and Final (UAS) exams validated by subject-matter experts. The findings revealed that students in the experimental group achieved significantly higher academic performance and demonstrated greater improvement from midterm to final exams compared to the control group, with a moderate effect size (Cohen's d = 0.59). The integration of peer tutoring within project-based activities effectively reduced anxiety, encouraged collaboration, and deepened conceptual understanding of statistical principles. These results confirm that peer-supported, project-based instruction offers a practical and contextually relevant approach to improving statistical learning outcomes among pre-service teachers. The study underscores the importance of active, student-centered pedagogies in preparing future educators to navigate data-rich educational environments. Future research is recommended to examine the long-term retention, scalability, and adaptation of this model across different subjects and institutional settings.

Keywords: Peer Tutoring, Project-Based Learning, Educational Statistics, Quasi-Experiment, Student Achievement.

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PRELIMINARY

In the era of digital transformation and data-driven education, statistical literacy has become an essential competence for education students. In Indonesia, many pre-service teachers face challenges in learning statistics. Students in education and social science programs often perceive statistics as difficult and intimidating due to their limited mathematical background and anxiety toward numerical analysis (Arbain, 2016; Dwijayanti & Suryani, 2022). Their previous learning, which emphasizes memorization over understanding, also makes it harder for them to interpret statistical data meaningfully. In

addition, classroom instruction in many Indonesian universities remains lecturer-centered, with students passively receiving information instead of engaging in active problem-solving or data exploration (Rahmawati et al., 2021). As a result, students often have low confidence, weak application skills, and see statistics as irrelevant to their future careers as educators.

Educational statistics not only provide a methodological foundation for processing quantitative data but also serve as a vital tool for making evidence-based decisions in educational settings (Moliner & Alegre, 2020). Nevertheless, numerous studies have consistently shown that students often struggle with statistical concepts due to the abstract nature of the material, limited numerical proficiency, and a lack of motivation (Chu et al., 2017; Irshad, 2024). These challenges contribute to low learning outcomes, which directly affect the quality of students' final projects, research, and interpretation of educational evaluations.

One of the key reasons for these challenges lies in the continued reliance on teacher-centered approaches, which are often characterized by passive learning, limited student engagement, and minimal contextualization of theoretical concepts (Nawaz & Rehman, 2017; Tsuei, 2017). To address this issue, there is a pressing need to adopt constructivist-based pedagogies that promote collaboration, exploration, and the application of knowledge in real-world contexts. In this regard, Project-Based Learning (PjBL) has emerged as a promising strategy that enhances students' conceptual understanding and engagement by involving them in structured, meaningful, and inquiry-driven projects (Biton, 2025; Herbert & Bragg, 2021). PjBL positions students as active participants in solving authentic problems, enabling the direct integration of theoretical knowledge and practical application.

However, implementing PjBL in higher education particularly in numerically intensive courses such as statistics presents unique challenges, especially with regard to varying student abilities and learning paces. To address this, peer tutoring has been recognized as a complementary pedagogical approach. Peer tutoring allows more advanced or proficient students to assist their peers, fostering horizontal, empathetic, and supportive learning interactions (Arthur et al., 2022; Houston & Lazenbatt, 1996). This form of academic support not only facilitates deeper cognitive understanding but also enhances social-emotional learning aspects such as confidence, a sense of belonging, and collaborative learning behaviors.

The integration of peer tutoring with PjBL has the potential to create an inclusive and collaborative learning ecosystem key features of 21st-century higher education as emphasized by UNESCO (2021). Despite the promise of this integrated approach, empirical

research examining its effectiveness within the context of educational statistics courses remains scarce, particularly in Indonesian higher education institutions. This gap highlights the need for a systematic investigation into the impact of combining peer tutoring and PjBL on student learning outcomes, encompassing cognitive achievement, affective responses (e.g., motivation and interest), and essential 21st-century skills such as communication, collaboration, and critical thinking.

Therefore, this study seeks to explore the effects of integrating peer tutoring with project-based learning in the context of an educational statistics course. It aims to provide both theoretical insights for the development of innovative instructional models and practical implications for designing adaptive and transformative learning environments in higher education.

To address this issue, pedagogical innovation is needed to foster deeper understanding and engagement. PjBL has gained prominence as an effective constructivist approach that situates learning in real-world contexts. By engaging students in solving authentic problems and producing tangible outcomes, PjBL encourages the development of critical thinking, collaboration, and self-regulation (Ennis, 2018; Houston & Lazenbatt, 1996). The model typically comprises five essential phases: (1) Driving Question Formulation: Students collaboratively define a complex, inquiry-based problem that guides the project. (2) Project Planning: Learners determine roles, resources, and timelines in coordination with the instructor. (3) Investigation and Development: Students engage in data collection, analysis, and iterative solution design. (4) Product Creation and Presentation: The outcome may include statistical reports, data visualizations, or presentations. (5) Reflection and Evaluation: Both process and product are critically assessed, promoting metacognitive development.

