

THE IMPLEMENTATION OF PROGRAMMING CODING-ASSISTED PROBLEM BASED LEARNING MEDIA TO IMPROVE STUDENTS' MATHEMATICS LEARNING OUTCOMES

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ABSTRACT

Mathematics learning at the junior high school level often encounters difficulties, particularly in students' understanding of plane geometry concepts. These difficulties are largely caused by abstract instructional approaches and the limited integration of technology that can support students' conceptual visualization and problem-solving processes. This study aims to improve students' mathematics learning outcomes on plane shapes through the implementation of a programming coding-assisted Problem Based Learning (PBL) model. This research employed a quasi-experimental method using a pretest-posttest control group design. The participants consisted of 32 seventh-grade students at SMP Dewi Sartika Bandung, selected through purposive sampling. The experimental group received instruction using the PBL model supported by C++ programming, while the control group was taught using conventional learning methods. Data were collected using learning achievement test, observation sheets, and documentation of learning activities. The data were analyzed using descriptive statistics, normalized gain analysis, and an independent samples t-test to determine the effectiveness of the learning model. The results showed a significant improvement in students' mathematics learning outcomes in the experimental group. The average pretest score increased from 55 to 82 in the posttest, with a normalized gain score in the medium-high category. In addition, students in the experimental group demonstrated higher learning activity motivation, and problem-solving skills compared to those in the control group. It can be concluded that programming coding-assisted Problem Based Learning is effective in improving students' understanding of plane geometry concepts and enhancing their mathematics learning outcomes. This learning approach also supports active learning and the development of 21 st-century skills.

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INTRODUCTION

Understanding mathematics is fundamental for students because it plays a vital role in developing logical reasoning, analytical thinking, and problem solving skill needed in everyday

life and future academic learning. Mathematics is not only a collection of formulas and procedures, but also a way of thinking that helps students interpret situations, make decisions, and solve real world problems systematically. Therefore, meaningful understanding of mathematical concepts is essential, especially at the junior high school level, where students begin to build foundational knowledge for more advanced mathematical learning.

However, in practice, many students experience difficulties in learning mathematics due to a lack of conceptual understanding. Mathematics learning is often dominated by procedural teaching methods that emphasize memorization rather than comprehension. As a result, students may be able to perform calculations mechanically but fail to understand the underlying concepts. Hudojo (2018) explains that students who learn mathematics only by memorizing formulas tend to struggle when forced with non-routine problems, which ultimately leads to low learning outcomes and weak problem-solving abilities. This issue is frequently found in plane geometry topics, where students have difficulty visualizing shapes and understanding the relationships between geometric elements such as area and perimeter.

One learning model that has been widely recognized as an effective solution to these problems is Problem Based Learning (PBL). PBL emphasizes student centered learning by engaging students in solving contextual and meaningful problems. According to Arends (2012), PBL encourages students to actively construct knowledge through investigation, discussion, and reflection, which helps improve conceptual understanding and higher order thinking skills. Several studies have shown that PBL can significantly improve students' mathematics learning outcomes. Hosnan (2019) and Lestari et al. (2017) found that students taught using PBL demonstrated better conceptual understanding, problem solving skill, and learning achievement compared to those taught using conventional methods. These findings indicate that PBL is an effective instructional approach for addressing students' difficulties in understanding mathematical concepts.

Along with the development of learning models, the integration of technology in education has become increasingly important in the digital era. Recently, researchers have begun to explore the integration of PBL with programming and coding activities. Coding assisted learning allows students to visualize abstract mathematical concepts, test ideas through simulations, and receive immediate feedback. Rizki et al. (2021) argue that programming activities can enhance students' mathematical reasoning by transforming abstract concepts into concrete representations. Wicaksana (2022) reported that integrating programming into PBL environments supports deeper conceptual understanding and improves students' learning outcomes. Despite these positive findings, studies that specifically examine programming coding assisted PBL in junior high school mathematics learning, particularly using C++ programming, are still limited.

Based on these considerations, this study aims to investigate the effectiveness of implementing a programming coding assisted Problem Based Learning model in improving seventh grade students' mathematics learning outcomes on plane geometry topics. This research is expected to provide empirical evidence that the integration of PBL and coding can enhance students' conceptual understanding, learning engagement, and problem solving skill in mathematics.

METHOD

This study uses a quasi experimental method with a pretest-posttest control group design. According to Sugiyono (2019) a quasi experimental method is used to find out the effect of a treatment even when the researcher cannot control all external variables closely. This design was chosen because it allows the researcher to compare students' initial and final abilities before and after the treatment. This aligns with Creswell (2018) who states that comparing learning outcomes between the experimental and control groups can more objectively show the effectiveness of an intervention.

