THE INFLUENCE OF PROBLEM-BASED LEARNING ON INNOVATION DIGITAL ECOSYSTEM STUDENTS' PROBLEM-SOLVING SKILLS

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Abstract

This study aims to examine the effect of Problem-Based Learning (PBL) on students' problem-solving skills. The study uses a quantitative approach with simple linear regression analysis. The respondents involved in this study were 72 students from the EID E class at ARS University, enrolled in the Digital Innovation Ecosystem course during the odd semester of the 2024/2025 academic year. The results of the regression analysis show that PBL has a significant impact on students' problem-solving skills, with an R value of 0.851 and an Adjusted R Square of 0.720. The ANOVA test indicates that the regression model is significant ($F = 183.162$, $p < 0.01$). Furthermore, the regression coefficient for the X variable (PBL) is 0.734, indicating that every one-unit increase in the implementation of PBL will improve students' problem-solving skills by 0.734 units. Based on these results, it can be concluded that PBL is effective in improving students' problem-solving skills, and it is recommended to implement this method more widely across various disciplines.

Keywords*:* Digital, Ecosystem, Problem-Based Learning, Problem-solving skills, Higher Education.

INTRODUCTION

Problem-Based Learning (PBL) has become one of the primary approaches in higher education aimed at enhancing student engagement in the learning process. In this method, students are presented with real-world problems that require them to think critically and creatively to find solutions. This is particularly important as problem-solving skills are essential for students to tackle professional challenges in the future. PBL not only focuses on mastering subject matter but also develops students' abilities to identify, analyze, and solve problems independently or collaboratively. Several studies indicate that PBL can improve students' problem-solving skills; however, its effectiveness largely depends on proper implementation and the supportive conditions within the educational environment (Oktaviana & Haryadi, 2020). Therefore, it is crucial to evaluate how problem-based learning affects students' problem-solving abilities across various educational contexts. Relevant research can provide deeper insights into the impacts and challenges students face when applying PBL, helping to identify ways to maximize the benefits of this method.

Problem-solving skills are among the competencies expected to develop in university students during their higher education journey. In this era of globalization, these skills are crucial as students are not only required to understand theories but also to apply knowledge in addressing various real-

life challenges. In this context, problem-solving encompasses analytical, critical, and creative skills that are essential in any profession. Moreover, many fields of study demand students to tackle complex and unstructured situations, such as in medicine, engineering, and social sciences. Effective learning should foster these skills in ways that can be applied to diverse situations (Salsabila & Asih, 2024). Problem-Based Learning (PBL) aims to achieve this by providing students with opportunities to engage with relevant and challenging problems while working in groups to find solutions. However, not all students can easily develop these skills, especially if they are unfamiliar with critical and analytical thinking processes. Therefore, it is important to assess the extent to which PBL can encourage the development of students' problem-solving abilities. Research shows mixed results, with some students feeling more engaged and progressing, while others find it difficult to apply this method effectively.

On the other hand, Problem-Based Learning (PBL) also faces challenges in its implementation within higher education. One of the biggest hurdles is the paradigm shift required in the learning process. Many lecturers still rely on traditional lecture methods as their primary teaching approach, focusing on delivering information and assessing understanding through written exams. In contrast, PBL requires lecturers to take on the role of facilitators who assist students in exploring and solving problems (Rachmawati et al., 2024). This demands new skills from lecturers, both in designing relevant problems and in guiding students to think critically and collaboratively. Additionally, not all educational institutions possess sufficient resources to support the optimal implementation of PBL. Adequate facilities and time, as well as effective training for both lecturers and students, are essential for the successful adoption of PBL. Factors such as resistance to change and resource limitations can hinder the effectiveness of this learning method. Therefore, further research is needed to explore the challenges faced in implementing PBL, particularly in the context of higher education in Indonesia, to identify the best solutions for its successful execution.

