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Flipped Classroom Model - PBL: Innovative Solutions to Improve Student Problem Solving

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Abstract:

The increasing integration of digital technology in higher education requires instructional approaches that can effectively develop students' higher-order thinking skills, particularly problem-solving ability. This study examines the effect of integrating the Flipped Classroom model with Problem-Based Learning (PBL) on university students' problem-solving skills. A quantitative approach was employed using a quasi-experimental design with a nonequivalent control group. The participants consisted of 66 undergraduate students enrolled in an Innovative Learning Media course, divided into an experimental group (31 students) and a control group (35 students). The experimental group was taught using the Flipped Classroom–PBL model, while the control group received conventional lecture-based instruction. Data were collected through pretests and posttests using a validated problem-solving test comprising non-routine essay questions, supported by observation sheets to ensure instructional fidelity. The data were analyzed using descriptive statistics, independent samples t-tests, and ANCOVA to control for initial differences between groups. The results indicate that students in the experimental group demonstrated a significantly greater improvement in problem-solving ability compared to those in the control group. These findings suggest that the integration of Flipped Classroom and PBL provides meaningful learning opportunities by encouraging active engagement, critical analysis, and collaborative problem-solving. This study contributes empirical evidence supporting the use of integrated active learning models as an effective strategy for enhancing problem-solving skills in higher education contexts.

Key Words: *Flipped Classroom, Problem-Based Learning, Problem-Solving Skills, Higher Education, Active Learning*

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INTRODUCTION

In recent years, higher education has been increasingly challenged to prepare students not only to master disciplinary knowledge, but also to deal with complex and uncertain problems encountered in real academic and professional contexts. Problem-solving ability is a critical competence required of university graduates, as it underpins analytical reasoning, decision-making, and collaborative work in contemporary societies (Jiang & Chang, 2023; Tongcua & Cajandig, 2025; Sugita, et al., 2024). Nevertheless, learning practices in many universities still rely heavily on lecturer-dominated instruction, where students are positioned primarily as recipients of information rather than active participants in knowledge construction (Cossu et al., 2022; Saraswat, 2024; Vermunt, 2023). This instructional pattern often provides limited opportunities for students to engage with authentic problems, test alternative solutions, or reflect on their reasoning processes. As a consequence, students' problem-solving skills tend to develop in a fragmented and procedural manner, rather than as integrated higher-order cognitive abilities.

In response to these challenges, a growing body of research has highlighted the potential of student-centered instructional models, particularly the Flipped Classroom and Problem-Based Learning (PBL). Flipped Classroom shifts the initial exposure to learning content outside the classroom through videos or digital materials, allowing in-class time to be devoted to higher-order learning activities such as discussion and application (Arul, 2025; Jeong & González-Gómez, 2025; Syska, 2021). Meanwhile, PBL places authentic and ill-structured problems at the center of learning, encouraging students to engage in inquiry, critical thinking, and collaborative solution development (Hidayah & Nurita, 2022; Usman et al., 2024; Wardana et al., 2024). Recent empirical studies suggest that integrating flipped learning with problem-based or project-based approaches can enhance students' problem-solving skills, creativity, and engagement (Karan & Brown, 2022; Nantha et al., 2022; Ruslan et al., 2024). However, much of this evidence is derived from descriptive studies or research conducted at the secondary education level, leaving questions about the causal effectiveness of such integration in higher education contexts insufficiently addressed.

This limitation points to a clear research gap in the existing literature. First, empirical studies that examine the integration of Flipped Classroom and PBL using a quasi-experimental design at the university level remain scarce, particularly those that directly compare this integrated model with conventional instruction. Second, prior research often focuses on general learning outcomes or student perceptions, rather than explicitly measuring gains in problem-solving ability as a primary outcome variable. Third, limited attention has been given to examining the effectiveness of the Flipped Classroom–PBL (FC–PBL) model across different academic programs, which restricts understanding of its robustness and applicability in diverse higher education settings. Accordingly, the novelty of the present study lies in its use of a quasi-experimental approach to provide empirical evidence on the effect of FC–PBL on university students' problem-solving skills, based on a controlled comparison with traditional teaching methods.

