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Implementation of Project-Based Learning to Enhance Activeness and Statistics Learning

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Abstrak

This study examines the effectiveness of the Project-Based Learning model in improving students' activeness and learning outcomes in the Statistics subject at SMK Negeri 3 Kesehatan dan Pekerjaan Sosial Mimika. The research was conducted to determine how far this learning model can foster active participation and enhance students' understanding through meaningful learning experiences. The main objective is to create a dynamic learning atmosphere where students are directly involved in exploring, designing, and presenting projects related to statistical concepts. The study applied a quantitative approach using a Classroom Action Research design consisting of planning, action, observation, and reflection stages. Data collection utilized observation sheets, project rubrics, and achievement tests. The findings indicated that students became more engaged during the learning process, showing greater initiative and collaboration in completing project tasks. Learning outcomes also demonstrated noticeable improvement, with students achieving higher levels of comprehension and problem-solving ability. Moreover, the project results reflected students' creativity and ability to apply statistical concepts in practical contexts. Overall, the implementation of the Project-Based Learning model succeeded in promoting an active, participatory, and student-centered classroom environment, supporting both cognitive and affective learning growth among students.

1. Introduction

Mathematics is an essential component of formal education, playing a crucial role in shaping students' cognitive abilities and preparing them for future academic and professional challenges (Cynthia & Sihotang, 2023; Syafi'i et al., 2025). As a fundamental discipline, mathematics not only equips students with problem-solving skills applicable to everyday life but also serves as the primary foundation for the advancement of science and technology (Tanujaya et al., 2021). Therefore,

mastering mathematical concepts from an early age is vital to support academic success and open opportunities in professional fields. Given the broad scope of mathematical content, careful and systematic planning is required to determine appropriate time allocation and material selection for each educational level. In Indonesia, mathematics holds a significant position in the educational curriculum across all levels, from primary to higher education (Handican et al., 2023; Mariana, 2017). Mathematics is considered essential due to its practical and logical aspects, which play a major role in the acquisition of scientific and technological knowledge (Hwa, 2018; Sheromova et al., 2020). Consequently, every Indonesian citizen is expected to possess an adequate level of mathematical literacy, both in terms of practical application and conceptual understanding (Hwa, 2018; Nurmasari et al., 2024; Suharta & Suarjana, 2018). This reinforces the rationale for integrating mathematics into the curriculum at all educational levels.

Mathematics at the vocational high school level plays a strategic role in developing students' ability to think logically and solve problems within their field of expertise. It is not limited to theoretical understanding but also serves as a practical tool in performing technical calculations required in various vocational areas (Djunaedy, 2020; Hardiningsih et al., 2023). The integration of mathematical skills in vocational learning enables students to analyze, interpret, and apply quantitative data relevant to real-life tasks in their profession. The mastery of mathematics helps prepare students to face the demands of the industrial world, where accuracy, precision, and analytical reasoning are essential for achieving professional competence. Implementation of mathematics learning at the SMK level must consider its dual role as both an adaptive and normative subject that complements vocational competencies (Bakrun et al., 2019; Feriandika, 2018). Teaching strategies should therefore focus on contextual and meaningful learning experiences that link mathematical concepts with vocational applications. Project-based and problem-oriented approaches are effective in improving students' engagement and conceptual understanding (Pepin et al., 2017; Sumandya & Widana, 2022). Through these methods, mathematics becomes not only a compulsory subject but also a key instrument in strengthening students' vocational readiness, creativity, and problem-solving ability in the workplace.

The primary goal of mathematics education in schools is to foster students' cognitive development, thinking skills, and character formation in a holistic manner (Ismail et al., 2022; Kilpatrick, 2020). Therefore, an ideal approach to mathematics learning should encompass the three learning domains: cognitive, affective, and psychomotor (Ahdiyat & Sarjaya, 2015; Harahap et al., 2023). Mathematics education aims not only to enhance intellectual intelligence but also to support students' personal development by cultivating logical thinking skills and good character, both of which are essential competencies for everyday life (Gravemeijer et al., 2017). Although not all students will directly apply every mathematical concept they learn, the ability to think logically and demonstrate positive character remains a highly valuable skill (Bora, 2020; Tyaningsih et al., 2020).

Effective mathematics learning is designed to enhance students' creative thinking abilities, improve their problem-solving skills, and provide new knowledge that strengthens their mastery of mathematical concepts (Aqilla et al., 2024; Khanifah et al., 2024). Student engagement in learning activities that involve both mental and physical processes plays a crucial role in learning success. As noted by

Sudjana (2010) and Juniyanto et al. (2020), mental activities include emotional, intellectual, and social interactions, while physical activities involve actions such as writing, playing, or other movements that support the learning process. These activities are interconnected and complementary, serving inseparable roles in effective learning.