Despite its strengths, PjBL alone may not sufficiently scaffold learners who lack foundational knowledge. Therefore, integrating Peer Tutoring within the PjBL framework may enhance its effectiveness. Peer tutoring involves structured learning interactions between academically stronger and weaker students. This method supports both the tutor through reinforcement of their understanding and the tutee via scaffolded explanations in a relatable peer language (Ayu Herdini et al., 2019; Ishartono et al., 2022; Julianingsih, 2018). This study therefore aims to examine the effect of combining peer tutoring with the PjBL model on students' academic performance in Educational Statistics. Unlike traditional interventions, this integration promotes collaborative and contextualized learning, aligning

with contemporary educational paradigms that emphasize learner autonomy, problem-solving, and authentic assessment.

METHODS

This study employed a quasi-experimental design with a pretest-posttest non-equivalent control group structure. The objective was to investigate the effect of peer tutoring integrated into a project-based learning model on students' academic performance in an Educational Statistics course. Two intact classes were assigned as the experimental and control groups without random assignment, preserving the authenticity of the classroom environment.

The participants were 42 undergraduate students enrolled in the Educational Statistics course under the Primary School Teacher Education Program (PGSD) at a state university in Indonesia. The participants were selected using purposive sampling, ensuring their enrollment in the same academic cohort and course structure. The students were divided evenly into: (1) Experimental group (n = 21): Received instruction using Project-Based Learning integrated with Peer Tutoring. (2) Control group (n = 21): Received instruction using conventional Project-Based Learning without Peer Tutoring.

Both groups were taught by the same course lecturer and followed an identical syllabus, learning objectives, instructional materials, project assignments, and assessment rubrics to control for instructor-related biases. The primary data used to measure students' academic achievement consisted of: (1) Midterm Exam Scores (UTS) These scores reflect students' mastery of statistical concepts and problem-solving abilities in the first half of the semester. (2) Final Exam Scores (UAS). These scores assessed students' cumulative understanding and application of educational statistics after completing all learning modules and projects. Both UTS and UAS were standardized assessments developed by the course lecturer, reviewed by academic peers, and aligned with the intended learning outcomes of the course.

Table 1. Overview of Quantitative Data Analysis Design

Analysis Type	Purpose	Applied To
Descriptive Statistics	To describe central tendency and variability	UTS and UAS scores of both groups
Paired Sample t-Test	To compare pre- and post-treatment scores	Within experimental & control groups
Independent Sample t-Test	To compare learning outcomes between groups	UAS scores only

Analysis Type	Purpose	Applied To
Effect Size (Cohen's *d*)	To assess the magnitude of intervention	Difference in UAS between groups

Descriptive statistics provided a summary of students' performance distribution across both groups. Paired samples *t*-tests were used to analyze within-group improvements from midterm to final assessments. An independent samples *t*-test was conducted to compare post-intervention outcomes (UAS scores) between the experimental and control groups. To determine the practical significance of the intervention, Cohen's *d* was calculated as a measure of effect size.

Assumptions of normality and homogeneity of variances were tested prior to inferential analyses to ensure validity of the statistical procedures. Used to compare the mean differences within each group (UTS vs UAS).

The primary instrument used in this study was an achievement test designed to measure students' academic performance in the *Educational Statistics* course. The assessment consisted of two main components: the Midterm Exam (UTS) and the Final Exam (UAS). Both instruments were developed to evaluate students' mastery of statistical concepts, computational skills, and application of statistics in educational contexts.

The indicators of academic achievement were aligned with the cognitive domain of the revised Bloom's taxonomy (Anderson & Krathwohl, 2001). The assessments covered six cognitive levels: (1) Remembering, (2) Understanding, (3) Applying, (4) Analyzing, (5) Evaluating, and (6) Creating. The Midterm Exam focused on students' understanding and application of basic statistical concepts, including data types, descriptive statistics (mean, median, mode, and standard deviation), frequency distribution, and data visualization using tables and graphs. Meanwhile, the Final Exam measured higher-order cognitive skills, emphasizing data interpretation, hypothesis testing, correlation and regression analysis, and the ability to design and analyze small-scale statistical projects. This exam required students to integrate and apply statistical knowledge to real-world educational data through project-based tasks.

Content and construct validity were established to ensure that the instruments accurately represented the intended learning outcomes. Content validity was verified through expert judgment involving two subject-matter experts in Educational Statistics and Mathematics Education. Each item was reviewed for its alignment with course objectives and cognitive indicators. The expert agreement index exceeded 0.80, indicating a high level of content relevance and representativeness. Construct validity was examined by analyzing

the correlation between individual item scores and the total test score (item-total correlation). Items with low correlation coefficients ($r < 0.30$) were revised or removed. The resulting instruments demonstrated coherent measurement of the underlying construct—academic achievement in educational statistics.

Reliability testing was conducted using Cronbach's Alpha (α) to determine the internal consistency of the instruments. The tests were piloted with a comparable group of students from the same program prior to the main study.

Table 2. Reliability Coefficients of UTS and UAS Test Instruments

Test	Number of Items	Cronbach's Alpha (α)	Reliability Level
Midterm Exam (UTS)	20	0.82	High
Final Exam (UAS)	25	0.87	Very High

The coefficients exceeded the minimum threshold of 0.70, confirming that both instruments were internally consistent and reliable for assessing students' academic achievement.