A study examining the impact of Problem-Based Learning (PBL) on students' problem-solving abilities can provide deeper insights into the effectiveness of this method. Several studies suggest that students involved in PBL tend to have better problem-solving skills compared to those who follow traditional learning methods. This is because PBL requires students to work in groups, discuss problems, and find solutions independently. This process encourages them to think critically and sharpen their analytical skills (Winarti et al., 2019). Moreover, PBL also enhances students' social skills, such as communication, teamwork, and time management. However, not all students experience the same level of improvement. Some studies have also found that certain students struggle with the PBL process, particularly if they lack motivation or are not accustomed to active learning methods. Therefore, it is important to assess the factors that influence the success of PBL, such as students' readiness, lecturers' abilities, and institutional support in providing facilities that support problem-based learning.

In the context of Problem-Based Learning (PBL), students' motivation plays a crucial role in determining the success of this method's implementation. Several studies indicate that students with high intrinsic motivation are more likely to engage actively in the problem-based learning process. They feel more challenged to solve problems and find the right solutions, which enhances their problem-solving skills. In contrast, students with low motivation may not find the given problems as interesting, leading them to put less effort into solving them effectively (Wijnen et al., 2017). Therefore, it is important to consider motivational factors when designing problem-based learning experiences. Lecturers must be able to create a learning environment that is engaging and relevant for students, so they feel motivated to actively participate in the problem-solving process. Additionally, support from classmates and lecturers can also influence students' motivation levels. Further research

is needed to explore how motivational factors interact with the implementation of PBL and how to enhance student motivation for more effective participation in problem-based learning.

In addition to motivational factors, institutional support also plays a key role in the success of Problem-Based Learning (PBL). Several studies show that educational institutions that support the implementation of PBL by providing training for lecturers, adequate facilities, and sufficient time for problem-solving, can enhance the effectiveness of this method. Implementing PBL requires more resources compared to traditional teaching methods, which may be a barrier in some educational institutions (Guo et al., 2020). Therefore, it is crucial for educational management to understand the importance of PBL in improving students' problem-solving abilities and to provide the necessary support. This includes offering effective training for lecturers in designing and implementing PBL, as well as creating an environment that fosters collaboration among students. In some cases, a lack of institutional support can diminish the potential success of PBL. Further research is needed to evaluate how institutional support affects the success of problem-based learning in enhancing students' problem-solving skills.

The implementation of Problem-Based Learning (PBL) in the context of local culture can also influence the effectiveness of this method in improving students' problem-solving abilities. In some countries, educational cultures that emphasize passive learning, such as listening to lectures and memorization, may make it difficult for students to adapt to more active, problem-based learning methods. On the other hand, in countries with strong collaborative and discursive cultures, PBL may be more easily accepted and implemented (Samo et al., 2018). Therefore, adapting PBL to align with the local cultural context is essential to ensure its effectiveness. More in-depth research is needed to explore how educational culture affects the implementation of PBL, and how this method can be adapted to be more effective in enhancing students' problem-solving skills across different cultural contexts. This research could also help identify the factors that need to be considered when designing and implementing PBL according to the cultural characteristics of students in a particular country or educational institution.

Overall, while Problem-Based Learning shows great potential in improving students' problem-solving abilities, its effectiveness is greatly influenced by various factors. Factors such as student motivation, institutional support, lecturer preparedness, and cultural context are key to the successful application of this method (Sa’idah et al., 2019). Therefore, further research is required to thoroughly evaluate how these factors interact and affect the outcomes of PBL. This way, the research can provide practical recommendations for educators and educational institution managers to optimise the implementation of PBL as a teaching method that can significantly enhance students' problem-solving skills.

This study aims to examine the impact of Problem-Based Learning (PBL) on students' problem-solving abilities. The research question in this study is how far the implementation of PBL can improve students' problem-solving abilities across various disciplines, and the factors that influence the effectiveness of this method. The goal of this research is to identify and analyze the influence of PBL on the improvement of students' problem-solving skills, as well as to evaluate the supporting and inhibiting factors in the implementation of PBL. This study will use a quantitative approach, collecting data through questionnaires and statistical analysis to measure the relationship between problem-based learning and students' problem-solving abilities. The scope of this study is limited to university students who participate in problem-based learning programs as part of their curriculum, focusing on the analysis of learning outcomes related to problem-solving skills both individually and in groups.