Building on this gap, the present study aims to analyze whether there is a significant difference in problem-solving ability between students who learn through the Flipped Classroom integrated with Problem-Based Learning and those who receive conventional instruction. By employing a quasi-experimental design, this study seeks to strengthen causal inference regarding the effectiveness of FC–PBL while maintaining ecological validity within authentic classroom settings. Beyond measuring post-instruction outcomes, the study emphasizes problem-solving as a higher-order cognitive skill that reflects students' ability to analyze problems, formulate strategies, and evaluate solutions. In doing so, this research is expected to contribute meaningful empirical insights into the design of innovative instructional strategies in higher education. The following section describes the research methodology adopted to systematically examine the impact of the FC–PBL model on students' problem-solving abilities.

RESEARCH METHODS

This study employed a quantitative approach using a quasi-experimental design, specifically the nonequivalent control group design . This design was selected because random assignment of participants is often impractical in educational contexts where classes are pre-established (Alshamrani et al., 2021; Dvorak et al., 2022; Lee & Sung, 2025). Accordingly, two intact classes with relatively comparable characteristics were involved: one class served as the experimental group and the other as the control group. The experimental group received instruction through the Flipped Classroom model integrated with Problem-Based Learning (FC–PBL), while the control group was taught using a conventional instructional approach dominated by lecturer-centered explanations and routine practice activities. This design allowed for a systematic comparison of learning outcomes while preserving the authenticity of the instructional setting (Lara, 2025; Ridley, 2023; Antón-Sancho, et al., 2024).

The population of this study consisted of undergraduate students enrolled in the Innovative Learning Media course in the Information Technology Education and Economics Education study programs. A purposive sampling technique was applied, with the criterion that students had not previously experienced learning through Flipped Classroom or Problem-Based Learning approaches. Based on this criterion, the sample comprised 31 students in the experimental group and 35 students in the control group. In the experimental group, learning began with pre-class activities in which students studied instructional videos and reading materials independently. Classroom sessions were then devoted to Problem-Based Learning activities, including problem identification, analysis of relevant information, formulation of solution strategies, and collaborative presentation of solutions. This learning sequence is consistent with flipped learning principles that emphasize pre-class content acquisition and in-class active learning (Deng & Gao, 2024; Sharom & Kew, 2025; Xin & Zhang, 2024).

The primary instrument used to measure the dependent variable was a problem-solving test consisting of non-routine essay questions aligned with the course content. The test assessed students' abilities to identify problems, design solution strategies, implement problem-solving procedures, and evaluate the effectiveness of the solutions obtained, in line with established problem-solving frameworks (Baity, 2021; Imron, 2025; Nasir & Syartina, 2021). Prior to implementation, the instrument was reviewed by experts and pilot-tested, with reliability established using Cronbach's Alpha coefficient. Observation sheets were also employed to monitor the fidelity of the FC–PBL implementation in the experimental group. Data collection was conducted through a pretest, followed by the instructional intervention, and a posttest. Descriptive statistics were used to summarize students' performance, while inferential analysis involved an independent samples *t*-test on gain scores. When differences in initial ability were identified, Analysis of Covariance (ANCOVA) was applied to control for pretest effects, as recommended for quasi-experimental studies (Emamipour et al., 2024; Kunce, 2021; Werida et al., 2025). Based on this analytical framework, the research hypothesized that students who learned through the FC–PBL model would demonstrate significantly higher problem-solving abilities than those who received conventional instruction.

RESULTS AND DISCUSSION

Results

Descriptive Analysis of Student Problem Solving

This research was carried out in the control class (economic education study program) and the experimental class (information technology education study program) to find out if there was a significant difference in the level of student problem-solving between the group that followed the Flipped Classroom learning model integrated with Problem-Based Learning and the group that followed the conventional learning model. This research is classified as experimental research because it has the purpose of knowing the consequences of giving a treatment to the experimental class group.

