**IMPLEMENTATION OF STEAM -BASED PROJECT BASED LEARNING (PjBL) TO IMPROVE STUDENTS’ NUMERACY AND LEARNING ACTIVITY**

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**Abstract**

Students’ numeracy skills and learning engagement are two important aspects in mathematics education in the modern era that demands mastery of 21st century competencies. However, the current reality shows that both aspects are still relatively low, especially in vocational high schools. This is largely due to the limited relevance of learning materials to real-life contexts and the widespread use of conventional teaching methods that do not stimulate student activity and participation. STEAM-based PjBL is believed to be able to improve students’ numeracy skills through exploratory, contextual, and collaborative activities, while encouraging active learning by directly involving students in project planning, implementation, and evaluation. This study is important because the systematic application of STEAM-based PjBL in vocational high school mathematics classes in Indonesia is still relatively rare. By using the topic of “Compound Interest and Annuities” in the context of making a game board, this study not only evaluates its impact on students’ numeracy skills and engagement, but also contributes to the development of a practical and relevant project-based learning model for current educational needs.

**Keywords :** Numeracy skills, Project Based Learning (PjBL), Board Games, STEAM, Student Activity

**INTRODUCTION**

In the context of 21st-century education, developing students' numeracy skills and learning engagement has become a fundamental need, particularly in mathematics learning. Numeracy is not only about the ability to calculate but also about using mathematical concepts, procedures, and reasoning to solve real-life problems in various contexts. However, various studies indicate that students' numeracy levels in Indonesia remain low, which negatively impacts their ability to think critically, make informed decisions, and function effectively in everyday life (Hartawan et al., 2024; Mohamad, 2024). In addition to low numeracy, students' passive behavior in the classroom further weakens the effectiveness of mathematics learning. This passivity is often caused by a lack of internal motivation, monotonous teaching methods, and limited contextual relevance of learning materials (Kanza et al., 2020; Widiani et al., 2023).

To address these issues, innovative learning models are needed—ones that can connect mathematical concepts to real-world applications while fostering student engagement. Project-Based Learning (PjBL), particularly when integrated with the STEAM (Science, Technology, Engineering, Arts, and Mathematics) approach, is a promising alternative. PjBL encourages students to investigate meaningful problems through collaborative projects, while the STEAM framework supports interdisciplinary exploration that mirrors real-world problem-solving (Aziz & Nurachadijat, 2023; Beers, 2011). Despite its potential, the application of STEAM-based PjBL in mathematics, especially at the junior high school level in Indonesia, remains underutilized (Torres et al., 2023). This study aims to fill this gap by exploring how STEAM-oriented project-based learning can enhance numeracy and student engagement.

Previous research has shown the effectiveness of PjBL in improving learning outcomes and student numeracy, particularly at the high school and vocational school levels (Pratiwi et al., 2020; Rohim et al., 2023; Fitriyah et al., 2024). However, differences in subject matter and student characteristics suggest that further investigation is needed, especially for topics like "lines and angles," which are relevant to various real-life fields such as architecture, navigation, and urban design. In this study, students are assigned a project to design a miniature city model using real-life measurements and geometry, integrating digital tools such as GeoGebra. This hands-on, creative, and collaborative approach is expected to foster a deeper understanding of geometric relationships while enhancing students' numeracy skills and active learning behaviors.

This research not only evaluates the implementation process of STEAM-based PjBL but also compares its impact on numeracy and engagement with that of conventional teaching methods. Furthermore, it examines whether student activeness influences the development of numeracy skills under both learning models. By focusing on a practical and meaningful topic, this study contributes to the growing body of evidence supporting innovative, student-centered approaches in mathematics education and provides insights for educators seeking to improve student learning outcomes in a rapidly evolving educational landscape.

**METHOD**

This study employed a convergent parallel mixed methods design, integrating both quantitative and qualitative approaches simultaneously to provide a comprehensive understanding of the research problem. According to Creswell (Indrawan & Yaniawati, 2020), this design allows for concurrent data collection and separate analysis of quantitative and qualitative data, which are then compared or combined during interpretation. The quantitative approach used a quasi-experimental design with a pretest–posttest nonequivalent control group, while the qualitative aspect involved interviews and observations to explore students’ engagement more deeply.

The quasi-experimental setup consisted of two groups: an experimental group that received STEAM-based Project-Based Learning (PjBL) and a control group that received conventional instruction. Both groups were assessed using pretests and posttests to measure numeracy improvement**.**

The population in this study consisted of seventh-grade students at SMK Indonesia Raya Bandung during the 2023/2024 academic year. The sampling technique used was **purposive sampling,** selecting two intact classes based on curriculum readiness and teaching schedules. Class XI OTKP was assigned as the experimental group and class XI TKJ as the control group, with 32 and 38 students in each class.