Literature Review

Constructivist Learning Theory

The first theory that supports this research is the Constructivist Learning Theory, proposed by Piaget and Vygotsky, which emphasizes that knowledge is built by individuals through interaction with their environment and their own experiences. In the context of Problem-Based Learning (PBL), this theory explains that students do not merely passively receive knowledge, but instead, they construct understanding through direct experiences in solving problems. PBL supports this concept by providing real-world problems that motivate students to search for solutions, collaborate, and learn from their experiences. This process helps develop better problem-solving skills because students are actively engaged in seeking solutions and reflecting on their process. Research by (Manuaba et al., 2022) states that applying a constructivist approach in PBL improves students' critical thinking skills, which is a crucial element in problem-solving.

Problem-Based Learning Theory

The second theory that supports this research is the Problem-Based Learning Theory, developed by Barrows & Tamblyn, (1986), which states that PBL is an approach that integrates problems at the core of learning to develop problem-solving skills. In PBL, students are given problems that do not have immediate solutions, requiring them to search for information, analyze situations, and develop creative solutions. Problem-Based Learning (PBL) Theory is a student-centered pedagogical approach where learning begins with a problem rather than traditional subject matter. In this approach, students are presented with a complex, real-world problem that lacks a clear, predefined solution. Through collaboration and critical thinking, they engage in self-directed learning to identify knowledge gaps, research solutions, and apply concepts to solve the problem. The role of the instructor shifts from a traditional "sage on the stage" to a facilitator or guide who supports students as they navigate the problem-solving process, encouraging independent and reflective learning (Barrows & Tamblyn, 1986).

In addition, Jonassen & Hung (2008) emphasized that PBL fosters the development of higher-order thinking skills, such as critical thinking, problem-solving, and decision-making, by placing students in the context of authentic challenges. PBL encourages active learning, where students learn by doing, thereby increasing motivation and engagement. It also develops essential lifelong learning skills, as students must assess the problem, formulate hypotheses, research relevant information, and communicate their findings effectively. Thus, PBL not only helps students grasp content but also equips them with the skills necessary to adapt and succeed in dynamic, real-world situations. This theory focuses on developing skills needed to solve real-world problems, which are highly relevant to today's professional demands. Research by Asyhari & Sifa'i (2021) shows that PBL can improve problem-solving skills because students are involved in an active, collaborative, and problem-based learning process related to real-life situations. This study affirms that PBL can result in better skill development compared to traditional learning methods.

Problem-Solving Skill Theory

According to Dewey, the problem-solving process is not just about finding a quick solution, but rather a critical and reflective way of thinking that helps individuals overcome challenges in a more systematic and effective way.. John Dewey was one of the first and most influential educational theorists to study the problem-solving process. Dewey said that the process is not just a sequence of ideas, but a sequential process such that each idea refers to the previous idea to determine the next step. Dewey gave five main steps in solving problems (Roskaputri et al., 2021):

1. Recognizing/presenting the problem: no problem-solving strategy is needed if it is not a problem;
2. Defining the problem: problem-solving strategies emphasize the importance of defining the problem in order to determine the number of possible solutions;
3. Developing several hypotheses: hypotheses are alternative solutions to solving the problem;
4. Testing several hypotheses and evaluating the weaknesses and strengths of the hypothesis;
5. Choosing the best hypothesis

Related Research

The first study relevant to this research is "The Effect of Problem-Based Learning Approach in Enhancing Problem Solving Skills in Chemistry Education: A Systematic Review" by (Raman et al., 2024). This study aims to evaluate the impact of implementing PBL on students' problem-solving abilities in the chemistry department. It uses a Systematic Review approach with a literature design to measure changes in problem-solving abilities before and after the implementation of PBL. The results show that PBL implementation significantly improves students' problem-solving abilities, especially in analytical and critical aspects. The similarity of this study with the ongoing research lies in the shared focus on the application of PBL and its measurement of students' problem-solving abilities. However, the difference lies in the disciplinary context, where (Raman et al., 2024) research focuses on the chemistry department, while this research encompasses students from various disciplines in higher education.

