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Implementation of Project-Based Visual Programming Modules on Problem-Solving Skills Information Technology Education students to Support the SDG's

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Abstract

Students in the Information Technology Education program need to master programming languages as an essential part of their competencies to support educational goals. One of the courses that require programming proficiency is Visual Programming or desktop-based programming. Problem-solving skills are crucial in the development of desktop-based applications. This study aims to analyze the visual programming problem-solving abilities of PTI students in supporting the SDGs through the implementation of the project-based visual programming module. This research employs a quantitative approach with a pre-experimental design of the One-Group Pretest-Posttest type. The sampling technique used is purposive sampling, involving 15 students currently taking the object-oriented programming course. The data used in this study consists of the test results of problem-solving abilities through the final project. Based on the analysis, the project-based visual programming module has been proven effective in improving students' problem-solving skills, as indicated by the paired sample t-test with a significance value of 0.002 < 0.05. In conclusion, there is a significant difference in students' problem-solving abilities before and after using the project-based module. The improvement in students' problem-solving skills through this module is considered high, with an N-Gain score of 0.839.

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INTRODUCTION

Information Technology Education is an educational study program that studies and emphasizes mastery of basic information technology knowledge. The fast-paced advancements in information technology demand that students not only gain technical expertise but also cultivate strong problem-solving skills to adapt and innovate effectively. One of the fundamental areas that must be mastered is programming languages. Programming languages are standard commands used to control computers (Setiawan et al., 2024). Information Technology Education students need to master programming languages as an integral part of the Graduate Competency Achievements that they must achieve. One of the courses that requires mastery of programming languages is Visual Programming using Visual Basic (VB). The purpose of this course is for students to be able to develop desktop-based applications. In developing desktop applications, complex problem-solving skills are essential.

In today's technology-driven world, programming has become an essential skill across many areas of life. Success in tackling both technical and non-technical challenges frequently hinges on a strong grasp of programming algorithms (Aisyah & Yahfizham, 2023). These skills are vital for the future as they involve careful information handling, enabling individuals to solve problems that may arise later (Bahar & Aksüt, 2020). Problem-solving skills include identifying the problem, analyzing key elements, exploring various solutions, taking action to resolve the issue, and learning from the experience (Maisya et al., 2020).

Problem-solving expertise is a fundamental and critical aspect for students. This is because problem-solving skills are considered a process or technique used to face challenges by applying the knowledge one possesses (Sundayana, 2016). Students trained in problem-solving will become proficient in sorting relevant information, analyzing, and evaluating results.

Problem-solving ability is one of the competencies that individuals must have in the 21st century. 21st-century education integrates knowledge, skills, attitudes, and ICT proficiency. 21st-century skills are known as the 4Cs (critical thinking, creative thinking, communicating, and collaborating). Problem-solving is crucial to be taught and practiced in schools. Polya explained that problem-solving is finding the sought meaning until it is clearly understood (Polya, 1973). Solving problems means finding a way to address issues, finding a way out of difficulties, overcoming obstacles, and achieving desired goals with the appropriate tools. Complex problem-solving involves a series of observations and decisions based on information used to find and apply solutions to a problem (Veríssimo et al., 2024). According to Polya, the indicators of problem-solving involve comprehending the problem, creating a strategy to address it, executing the strategy, and reviewing the solutions achieved (Polya, 1973).

To develop these skills, students need to use cognitive and metacognitive skills and can utilize various learning resources. Additionally, problem-solving skill development can be achieved through learning that uses references. One of the references supporting the development of these skills is a module. Modules are a learning resource designed to enhance students' self-directed learning in Visual Programming post-pandemic with a hybrid learning approach. Project-Based Learning is an educational approach that motivates students to learn by engaging in projects that reflect real-world scenarios. This approach integrates various skills, such as critical thinking, collaboration, creativity, and communication. Problem-solving skills are key skills acquired through PBL, as students face real challenges that require innovative and effective solutions (Bell, 2010). In this context, using the project-based learning (PjBL) approach, especially through visual programming modules, has gained considerable attention as an effective teaching method. Project-based learning involves students in intricate real-world projects, promoting active engagement and the development of higher-order thinking skills such as analysis, synthesis, and evaluation. These skills are crucial for PTI students, as the ability to solve problems creatively and efficiently is essential.