Learning outcomes serve as a measure of students' ability to understand and master the material presented and act as motivation to improve knowledge and skills (Lin et al., 2017). In mathematics learning, assessment results can help identify areas that require special attention, enabling teachers to provide appropriate support (Nortvedt & Buchholtz, 2018; Wiliam et al., 2004). One of the main challenges in improving learning outcomes is encouraging active student participation in the learning process. Often, students perceive mathematics as difficult and monotonous, an issue typically stemming from teaching methods that rely heavily on lectures and repetitive problem-solving exercises.

One of the models that can enhance students' activeness and learning outcomes is Project-Based Learning (PjBL). This model provides students with opportunities to learn through self-directed projects or activities, allowing them to develop their intellectual potential in seeking solutions to real-world problems (Oyibe et al., 2015). As cited by Khoiruddin (2021), project-based learning enables students to engage actively in the learning process by collecting data, analyzing information, and thinking logically, critically, and systematically. The implementation of project-based learning is expected to create a more enjoyable learning atmosphere, improve students' understanding of the subject matter, and encourage their active participation in the learning process (Artini et al., 2018; Kokotsaki et al., 2016). Through the application of this model, students are expected to achieve more optimal learning outcomes in both cognitive and psychomotor aspects.

2. Methods

This study employed a quantitative approach using Classroom Action Research (CAR) as its research design. The choice of this method was based on its suitability for improving learning practices through systematic reflection and action in the classroom setting. The research aimed to identify and address learning challenges by implementing and evaluating interventions that could enhance students' engagement and performance. This approach allows the researcher to work collaboratively with students during the learning process, ensuring that improvements are based on actual classroom experiences and empirical observations. The design of this research followed the Classroom Action Research model developed by Kemmis and McTaggart (1998). This model consists of four iterative stages: planning, action, observation, and reflection. In the planning stage, the researcher identified learning problems and developed a strategy for improvement. The action stage involved implementing the planned learning model in the classroom. The observation stage focused on collecting data related to students' activities and learning outcomes, while the reflection stage was used to evaluate the effectiveness of the implemented actions and plan further improvements for the next cycle.

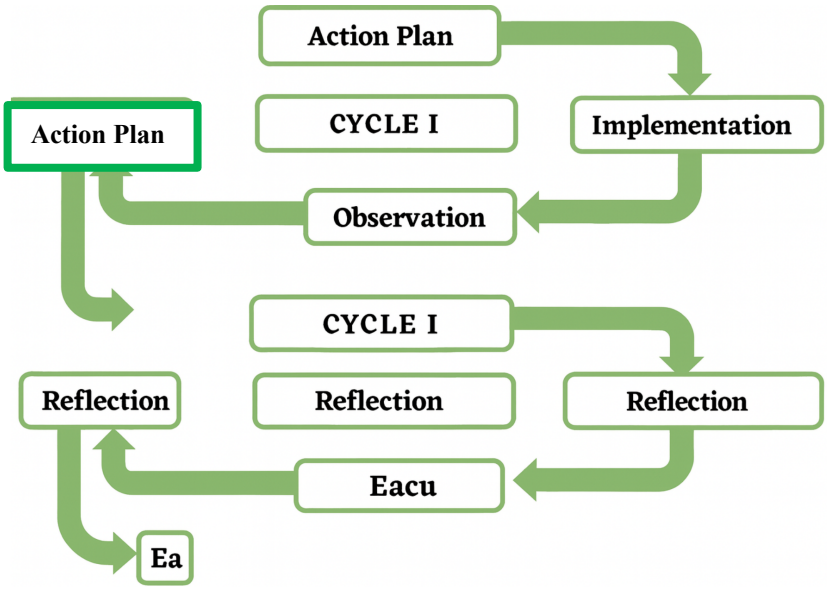

Figure 1. Classroom Action Research Cycle

The subjects of this study were students of Class X Nursing B at SMK Negeri 3 Kesehatan dan Pekerjaan Sosial Mimika during the 2024/2025 academic year. A total of 25 students participated in the study, consisting of 2 male and 23 female students. The instruments used in this research included observation sheets, project assessment rubrics, and learning outcome evaluation instruments. These instruments were developed based on predetermined indicators of student activeness and learning achievement.