The second relevant study is "Meta-Analysis of Problem-Based Learning on Students' Problem-Solving Skills in Higher Education" by Atmaja et al., (2024). This study also uses a quantitative approach and focuses on students from various departments at a university. It examines whether the implementation of PBL can improve problem-solving skills in a multidisciplinary learning context. The results indicate that students who learned using the PBL method showed a significant improvement in problem-solving skills compared to students who followed conventional teaching methods. The similarity with this research is that both examine the impact of PBL on students' problem-solving abilities. The difference is that Atmaja et al., (2024) study places more emphasis on meta-analysis, while this study focuses more on the factors that influence the effectiveness of PBL across various disciplines.

RESEARCH METHODS

This study uses a quantitative method with a simple linear regression analysis approach to examine the impact of Problem-Based Learning (PBL) on students' problem-solving abilities. A quantitative method was chosen because it allows the researcher to measure and analyze data objectively and systematically. In this study, simple linear regression analysis is used to explore the

relationship between two variables: the implementation of PBL as the independent variable and students' problem-solving abilities as the dependent variable. This analysis technique is used to determine the extent of PBL's influence on students' problem-solving skills based on the data collected from respondents. This method has been used in various educational studies to assess the impact of teaching methods on learning outcomes (Astuti et al., 2023).

The respondents in this study consist of 72 students from ARS University, class EID E, who are taking the Digital Innovation Ecosystem course in the odd semester of the 2024/2025 academic year. Class EID E comprises students from various programs, such as Computer Engineering, Information Systems, Communications, Management, Visual Communication Design, and Nursing. This class was chosen to obtain a representative sample of students from multiple disciplines, allowing the study to assess how effectively PBL is applied in improving problem-solving skills across different academic backgrounds. This also allows the researcher to observe variation in problem-solving abilities across various fields of study (Kardoyo et al., 2020).

The instrument used in this study is a questionnaire consisting of questions related to students' problem-solving abilities, which are measured both before and after the implementation of the Problem-Based Learning method. The questionnaire includes items that measure aspects such as analytical skills, creativity, and teamwork in problem-solving. The questionnaire is designed using a 5-point Likert scale to obtain more detailed responses regarding the extent to which students feel capable in various aspects of problem-solving (Lutfauziah et al., 2023). Data collection is conducted at the end of the semester, after the implementation of PBL, which allows the researcher to measure changes in students' problem-solving abilities after taking the Digital Innovation Ecosystem course. The measurement of the variables contained in this research analysis model is sourced from the answers to the questions contained in the questionnaire. Because all of these answers are descriptive, they are given a value to become quantitative data. Determination of the answer value for each question uses the Likert Scale method with the following weighting of each statement:

1. If choose the answer Strongly Agree (SA), then it is given a value of 5
2. If choose the answer Agree (A), then it is given a value of 4
3. If choose the answer Quite Agree (QA), then it is given a value of 3
4. If choose the answer Disagree (D), then it is given a value of 2
5. If choose the answer Strongly Disagree (SD), then it is given a value of 1

The data collection technique used in this study involves students completing the questionnaire directly and anonymously. The collected data is then analyzed using simple linear regression analysis to determine the extent of PBL's impact on students' problem-solving abilities. Simple linear regression is chosen because it allows the researcher to test the relationship between one independent variable (PBL) and one dependent variable (problem-solving abilities) (Winarti et al., 2019). The results of the linear regression analysis will provide information on the regression coefficient, which indicates the magnitude of PBL's impact on students' problem-solving skills.