The description of student problem-solving data in this study is in the form of posttest quantitative data. The posttest aims to find out the students' problem-solving skills after receiving treatment. Research data for student problem solving was obtained based on the results of test instruments in the form of description questions to test student problem solving. Student problem-solving data from posttest results in the experimental class and the control class are presented in the table below.

Table 1. Description of Experimental and Control Student Problem-Solving Data

Statistics			
		Control_Class	**Experimental_Class**
N	**Valid**	**35**	**31**
	Missing	**0**	**4**
Mean		75,8857	84,9355
Median		81,0000	86,0000
Std. Deviation		18,87851	8,06199
Minimum		17,00	65,00
Maximum		99,00	97,00

Based on the descriptive summary, as shown in the table above, it is stated that the highest test result achieved by students in the experimental class was 97, and the control class was 99. The lowest test result of the experimental class was

65, and the control class was 17. From the table, the average of the control class and the experimental class can also be known. From the table, it can be seen that the experimental class is 84.9355 from the average. The control class is 75.8857.

From the table, it can be seen that the rate of improvement in student problem-solving in the experimental class is higher than in the control class. The trend of post-test results can be determined by setting categorization criteria. From the description of the data, it is known that the student problem solving is known to have a minimum value (X min) and a maximum value (X max) is known, then it is known that the ideal average value (Mi) with the Formula Mi = 1/2 (X max + X min), looking for the ideal standard deviation (SDi) with the formula SDi = 1/6 (X max-X min), then it is known that the student problem solving is known to have a minimum value (X min) and a maximum value (X max) is known, then then look for the ideal average value (Mi) with the formula Mi = 1/2 (X mak + X min), find the ideal standard deviation (SDi) with the formula SDi = 1/6 (X mak-X min). Based on these references, the ideal mean of the experimental class is 85. The ideal standard deviation is 8. The control class is 76. The ideal standard deviation is 19.

Based on the score category, the results of the analysis of the posttest data score category for student problem solving in the experimental class and the control class are presented in Table 2.

Table 2. Categorization of student problem-solving scores: Experiment and Control Class

Category	Control Class	(%)	Experimental Class	(%)
	Frequency		Frequency	
Low	1	2.9	5	14.4
Moderate	28	80.5	19	54.5
High	3	8.6	7	20.0
Total Students	35	—	31	—

The table above can explain the problem-solving tendencies of students from each class, both experimental classes and control classes. Based on the table, it can be seen that in the control class, as many as 28 students or 80.5% are classified as medium categories. Meanwhile, student problem-solving in the experimental class, as many as 19 students or 54.5% were classified as medium and 7 (20%) were classified as high. From the results of the analysis of the score categories of the control class and the experimental class, there was a difference in the percentage increase in students' problem-solving ability in the experimental class, showing be higher increase than the control class.

Normality Test

The normality test is used to find out whether the samples taken from each bound variable come from a normally distributed population or not. The normality test is very important to be carried out as part of the prerequisite test in order to determine the right analysis technique. The normality test used the

Kolmogorov-Smirnov test with the help of SPSS 24 software. The hypotheses proposed to measure the normality of the data are; (1)Ho: Data from a normally distributed population, (H1): The Data are not from a normally distributed population.

The decision criteria state that if the significance value is greater than 0.05, the null hypothesis (H_0) is accepted; conversely, if the significance value is less than 0.05, H_0 is rejected. The results of the normality test are presented in Table 3.

Table 3. Normality Test Results

Variable	Study Program / Group	Kolmogorov–Smirnov[a]			Shapiro–Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
Problem-Solving Ability	Control Class (Economics Education Program)	0.158	35	0.058	0.865	35	0.001
	Experimental Class (Information Technology Education Program)	0.125	31	0.200*	0.940	31	0.084

Based on the results of the normality test, it was shown that the problem-solving data in the experimental class and the control class had a significance value greater than the alpha value (0.05) so that Ho was accepted. Thus, it can be known that the problem-solving in the experimental class and the control class in both classes is normally distributed.