The research was conducted at SMP Dewi Sartika in Bandung, involving 32 students from class VII, selected using purposive sampling. This technique was chosen because the class has characteristics that match the research objectives. According to Arikunto (2020) purposive sampling is used to select samples based on considerations that meet the research needs. In this study, the independent variable is the Problem Based Learning (PBL) model, which uses the C++ coding media, while the material covers flat shapes the determination of these variables is based on the quantitative research concept from Sugiyono (2019).

The research instruments consist of a learning achievement test, an observation sheet, and documentation. The learning achievement test includes pretest and posttest questions to measure students understanding of flat shape concepts. The observation sheet is used to assess students activities, participation, and problem solving abilities during PBL lessons with C++ coding assistance. Documentation includes photos of activities field notes, and the C++ code created by students according to Mardapi (2017), using a variety of valid instruments can provide a clearer picture of students abilities in terms of cognitive, affective, and psychomotor aspects.

The research procedure was carried out three stages : preparation, implementation, and conclusion. In the preparation stage, the researcher prepared the PBL learning tools with the help of C++ coding, made pretest and posttest questions, and validated the instruments with experts. The implementation stage involved giving a pretest to both classes, then delivering PBL lessons with C++ coding support to the experimental class and C++ coding support to the experimental class and conventional lessons to the control class. During the learning process, the researcher also observed students learning activities. In the final stage, the researcher gave a posttest to both classes, processed the data, and concluded about the impact of applying the PBL model with C++ coding on students learning out comes. This procedure follows the educational experimental research process as described by Frankel et al (2015).

To assess the quality of the learning implementation, a learning process rating scale with values ranging from 1 to 4 is used. This scale provides an overview of student activities, teacher activities, group collaboration, and the quality of using C++ coding media during the learning process. The categories of the learning quality scale scores can be seen in the table below :

Table 1. Categories of the Learning Process Quality Scale

Score Range	Category
3.25–4.00	Very Good
2.50–3.24	Good
1.75–2.49	Fair
1.00–1.74	Poor

The data analysis in this study was carried out in several steps, including a normality test using Kolmogorov-Smirnov to determine whether the data follows a normal distribution, a homogeneity test using Levene to ensure equal variance across groups, and a significant difference between the posttest scores of the experimental class and the control class. These analytical techniques were chosen according to statistical guidelines in quantitative research, as explained by Santoso (2020).

RESULTS AND DISCUSSION

Results

This study aimed to examine the effectiveness of implementing a programming coding assisted Problem Based Learning (PBL) model in improving seventh grade students mathematics learning outcomes on plane geometry topics. This results are presented based on students

learning outcomes, normalized gain scores, statistical testing, and observations of the learning process.

1. Students Mathematics Learning Outcomes

The result of the learning achievement tests indicate a substantial improvement in students mathematics learning outcomes after the implementation of PBL assisted by C++ programming. In the experimental class, the average pretest score was 55, indicating that students initial understanding of plane geometry concepts was relatively low. After the treatment, the average posttest score increased to 82, showing a significant improvement in students conceptual understanding. In constrast, the control class, which received conventional instruction, showed a smaller increase in learning outcomes. The average pretest score in the control class was 54 and increased to 67 in the posttest. Although improvement occurred, the magnitude was considerably lower than that of the experimental class.

Table 2. Average Pretest and Posttest Scores

Class	Pretest	Posttest	Improvement
Experiment	55	82	+27
Control	54	67	+13

These results indicate that students who learned through PBL supported by C++ coding achieved higher learning gains that those who learned through conventional methods.

2. Normalized Gain Analysis and Statistical Test Results

Further analysis using normalized gain (N-gain) scores showed that the experimental class achieved an N-gain score of 0.60, which falls into the medium-high category. Meanwhile, the control class obtained an N-gain score 0.31, categorized as medium. This finding suggests that the learning improvement in the experimental class was more effective and meaningful. The independent samples t-test showed a significance value of $p < 0.05$, indicating a statistically significant effect on students mathematics learning outcomes.

3. Learning Process Quality and Student Activities

Observational data reveled that the quality of the learning process in the experimental class was categorized as very good. Students actively participated in group discussions, explored mathematical problems, modified coding syntax, and presented their programming resluts. The use of C++ programming encouraged students to verify their calculations of perimeter and area through direct execution of the program, which strengthened conceptual understanding.

Table 3. Observation Score of Learning Activities in the Experimental Class

Aspect Being Assessed	Average Score	Category
Student Activity	3.45	Very Good
Teacher Activity	3.40	Very Good
Group Cooperation	3.38	Very Good
Use of Coding Media	3.52	Very Good

The C++ programming media used in this study allowed students to input dimensions of plane shapes and automatically calculate perimeter and area. Students interacted with the program by modifying input values and observing changes in the output, enabling them to understand mathematical relationships more concretely.