The independent variable in this study is STEAM-based project-based learning, while the dependent variables are student activity and mathematical numeracy. Student activity was measured using a closed Likert scale questionnaire consisting of 20 items—both positive and negative—based on indicators such as student participation in setting learning objectives, affective aspects, student participation in carrying out teaching and learning activities, class coherence, and freedom to make decisions. Mathematical numeracy was measured using open-ended questions designed with reference to PISA indicators. The test consists of five items that have been validated and tested to determine validity, reliability, difficulty level, and index discrimination. Validity was measured using Pearson correlation, and reliability was measured using Cronbach's Alpha.

The research instrument was developed based on the theoretical framework and field studies, validated by three media experts and three content experts, and tested through alpha and beta testing. Data collection techniques included questionnaires, tests, observations, interviews, and documentation. Qualitative data were analyzed using triangulation techniques to gain in-depth insights into students' perceptions and experiences during the learning process. Quantitative data were analyzed using descriptive and inferential statistics. The validity and feasibility of multimedia were analyzed using mode and median. The Mann-Whitney U test was used to test students' learning activeness, while the independent t test was used to assess the effect of mathematical numeracy. In addition, a simple linear regression analysis was conducted to determine the effect of student activeness on mathematical numeracy. The assumptions of normality, linearity, and autocorrelation were also tested to validate the regression model.

**RESULTS AND DISCUSSIONS**

This study resulted in the use of STEAM-based project based learning (PjBL) aimed at improving the numeracy and activeness of vocational high school students on the subject of compound interest and annuities. The project began with project determination, information gathering, drafting a project plan, compiling an activity schedule, completing the project, making reports and assessment presentations, evaluation. In this stage, teachers and students together review the strengths and weaknesses of the projects that have been worked on, including the quality of the final product (e.g., compound interest and annuity board games), group work dynamics, and the level of student engagement and understanding of the material. Evaluation also contains elements of self-development, where students are invited to reflect on their learning experiences, identify aspects that need to be improved, and plan steps for improvement for the next project or learning. This evaluation is holistic and can be done through class discussions, feedback surveys, student reflection journals, or interviews. Thus, the evaluation stage is an important foundation for improving the quality of project-based learning in a sustainable manner and fostering critical attitudes and a sense of responsibility in students.

Overview of students' numeracy skills after participating in learning, descriptive analysis was carried out on posttest data from both classes, namely the experimental class and the control class. This analysis includes the average value (mean), minimum value, maximum value, and standard deviation for each group.

Based on the results of descriptive statistical analysis, it can be seen that the numeracy ability of students in the experimental class shows a higher tendency compared to the control class. This can be seen from the average value and distribution of student scores which are larger in the experimental class, indicating a more even increase in numeracy ability among students. In addition, the range of scores in the experimental class is also wider, indicating that the learning method applied provides more space for students to develop their abilities individually. Meanwhile, the control class has a narrower range of values ​​and variations, reflecting a relatively homogeneous distribution of scores but at a lower level of achievement. These findings indicate that the learning approach used in the experimental class is more effective in improving students' numeracy abilities.

Based on the results of the normality test using the Shapiro-Wilk test, it is known that the numeracy ability data in both the experimental and control classes are not normally distributed, as indicated by the significance value below 0.05. This indicates that the distribution of data in both groups deviates from the normal distribution. Because the data does not meet the normality assumption, the homogeneity test does not need to be carried out, considering that one of the requirements for the homogeneity test is that the data must be normally distributed. For further testing, it is recommended to use a non-parametric test such as the Mann-Whitney U test to compare the two groups.

Based on the results of the one-tailed Mann-Whitney U test, a significance value of 0.000 was obtained, which is smaller than the significance level of 0.05. This indicates that there is a statistically significant difference between the numeracy abilities of students in the experimental class and the control class. Because the test was conducted one-way and the experimental class was a group that received treatment in the form of STEAM-based Project Based Learning, these results indicate that the numeracy abilities of students in the experimental class were significantly better than those of students in the control class who received conventional learning.

**CONCLUSION**

Based on the results of data analysis and findings during the research on the application of project based learning (PjBL) to improve the numeracy and activeness of class XI students of SMK Indonesia Raya Bandung, the following conclusions were obtained: The implementation of STEAM-based Project Based Learning (PjBL) in vocational high school students shows good potential in improving students' conceptual understanding and application skills, The learning activity of students who use STEAM-based project based learning (PjBL) is better than the learning activity of students who use conventional models. This study found that students were enthusiastic, proactive in asking questions, discussing, collaborating in groups, and independently seeking solutions to the projects given.and There is a significant and positive influence on the increase in numeracy from classes that use STEAM-based project based learning (PjBL).

Learning using STEAM-based project-based learning (PjBL) should be an alternative for teachers in implementing mathematics learning in the classroom, with the aim of improving students' numeracy and activeness. For other researchers who will use STEAM-based project-based learning (PjBL) to better prepare themselves to become facilitators and mediators during the learning process, because sometimes students do not always follow the learning as they should.

Considering the limited scope of the research, which is only within the scope of SMK Indonesia Raya class XI on the material Compound Interest and Annuities, it is necessary to conduct further research with a larger population and other mathematical materials and Further research is needed on the application of STEAM-based project-based learning (PjBL) to mathematical abilities and other affective abilities.

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