Data collection in this study was carried out through multiple instruments to obtain comprehensive information about students' activeness and learning outcomes. The main instruments used were observation sheets, project assessment rubrics, and learning outcome tests. The observation sheets were used to record students' level of participation, attention, and collaboration during the learning process using the Project-Based Learning (PjBL) model. The project assessment rubric was applied to evaluate students' performance in completing their assigned projects, focusing on aspects such as creativity, concept application, teamwork, and presentation quality. Meanwhile, the learning outcome test was administered at the end of each cycle to measure students' understanding of statistical concepts and their ability to apply them in problem-solving situations.

The data obtained from observations and tests were analyzed using quantitative descriptive techniques. The results of the observation sheets were calculated in the form of percentages to determine the level of student activeness in each cycle. Similarly, students' project scores and test results were processed to determine the average learning achievement and the percentage of students who met the minimum mastery criteria (KKM). The comparison between the results of Cycle I and Cycle II was then analyzed to identify improvements in both activeness and learning outcomes. The findings were interpreted to evaluate the effectiveness of the PjBL model in enhancing students' engagement and mastery of statistical material.

3. Findings and Discussions

3.1 Findings

Improvement of Student Activeness

The improvement of student activeness was measured through a series of structured observations that focused on various aspects of behavior and participation during the learning process. These aspects included students' participation in classroom discussions, engagement in completing project assignments, collaboration with peers, and involvement in all class activities related to the Project-Based Learning (PjBL) model. During the observation stage, several indicators were carefully monitored, such as the frequency of students asking and answering questions, their initiative in sharing opinions, enthusiasm in group work, and consistency in accomplishing learning tasks. Each indicator provided valuable insight into the development of students' proactive learning attitudes as the learning cycles progressed. The improvement in activeness was reflected not only in the numerical increase of participation scores but also in qualitative aspects such as higher self-confidence, stronger communication skills, and greater responsibility in completing project tasks. Overall, the implementation of the PjBL model successfully created a more interactive, participatory, and student-centered learning environment, where learners were actively engaged in constructing knowledge and contributing meaningfully to the learning process.

Table 1. Recapitulation of Student Activeness Observation Results Before and After the Implementation of the PjBL Model

Aspect of Activeness	Before Implementation (%)	Cycle I (%)	Improvement (%)
Participation in discussion	61.80	80.33	18.53
Completion of project tasks	62.00	81.50	19.50
Interaction with peers	60.50	79.80	19.30
Involvement in classroom activities	63.00	82.00	19.00

Before the implementation of the PjBL model, the average level of student activeness was recorded at 61.80%. After the application of the PjBL model, student activeness increased significantly to 80.33%. This improvement was reflected in 84% of students being categorized as active or highly active. These findings indicate that the PjBL model successfully enhanced students' engagement in the learning process, enabling them to participate more actively in discussions, collaborate effectively in groups, and apply their knowledge to real-world projects. The increase also suggests that learning through projects provides students with greater opportunities to take initiative, express ideas, and develop a sense of responsibility toward their learning outcomes. Overall, the application of the PjBL model created a more dynamic and participatory classroom atmosphere, fostering meaningful learning experiences that strengthened both cognitive and social aspects of student development.

Improvement of Student Learning Outcomes

The improvement of student learning outcomes was assessed through achievement tests administered at the end of each learning cycle to measure students' understanding and mastery of the statistical material taught using the Project-Based Learning (PjBL) model. The tests were designed to evaluate not only the students' ability to recall mathematical concepts but also their capacity to apply these concepts to real-life problems and project-based tasks. Prior to the implementation of the PjBL model, many students demonstrated limited comprehension of abstract statistical ideas and often struggled to connect theoretical concepts with practical applications. However, after the introduction of project-based learning, students showed remarkable improvement in critical thinking, problem-solving, and data interpretation skills. The process of engaging in projects allowed students to explore statistical problems in a contextual manner, analyze information collaboratively, and present their findings creatively. As a result, the average test score increased significantly, and the number of students achieving mastery learning also rose. This finding indicates that PjBL not only enhanced students' academic achievement but also promoted deeper learning, where students developed a meaningful understanding of the subject matter, improved self-confidence, and demonstrated greater motivation to learn mathematics actively and independently.

Table 2. Recapitulation of Student Test Results Before and After the Implementation of the PjBL Model

Assessment Aspect	Before Implementation (%)	Cycle I (%)	Improvement (%)
Average score on statistics test	69.56	82.14	12.58
Number of students achieving mastery level	40.00	84.00	44.00

Before the implementation of the PjBL model, the average student learning score was 69.56%. After the application of the PjBL model, the average score increased to 82.14%. This improvement was also reflected in the learning mastery rate, which rose significantly from 40% to 84%. These results indicate that the PjBL model effectively enhanced students' understanding of statistical concepts and their ability to apply them in problem-solving situations. The increase in both average scores and mastery levels demonstrates that learning through projects encouraged students to engage more deeply with the material, connect theory to real-life contexts, and develop analytical and reasoning skills. Moreover, by involving students in active exploration and collaborative project work, the PjBL model fostered a sense of ownership and responsibility toward learning outcomes, resulting in improved academic performance and a more meaningful learning experience in the study of statistics.