RESULT AND DISCUSSION

Descriptive analysis was conducted to understand the central tendency and dispersion of student performance in both experimental and control groups. The results are presented below:

Table 3. Descriptive Statistics of UAS Scores for Experimental and Control Groups

Group	N	Mean	Median	SD	Min
Experimental	21	86.10	92.00	10.28	0.00
Control	21	79.79	77.50	11.03	0.00

The experimental group demonstrated a higher mean and median score than the control group, indicating better overall performance and more consistent achievement. Although both groups had the same minimum score of 0, this value likely represents participants who did not complete or submit the final project, rather than students who answered all items incorrectly. The maximum score in the experimental group was higher, and the interquartile range was narrower, suggesting that higher-performing students in this group showed less variability in their results. Compared to the Midterm Exam (UTS), the Final Exam (UAS) scores of both groups showed a general improvement, particularly in the experimental group.

Paired-samples *t*-tests revealed statistically significant gains from the Midterm (UTS) to the Final Exam (UAS) in both groups. The experimental group achieved a higher mean score (M = 86.10, SD = 10.28) compared to the control group (M = 79.79, SD = 11.03). An independent-samples *t*-test further confirmed that this difference was statistically significant, $t(40) = 2.02$, $p = 0.049$ ($\alpha = 0.05$), indicating that the learning model had a positive effect on students' academic achievement in the Educational Statistics course.

The results suggest that the combination of peer tutoring and project-based learning enhances student engagement and performance in the Educational Statistics course. These findings align with previous studies indicating that peer-assisted learning can improve academic performance by fostering collaborative and active learning (Calkins et al., 2020; Ng et al., 2020). Moreover, integrating project-based learning encourages critical thinking and problem-solving skills, which are essential in mastering complex statistical concepts (Campit & Garin, 2017; Ng et al., 2020). The significant difference in outcomes between the experimental and control groups confirms the pedagogical value of these strategies, particularly in higher education contexts where statistical anxiety and disengagement are common (Calkins et al., 2020; Chapman, 2004; Oloo et al., 2016). Implementing peer tutoring not only helps lower-performing students improve but also deepens the understanding of peer tutors themselves, Moreover, the role of peer tutors is particularly noteworthy.

As suggested by Vygotsky's *Zone of Proximal Development*, learning is most effective when guided by someone slightly more advanced in the learning process. Tutors not only support their peers but also consolidate their own knowledge, developing leadership and instructional skills valuable in their future teaching careers (Abdurrahman et al., 2020). In sum, the statistically significant improvement in academic performance, coupled with the moderate effect size, provides strong empirical support for incorporating peer tutoring within project-based learning frameworks in teacher education programs. This pedagogical strategy aligns with broader educational reforms that emphasize active, collaborative, and meaningful learning experiences in the preparation of future educators (Mailantri et al., 1970). This study contributes to the growing body of literature emphasizing student-centered learning environments and supports the adoption of active learning models in teacher education programs.

From a theoretical standpoint, the results reinforce Vygotsky's sociocultural theory and his concept of the Zone of Proximal Development (ZPD). Peer tutoring provides a scaffold through which learners can internalize complex ideas with the assistance of more

capable peers, facilitating cognitive development beyond what they could achieve independently (Fani & Ghaemi, 2011; Phelps et al., 1989). In this study, peer tutors functioned as "more knowledgeable others" who guided their peers through challenging tasks, particularly during data analysis and interpretation in project activities.

Furthermore, the integration of Project-Based Learning (PjBL) and peer tutoring aligns with constructivist learning theory, which emphasizes active knowledge construction through real-world problem solving, social interaction, and reflective practice (Alegre et al., 2019; Khotimah & Yuliastuti, 2019). Through project activities that simulate authentic educational contexts—such as analyzing students' academic performance data or evaluating learning outcomes—students were able to apply statistical concepts in meaningful ways. This process not only enhanced their understanding of statistical methods but also fostered essential competencies such as critical thinking, collaboration, and communication, which are crucial for their professional growth as future educators.

The improved UAS scores of the experimental group further reflect the positive impact of this learning design, suggesting that the combination of PjBL and peer tutoring effectively supports students' conceptual understanding and application of statistical knowledge in educational contexts.

CONCLUSION

This study demonstrated that the application of peer tutoring combined with a project-based learning model had a significant positive impact on students' academic performance in the Educational Statistics course. The experimental group showed higher average scores and exhibited statistically significant improvement compared to the control group. The effect size (Cohen's d = 0.59) indicated a moderate impact of the intervention, suggesting that this blended instructional strategy effectively enhanced students' understanding and engagement in learning statistical concepts.

It is recommended to integrate peer tutoring and project-based learning in analytical courses like statistics to foster collaborative learning and real-world application of concepts. Higher education institutions, especially those with teacher education programs, should consider training educators in designing project-oriented tasks and peer-led instructional models to improve student outcomes. Further studies could expand on this work by including larger samples, exploring longitudinal effects, or incorporating qualitative measures (e.g., interviews, observations) to gain deeper insights into students' learning processes.

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