In this study, the analyzed data will be presented in the form of tables and graphs to facilitate the interpretation of the results. As a next step, the results of the simple linear regression will be tested for significance using a t-test to determine whether the relationship between PBL and students' problem-solving abilities is significant (Schmidt et al., 2023). Additionally, the coefficient of determination (R^2) will be calculated to assess how much of the variation in students' problem-solving abilities can be explained by the implementation of PBL. By using this method, the study aims to

provide clearer insights into the impact of PBL on students' problem-solving skills and to offer recommendations for the development of problem-based learning at universities.

Based on the objectives and findings of this study, the following hypotheses are proposed:

- Main Hypothesis (H_1): The implementation of problem-based learning (PBL) has a positive and significant effect on students' problem-solving abilities.
- Null Hypothesis (H_0): The implementation of problem-based learning (PBL) does not have a significant effect on students' problem-solving abilities.

The main hypothesis (H_1) suggests that applying the problem-based learning method can enhance students' ability to solve problems, which aligns with the analysis showing a significant relationship between the two variables. In contrast, the null hypothesis (H_0) asserts that there is no significant effect of PBL on students' problem-solving abilities.

Validity test is used to find out how accurate an instrument or items are in measuring the questionnaire. Valid means that the instrument can be used to measure what should be measured. So, this aims to find out the level of validity of the questionnaire instrument used in data collection (Taherdoost, 2016). The decision-making method for validity testing in this study is based on the correlation value, so the r table value must be found first. Then the calculated r value is compared with the r table as follows:

- If the calculated r value < r table, then the item is declared invalid.
- If the calculated r value > r table, then the item is declared valid.

Reliability test is used to determine whether the data collection tool shows the level of accuracy, level of accuracy, stability or consistency in revealing certain symptoms. The minimum requirement that is considered to meet the requirements is if the alpha Cronbach's coefficient obtained is 0.6. If the coefficient obtained is less than 0.6, the research instrument is declared unreliable. If in the trial this instrument is valid and reliable, then it can be used for measurement in the context of data collection (Namdeo & Rout, 2016).

RESEARCH RESULTS AND DISCUSSION

In this study, the main objective was to determine the impact of problem-based learning (PBL) on students' problem-solving abilities. In regression analysis, the "R value" refers to the correlation coefficient (r) or coefficient of determination (R^2). The correlation coefficient (r) measures the strength and direction of the linear relationship between two variables, with values ranging from -1 to +1. The coefficient of determination (R^2) indicates the proportion of variance in the dependent variable that can be explained by the independent variables, with values ranging from 0 to 1 (Gao, 2024). In short, the "R value" helps us understand the relationship and predictive power in a regression model. Based on the results of simple linear regression analysis, presented in the Model Summary, there is a strong and significant relationship between the influence of problem-based learning (X) and students' problem-solving abilities (Y). The R value of 0.851 indicates a very strong correlation between the two variables, with an Adjusted R Square of 0.720, meaning that approximately 72% of the variation in students' problem-solving abilities can be explained by problem-based learning. These results are consistent with previous research, which shows that the PBL method can enhance students' ability to solve problems more effectively (Dakabesi & Luoise, 2019).

Table 1. Model Summary[b]

R	R Square	Adjusted R Square	Std. Error of the Estimate
.851[a]	.723	.720	3.768

a. Predictors: (Constant), PBL_X

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R	R Square	Adjusted R Square	Std. Error of the Estimate
.851[a]	.723	.720	3.768

b. Dependent Variable: PROBSOLV_Y

The results of the ANOVA test show that the regression model is significant, with an F value of 183.162 and a very small p-value (0.000), which is much smaller than 0.05. This indicates that problem-based learning has a highly significant effect on students' problem-solving abilities. In the context of statistics, especially in regression analysis and ANOVA (Analysis of Variance), the F value is the result of the F test, which is used to test the overall significance of a regression model. In linear regression, the F test is used to determine whether there is a significant linear relationship between the independent variables and the dependent variable. A high F value indicates that the overall regression model is significant, meaning that at least one independent variable has a significant effect on the dependent variable. A low F value indicates that the regression model is insignificant, meaning that none of the independent variables significantly affect the dependent variable (Sureiman & Mangera, 2020). The F-test results suggest that the model developed effectively explains the relationship between variable X (Problem-Based Learning) and Y (Problem-Solving Ability). This is consistent with the theory that learning methods involving real-world problem-solving can facilitate the development of students' critical and creative thinking skills, which are essential for solving problems in real-life situations (Barrows & Tamblyn, 1986).