Improvement of Student Project Results

The improvement of student project results was evaluated using a detailed project assessment rubric that included several key aspects such as creativity, accuracy, and the application of statistical concepts. This rubric was designed to provide a comprehensive measure of students' ability to integrate knowledge with practice, emphasizing both process and product-oriented outcomes. Before the

implementation of the Project-Based Learning (PjBL) model, most students showed limited creativity and tended to rely on conventional approaches when completing assignments. Their projects often lacked originality, conceptual accuracy, and coherence in data presentation. However, after the application of the PjBL model, there was a remarkable improvement in the quality and depth of students' projects. They began to demonstrate greater initiative in exploring real-world problems, applying statistical concepts more effectively, and presenting their findings in innovative ways. The collaborative nature of PjBL also encouraged students to share ideas, divide responsibilities, and evaluate their progress critically throughout the project process. As a result, students' work became more structured, visually engaging, and conceptually sound. Furthermore, the inclusion of authentic assessment allowed students to reflect on their learning process and make continuous improvements. This development highlights that the PjBL model not only enhanced students' academic performance but also cultivated essential twenty-first-century skills such as creativity, critical thinking, communication, and collaboration, which are crucial for their future academic and professional success.

Table 3. Recapitulation of Student Project Assessment Results

Project Assessment Aspect	Average Project Score Before PjBL (%)	Average Project Score After PjBL (%)	Improvement (%)
Creativity	68.00	85.00	17.00
Accuracy in applying concepts	70.00	86.00	16.00
Quality of presentation	65.00	82.00	17.00

The assessment results showed a significant improvement across all evaluated aspects. Before the implementation of the PjBL model, the average project assessment score of students was 68%, while after the implementation, it increased to 85%. This substantial improvement reflects that students were able to apply the concepts they learned more effectively in their projects and produce higher-quality outputs both creatively and technically. The enhancement in creativity indicates that students became more innovative in developing project ideas and presenting solutions, while the improvement in concept application demonstrates a deeper understanding of statistical principles and their practical use. Furthermore, the higher scores in presentation quality highlight that students were able to communicate their findings more clearly and confidently. Overall, these results affirm that the PjBL model not only improved academic achievement but also fostered essential skills such as creativity, critical thinking, collaboration, and communication, which contribute to a more meaningful and holistic learning experience.

Overall Evaluation of Learning Outcomes

The implementation of the Project-Based Learning (PjBL) model successfully enhanced both student activeness and learning outcomes in the statistics material. The significant improvement in student engagement indicates that learners became more involved, motivated, and responsible in participating throughout the learning process. They were more eager to take part in discussions, collaborate with peers, and explore project-based tasks that connected theoretical concepts with practical applications. Furthermore, the increase in learning outcomes demonstrates that

students were able to master the material more effectively after the application of the PjBL model. This improvement reflects not only a better understanding of statistical concepts but also a development in higher-order thinking skills such as analysis, synthesis, and evaluation. The findings highlight that the PjBL approach creates a more meaningful learning experience by positioning students as active constructors of knowledge rather than passive recipients. To illustrate the research results visually, the following chart presents a comparison of student activeness and learning outcomes before and after the implementation of the Project-Based Learning model.

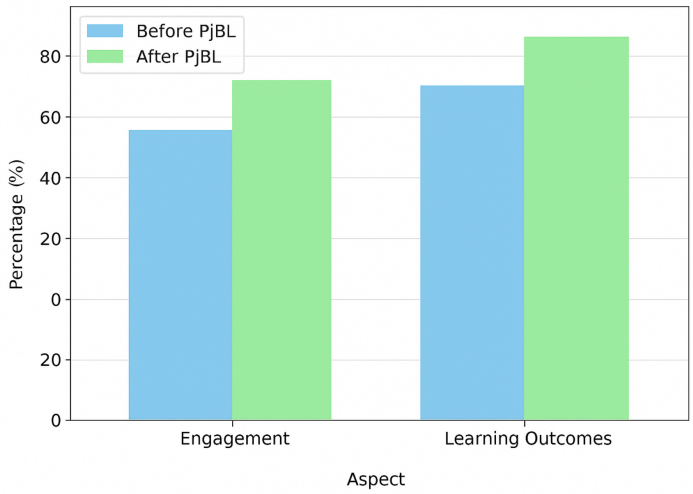

Figure 2. Comparison of Student Activeness and Learning Outcomes Before and After the Implementation of PjBL

From the graph above, it can be seen that there was a significant increase in both student activeness and learning outcomes after the implementation of the Project-Based Learning (PjBL) model. This improvement reflects the effectiveness of the project-based learning approach in creating a more dynamic and student-centered learning environment. The results indicate that students became more engaged, motivated, and collaborative during the learning process, while also achieving a deeper understanding of the subject matter. Overall, the application of the PjBL model contributed to enhancing not only academic achievement but also the development of essential learning skills such as critical thinking, creativity, and teamwork.