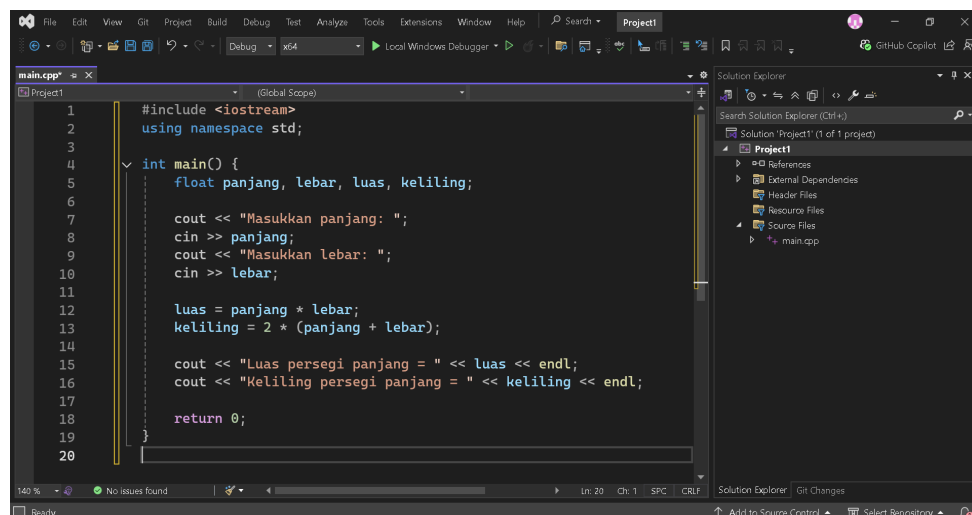


Figure 1. C++ Coding Design Example

Discussions

The findings of this study demonstrate that the implementation of Problem Based Learning Assisted by C++ programming significantly improves students mathematics learning outcomes on plane geometry topics. These results are consistent with and supported by several previous studies.

First, the significant improvement in learning outcomes aligns with the findings of Arends (2012), who reported that PBL enhances students conceptual understanding through actives engagemet in structured problem solving activities. In this study, students were not only solving mathematical problems but also translating those problems into computational logic using C++, which deepened their understanding.

Scored, the higher N-gain score in the experimental class supports the findings of Hosnan (2019), who found that PBL effectively improves students learning outcomes and critical thinking skills compreaed to conventional teaching methods. The integration of coding in this study futher strengthened the impact of PBL by providing immediate feedback and concrete representations of abstract concepts.

Thired, the increased student activity and engagement observed in this study are consistent with Rizki et al. (2021), who reported that integrating coding into mathematics learning increases students curiosity, motivation, and involvement. The use of C++ programming enabled students to visualize the calculation of perimeter and area, making learning more interactive and meaningful.

Fourth, the results are in line with Lestari et al. (2017), who found that PBL improves students mathematical problem solving skills. The problem based tasks in this study required students to analyze real world problems, design algorithms, and implement solutions through coding, thereby enhacing problem solving abilities.

Overall, compared to previous studies that applied PBL of technology assisted learning separately, this study highlights the added value of integrating PBL with C++ programming in junior high school mathematics learning. The combination of problem based activities and coding not only improved learning outcomes but also fostered 21 st century skill such as critical thinking, creativity, collaboration, and technological literacy.

CONCLUSION

This study was conducted to answer the research question regarding whether the implementation of a Problem Based Learning (PBL) model assisted by C++ programming media is effective in improving seventh grade students mathematics learning outcomes on plane geometry topics. Based on the results of the study, it can be concluded that the use of PBL integrated with C++ coding has a significant positive effect on students mathematics learning outcomes. This is evidenced by the substantial increase in the experimental class average score from 55 in the pretest to 82 in the posttest, which was significantly higher than the improvement observed in the control class. These findings confirm that PBL assisted by C++ programming is more effective than conventional learning methods in enhancing students understanding of plane shape concepts.

In addition to improving learning outcomes, the implementation of PBL with C++ coding also enhanced the quality of the learning process. Students demonstrated higher levels of learning activity, motivation, and collaboration during lessons. The coding activities enabled students to explore mathematical problems actively, test their own calculations of perimeter and area, and receive immediate feedback through program execution. This learning process supported deeper conceptual understanding and the development of critical thinking skill, which are essential competencies in the digital era.

Based on these findings, several recommendations for future research can be proposed. Future studies may involve a large sample size and different school contexts to strengthen the generalizability of the result. In addition, further research could explore the integration of PBL with other programming languages or digital tools, such as Python or visual programming environments, to examine their effectiveness in different mathematics topics. Future researchers are also encouraged to investigate the long-term impact of coding assisted PBL on students retention of mathematical concepts and the development of higher order thinking skills.

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