Modules are systematically and attractively designed, covering content, methods, and evaluations to achieve learning objectives (Permana et al., 2021). Research (Hasanah et al., 2022) indicates that project-based learning modules can facilitate students in gaining insights and understanding material. The application of the PjBL model in this Visual Programming module includes delivering content, practical sessions, and practical assignments in the form of interrelated projects, with the expectation that students will produce desktop-based applications upon completing the course. Recent research has shown that project-based visual programming can improve problem-solving skills by allowing students to visualize complex algorithms and data structures, making abstract concepts more tangible (Basu et al., 2020). This is especially pertinent in the context of the Sustainable

Development Goals (SDG's), which highlight the need for quality education (SDG 4) and the advancement of innovation and infrastructure (SDG 9) (United Nations, 2015). By enhancing problem-solving abilities through innovative teaching methods, educators can help develop a skilled workforce equipped to tackle global issues and promote sustainable development. In addition, based on research, (Wisic & Makiyah, 2021) implementing modules can improve problem-solving skills. Research has shown that PjBL can encourage students to produce projects at the end of learning (Oksa & Soenarto, 2020), and help student-centered learning. PjBL can contribute to achieving these goals by enhancing the quality of education through relevant and practical learning experiences. By engaging in PBL, students apply their knowledge to real-world scenarios, thereby improving their understanding and skills. Developing a relevant module design is a crucial step to maximize the impact of PBL on problem-solving abilities and support the SDG's. PBL-based modules should be designed to reflect real problems that are relevant to SDG's goals so that students can see the direct impact of their learning.

Education is one of the main pillars in supporting the Sustainable Development Goals (SDG's) set by the PBB. PjBL-based modules are a pedagogical approach that can improve students' problem-solving skills, which in turn support the achievement of various SDG goals. The SDG's comprise 17 goals addressing different dimensions of sustainable development, including quality education, decent work and economic growth, industrial innovation, and reduced inequality. PBL can support the achievement of SDG's, one of which is the PBL model, which improves the quality of education by providing relevant and applicable learning experiences. Through PBL, students learn to apply their knowledge in real situations, which improves their understanding and skills (Surahman, 2024). To optimize the influence of PBL on problem-solving skills and support SDG's, one step that can be taken is to create a relevant module design. PBL-based modules should be designed to reflect real problems that are relevant to SDG's goals so that students can see the direct impact of their learning.

In previous research, studies have been conducted on building complex problem-solving skills of Information Technology Education students post-pandemic through PjBL modules in visual programming courses. This research resulted in a project-based learning visual in programming modules. Therefore, this study will analyze the problem-solving abilities of Information Technology Education students to support the SDG's through the implementation of PjBL-based modules.

RESEARCH METHODS

The study employs a quantitative research design with a pre-experimental approach, specifically the One-Group Pretest-Posttest Design. It aims to evaluate students' problem-solving skills through project-based modules by applying an intervention to a group and then observing the outcomes. The researcher does not perform randomization but designates the study group (Hadi S, 2019). The research design is illustrated in Figure 1.

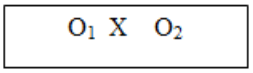

Figure 1. One – Group Pretest-Posttest Design

Description:
O_1 = Pretest
O_2 = Posttest
X = Treatment

The research population includes students from the Information Technology Education Program at FPIP UMSIDA. Sampling was conducted using purposive sampling, which involves applying specific criteria (Arikunto, 2019). The criteria for sampling were students currently enrolled in the Visual Programming course, totaling 15 students. This research was conducted in 3 meetings. The materials used were multiple document interfaces, databases, and exception handling.

The instrument used in this study is a project-based problem-solving ability test. The instrument validation for this research is construct validation by the instructor of the Visual Programming course. Expert judgment can be used to test construct validity. The indicators of programming problem-solving abilities used refer to Polya's theory and include understanding the problem, devising a problem-solving plan, executing the plan, and reviewing the obtained solution (Polya, 1973).