3.2 Discussions

One of the key findings of this study is the significant improvement in student activeness. Before the implementation of the Project-Based Learning (PjBL) model, the average level of student activeness was recorded at 61.80%, indicating that most students were still not actively engaged in learning activities. However, after the application of the PjBL model, the average activeness increased substantially to 80.33%, with 84% of students categorized as active or very active. This increase demonstrates that the PjBL model successfully encouraged students to become more involved in the learning process. Activities such as collecting data at the community health center, participating in group discussions, and presenting project results provided students with opportunities to apply their knowledge in real-world

contexts. These experiences fostered a greater sense of responsibility and engagement in learning. This finding aligns with the fundamental principles of PjBL, which emphasize active learning and motivate students not only to receive information but also to process, interpret, and apply it meaningfully in relevant situations.

The students' learning outcomes also showed a notable improvement. Before the intervention, the average student learning score was 69.56%, whereas after the implementation of the PjBL model, the average increased to 82.14%. This improvement was also reflected in the mastery learning rate, which rose from 40% to 84%. These results indicate that the PjBL model not only made the learning process more engaging but also helped students achieve a deeper understanding of the subject matter (Maskur et al., 2020; Prast et al., 2015). The improvement in learning outcomes suggests that project-based learning has a positive impact on students' mastery of statistical concepts. Through project activities that required them to collect data, analyze information, and present their findings, students were engaged in a more contextual and meaningful learning process that strengthened their conceptual understanding and analytical thinking skills.

In addition to its influence on student activeness and learning outcomes, the Project-Based Learning (PjBL) model also had a positive impact on students' collaboration skills. Project-based learning provides opportunities for students to work in groups, solve problems collectively, and communicate their ideas effectively (Dianti et al., 2023). In this study, students' collaborative skills showed a significant improvement, as reflected in their ability to work together in completing projects, share relevant information, and coordinate tasks efficiently. These skills are essential in modern education since teamwork and communication have become integral parts of professional and social life in today's complex world (Darel, 2024; Irawan, 2023). The collaborative learning environment fostered by the PjBL model also encouraged mutual respect, active participation, and a sense of shared responsibility among students. As they worked on projects, students learned to value different perspectives, make collective decisions, and build consensus, which not only enhanced the quality of their projects but also strengthened their interpersonal and problem-solving abilities.

Student enthusiasm during the learning process also increased after the implementation of the PjBL model. Activities such as collecting data at the community health center (Puskesmas) allowed students to engage directly with real-world situations, which significantly boosted their motivation and curiosity toward the subject matter. The group discussions that occurred throughout the learning process provided students with opportunities to exchange ideas and experiences, enriching their understanding of the material from multiple viewpoints. Furthermore, the project presentation stage offered students a meaningful platform to express their understanding creatively and confidently (Chua & Islam, 2021; Gan et al., 2015). This experience not only deepened their comprehension of statistical concepts but also helped them develop public speaking and effective communication skills—abilities that are crucial for both academic and professional success (Artini & Nitiasih, 2017; Simatupang & Hz, 2024). Overall, the PjBL model cultivated an engaging, cooperative, and empowering learning environment where students learned by doing, sharing, and reflecting collaboratively.

4. Conclusion

The implementation of the Project-Based Learning (PjBL) model in mathematics instruction has been proven to significantly enhance students' activeness and learning outcomes. The use of the PjBL model successfully increased student participation in discussions, project task completion, peer interaction, and engagement in classroom activities. In addition, students' learning outcomes improved considerably, as reflected in higher test scores and an increased level of learning mastery. The evaluation of project results also revealed that students were able to apply the concepts they had learned more effectively, producing projects that were both creative and of higher quality. Overall, the PjBL model proved to be effective in creating a more dynamic and student-centered learning environment that fostered deeper understanding of mathematical concepts and enhanced logical thinking skills. The success of this model serves as a promising solution to address challenges in mathematics learning, particularly in improving student engagement, motivation, and academic achievement.

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