Table 2. ANOVA[b]

Sum of Squares	df	Mean Square	F	Sig.
2599.996	1	2599.996	183.162	.000[a]
993.657	70	14.195		
3593.653	71			

a. Predictors: (Constant), PBL_X

b. Dependent Variable: PROBSOLV_Y

In regression analysis, the “B value” refers to the regression coefficient that indicates the magnitude of the change in the dependent variable (Y) for every one unit change in the independent variable (X). This B value measures the strength of the influence of variable X on Y, where a positive value indicates a positive relationship (an increase in X is followed by an increase in Y), and a negative value indicates a negative relationship (an increase in X is followed by a decrease in Y) (Pearson, 2010). In the regression coefficients section, the B value for variable X is 0.734, indicating that for every one-unit increase in the implementation of problem-based learning, students' problem-solving abilities increase by 0.734 units. The standardized Beta value of 0.851 shows that the impact of problem-based learning on students' problem-solving abilities is quite substantial, with a greater effect compared to other variables involved. The positive B coefficient indicates a direct and positive relationship between the two variables—meaning the more extensively PBL is applied, the better students' problem-solving abilities become. A similar finding was reported by Asyhari & Sifa’i (2021), where the implementation of PBL strengthened students' problem-solving skills.

Table 3. Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	7.809	1.865		4.188	.000
	PBL_X	.734	.054	.851	13.534	.000

a. Dependent Variable: PROBSOLV_Y

Furthermore, the residual analysis indicates that this regression model meets the basic assumptions of regression, particularly the normality of the residuals. The Normal P-P Plot shows that the residual points are distributed along the diagonal line, suggesting that the residuals follow a normal distribution. This is an indication that the regression model used is valid and reliable for predicting students' problem-solving abilities based on problem-based learning. Meanwhile, the residual histogram shows a symmetric and nearly normal distribution, which supports this finding. Therefore, this regression model meets the important assumption of normality in regression analysis, making the results of this study trustworthy.

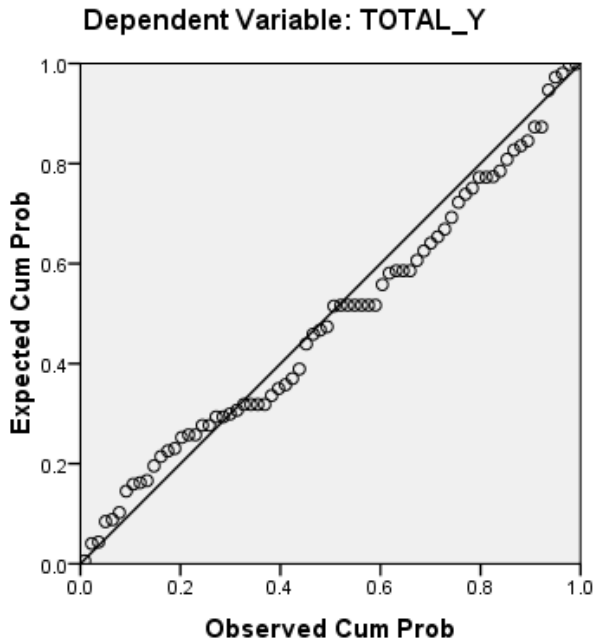

Figure 1. Normal P-P Plot Graphic

Additionally, the results of the Pearson correlation show that all the variables analyzed in this study have a positive and significant correlation. For example, the correlation between the problem-based learning (PBL) variable (X) and students' problem-solving abilities (Y) is very strong, with a Pearson correlation value of 0.851 and a very low significance value ($p < 0.01$). This indicates a highly significant relationship between the implementation of PBL and students' ability to solve problems. These results support the theory that problem-based learning encourages students to actively engage in the problem-solving process, which in turn enhances their ability to tackle real-world challenges.