The effectiveness of project-based modules is assessed through pre-tests and post-tests, with the results analyzed using a paired sample t-test. Before conducting statistical tests, it is essential to ensure that the data is normally distributed. Normality tests are employed to verify whether the sample originates from a normally distributed population, with this study using SPSS for Windows for the analysis. The paired sample t-

test compares the means of two related groups. If the significance value (sig.) is less than 0.05, H0 is rejected in favor of Ha. The hypothesis in this study is (Ha) that there is a significant difference in problem-solving abilities before and after implementing the project-based module.

The next test is the N-Gain Score test, which measures the improvement in students' problem-solving abilities by calculating using the formula (Zhafirah et al., 2021). The formula of the N-Gain score test is in Equation 1.

$$\text{N-Gain} = \frac{Spost - Spre}{Smax - Spre} \quad (1)$$

The results of the N-Gain test are classified based on the normalized Gain (g) interpretation. The N-Gain is considered low if it is less than 0.3, medium if it falls between 0.3 and 0.7, and high if it exceeds 0.7. N-Gain results are deemed satisfactory if the value is greater than 0.3.

RESULT AND DISCUSSION

Effective learning can be influenced by many factors, including the learning environment, lecturers or teachers, students, and learning resources. One of the effective learning resources used in practical learning is the teaching module (Hasanah et al., 2020). A well-designed module facilitates learning both independently and with the support of instructors. In this study, the effectiveness of project-based modules was evaluated using the paired sample t-test and the N-gain test. Before conducting these tests, a normality test was performed using the Shapiro-Wilk test to assess the data distribution.

Table 1. Results of the Normality Test

	Shapiro-Wilk		
	Statistic	**df**	**Sig.**
pretes	0.897	15	0.085
postes	0.909	15	0.133

According to the analysis results shown in Table 1, the significance values for the pretest and posttest were 0.085 and 0.133, respectively, indicating that the data for both tests were normally distributed, as the significance values were greater than 0.05. Once the normality of the data was confirmed, the analysis proceeded with a paired sample t-test to examine the differences between the pretest and posttest values, as detailed in Table 2.

Table 2. Paired Sample T-Test Results

	t	**df**	**Sig. (2-tailed)**
pretes - postes	-3.698	14	0.002

From the test in Table 2, the sig value is obtained, namely 0.002 <0.05, so it can be concluded that H0 is rejected. Based on the results of the analysis test, it can be concluded that there is a difference in problem-solving ability before and after using the project-based module. Data analysis of problem-solving ability was carried out using the N-Gain test which was used to determine the increase in students' problem-solving ability after using the project-based visual programming module which was carried out per indicator according to Polya. The results of the N-Gain Test analysis can be seen in the graph in Figure 1.

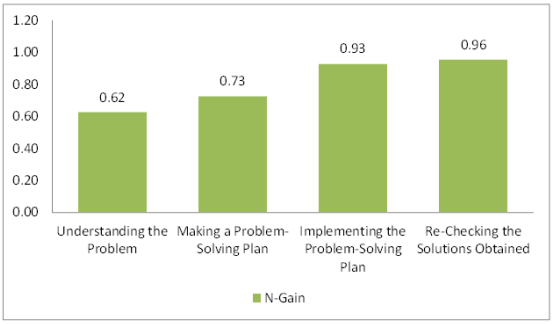

Figure 1. N-Gain test result

Figure 1 demonstrates that each problem-solving indicator has shown improvement. Analyzing the four indicators reveals that utilizing project-based visual programming modules enhances the problem-solving skills of PTI students. The overall N-Gain analysis yielded a score of 0.839, placing it in the high category. Therefore, it can be concluded that project-based visual programming modules significantly enhance students' problem-solving abilities, achieving a high level of improvement.

These findings align with the research by (Permana et al., 2021) which indicates that the use of modules can enhance students' problem-solving skills, with an average N-Gain of 0.57 categorized as moderate. In implementing the project, students are required to be able to understand the concept of the problem well and, at the same time, be able to produce products that are in accordance with the concept of the problem studied in the course. Students need high-level thinking skills to complete products that are adapted to real life (Susanto & Susanta, 2020).

Increasing students' problem-solving abilities by using project-based modules can occur because using project-based modules can train and encourage students to think critically and creatively in solving problems (Rosmana et al., 2024). Projects given in project-based learning are often real problems that require a critical and

creative approach to solve. This encourages students to think critically in solving problems.

Through systematic problem-solving steps in project-based learning, students can not only produce correct solutions, but can also develop students' analytical skills in making decisions and helping to solve problems in various conditions (Astria et al., 2024). Project Based Learning is a student-centered learning method, where they learn by actively engaging in meaningful projects. This model emphasizes the process of exploration, investigation, and problem-solving through projects designed to reflect real-world situations. The presence of a learning module that incorporates the project-based learning model at every stage enables students to effectively identify, analyze, and resolve problems.

The study results reveal that the first problem-solving indicator, understanding the problem, had an N-Gain value of 0.62, placing it in the moderate category. In this project-based programming module, problems are framed as projects that students need to address. This approach requires students to grasp the issues and devise solutions, thereby actively engaging them in the learning process. As students tackle projects, they are more likely to enhance their problem-solving skills, as they must find solutions to the challenges presented in the project (Wijnia et al., 2024).

The second indicator, which is creating a problem-solving plan, achieved an N-Gain of 0.73, categorized as high. This indicates that the project-based programming module effectively enables students to develop problem-solving plans through structured projects. Project-Based Learning (PjBL) is a teaching method that focuses on learning through projects aimed at addressing real-world problems. PjBL-based modules are designed to cultivate students' critical, collaborative, and creative thinking skills in formulating problem-solving plans. The initial phase of the PjBL model involves identifying relevant problems or challenges associated with the project, which includes data collection and a thorough understanding of the problem's context.

Likewise, the indicator of implementing the problem-solving plan obtained an N-Gain value of 0.93, this proves that students' ability to implement the project problem-solving plan is in the high category. By facing real problems, students are encouraged to find innovative and creative solutions. They learn to combine various ideas and approaches to achieve goals (Hindriyanto et al., 2019). Project-based programming modules can also make students more careful in re-examining the solutions that have been planned and created in completing the project, as evidenced by the N-Gain value of 0.96 with high criteria.

PjBL modules greatly influence the enhancement of students' problem-solving skills, which directly contributes to achieving several SDG goals. A key objective of the SDGs is to provide inclusive and high-quality education and to promote lifelong learning opportunities for everyone. This study found that the implementation of PjBL visual programming modules significantly improved problem-solving skills among Information Technology Education students. The active and practical approach of PjBL encourages students to engage deeply with the material, thereby enhancing critical thinking skills and creativity. By visualizing programming concepts and applying them to real-world problems, students develop a stronger understanding of complex topics, which enhances their overall learning experience. These results directly contribute to SDG 4 by promoting quality education through innovative teaching methodologies that go beyond traditional lecture-based approaches. By providing relevant, applicable, and innovative learning experiences, PjBL can improve the quality of education, prepare students for the workforce, encourage innovation, and reduce inequality (Anggrella & Sudrajat, 2024). Educational institutions need to consider implementing PjBL as a key strategy in supporting sustainable development through improved skills and more equitable opportunities for all students.

CONCLUSION

The project-based programming module was considered effective in improving students' problem-solving abilities, as indicated by the paired sample t-test with a significance value of 0.002, which is smaller than 0.05. This finding indicates a significant increase in students' problem-solving abilities before and after using the module. This shows that the PjBL module greatly influences the improvement of students' problem-solving abilities, which directly contributes to the achievement of several SDG goals, namely quality education by providing relevant and applicable learning experiences. In addition, the results of the N-Gain test showed an increase in students' problem-solving abilities, with a score of 0.839, which is categorized as high. Therefore, this study will analyze the problem-solving abilities of IT students to support the SDGs through the implementation of PjBL-based modules.

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