In this study, the variation in the data shows a positive and significant influence of PBL on students' problem-solving abilities, although there are some differences among students. Some students may face difficulties in adopting the PBL method, especially those who are accustomed to conventional learning. Therefore, it is important to understand the factors that affect the success of PBL, such as students' motivation, mental readiness, and academic background. Research by (Dakabesi & Luoise, 2019) also found that motivation is a crucial factor in maximizing the benefits of PBL, with students who have high intrinsic motivation showing better results in problem-based learning.

From the correlation analysis results presented in the Pearson correlation table, it is evident that many variables have a strong and significant relationship with students' problem-solving abilities. For example, variable X6 (use of technology in learning) shows a correlation of 0.878 with the total problem-solving ability score (PBL_X), indicating that the use of technology in PBL can significantly enhance students' problem-solving skills. This aligns with research by Asyhari & Sifa'i (2021), which showed that integrating technology in PBL can enrich the learning experience and encourage students to be more active in the learning process.

Table 4. Correlations

	PBL_X
X1	.726**
X2	.668**
…	…
X6	**.878****
…	.793**
X10	.894**

**. Correlation is significant at the 0.01 level (2-tailed).

However, despite the strong positive correlation, this study also shows that there are several factors to consider in the implementation of PBL. One of these factors is the variability in students' responses to this method. Some students may need more time to adjust to the active learning approach used in PBL. Additionally, effective classroom management and support from instructors are crucial to ensure that PBL is implemented effectively. Therefore, training for instructors to master PBL techniques and provide appropriate guidance to students is essential for the successful implementation of this method.

The analysis also indicates that there is a significant relationship between problem-based learning and students' problem-solving abilities across various disciplines. Students from different study programs, such as Computer Engineering, Information Systems, and Management, showed significant improvement in their ability to solve problems after participating in PBL. This suggests that PBL can be applied across disciplines to enhance students' problem-solving skills, which are relevant to the demands of the professional world today, requiring critical, creative, and collaborative thinking.

In conclusion, this study shows that problem-based learning (PBL) has a significant impact on students' problem-solving abilities. The linear regression model used in this study proves effective

in explaining the relationship between the two variables, with results showing a strong positive correlation. Furthermore, the residual analysis and P-P plot demonstrate that the model is valid and reliable. Therefore, PBL can be a highly effective approach for developing students' problem-solving skills, which are essential for facing future academic and professional challenges.

CONCLUSION

This study shows that the problem-based learning (PBL) method has a strong influence on students' problem-solving abilities. Statistical analysis revealed a very close relationship between the implementation of PBL and the improvement of students' problem-solving abilities. Most of the variation in students' problem-solving abilities can be explained by the implementation of PBL. The statistical model used proved significant, meaning that the results of this study were not coincidental. Any increase in the implementation of PBL correlated with an increase in students' problem-solving abilities. Although the study shows a positive impact of PBL, there are several limitations such as the generalization of the results that may be limited to the sample and context of the study, the measurement of variables that may not be comprehensive, and other factors outside of PBL that affect students' problem-solving abilities. This study also has limitations in the design and interpretation of data, so further research is needed by considering these factors to optimize the implementation of PBL. The recommendation that can be given is for educational institutions to use more PBL methods in various fields of study to improve students' problem-solving skills. The implementation of PBL needs to be supported by training for teachers and adequate facilities to support an active and collaborative learning process. Further research is needed to understand other factors that influence the effectiveness of PBL, such as student motivation and the role of technology. Thus, PBL can be optimized to improve the quality of education and prepare students with relevant skills for the world of work.

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