Homogeneity Test

The homogeneity test is intended to test the similarity of the samples from the dependent variables in this study. Homogeneity tests are performed to ensure that the data sample comes from a homogeneous population. The homogeneity test in this study was carried out on critical thinking skills and digital literacy abilities, separately carried out with the Levene test. The following is a summary of the homogeneity test results calculated with the help of SPSS 20 for Windows.

Table 4. Box's Test of Equality of Covariance Matrices[a]

Box's M	38,837
F	6,141
df1	6
df2	28476,747
Sig.	,050

Tests the null hypothesis that the observed covariance matrices of the dependent variables are equal across groups.

a. Design: Intercept + Study Program

The table above shows that the significance value of the Levene's Test results for each bound variable for the experimental class and the control class has a significance value greater than 0.05, so that Ha is accepted, which means that all research subjects related to the bound variable, namely critical thinking skills and learning outcomes, are the same or homogeneous.

T-Test

After the researcher gets the data, the data is analyzed with statistics. At this stage of data analysis, the researcher used the t-test formula, which is to test the hypothesis that there is a significant difference in the level of students' problem-solving ability between the group that follows the Flipped Classroom learning model integrated with Problem-Based Learning and the group that follows the conventional learning model and the student group. The results of the calculation, with the help of SPSS 24.00 for Windows, are the following is a summary table of independent sample t-test results of the experimental class and control class post-test results.

Table 5. Hypothesis Test Results with Independent T-test

Group Comparison	t-value	df	Sig. (p-value)	Interpretation
Experimental Class vs Control Class	-2.475	64	0.016	There is a significant difference

Based on the calculation results of the SPSS *Output Independent Samples Test* above, it can be interpreted from the table that the result of Sig. (2-sided) is 0.016. Because the Sig. value of 0.016 < real level (α= 0.05), Ho was rejected, and Ha was accepted, which means that there was a significant difference in the level of students' problem-solving ability between the group that followed the *Flipped Classroom* learning model integrated *with Problem-Based Learning* and the group that followed the conventional learning model.

Discussion

This research is motivated by the demands of higher education in the era of Society 4.0 and Industrial Revolution 5.0 which emphasizes the importance of problem-solving skills as part of 21st century competencies. Various studies show that conventional lecturer-centered learning has not been fully able to develop students' high-level thinking skills, because students tend to play a passive role and are less involved in the process of analysis and authentic problem-solving. Therefore, this study aims to examine the effectiveness of the integration of the Flipped Classroom model with Problem-Based Learning (FC-PBL) in improving students' problem-solving skills. Conceptually, this study is significant because it expands the empirical evidence on active learning in higher education, especially related to the application of FC-PBL which has been more researched at the secondary education level.

The results of the study showed that students who participated in learning with the FC-PBL model had significantly higher problem-solving skills than students who participated in conventional learning. This difference is reflected in the higher average posttest scores in the experimental class as well as the results of statistical tests that show significant differences. These findings indicate that FC-PBL is able to create a learning environment that is more conducive to the development of students' analytical, evaluative, and creative abilities. However, the results also showed that not all students in the experimental class reached the high ability category, which suggests that there is a variation in students' responses to this learning model. This variation is an indication that the effectiveness of FC-PBL is also influenced by internal student factors, such as readiness to study independently and the ability to self-regulate.

When compared to the results of previous research, these findings are in line with studies that report that flipped learning combined with a problem-based approach can improve students' problem-solving skills and learning engagement (Karan & Brown, 2022; Nantha et al., 2022; Ruslan et al., 2024). In particular, the results of this study support the view that moving material delivery activities to the pre-class stage allows face-to-face time to be used more effectively for discussion, collaboration, and exploration of solutions. However, in contrast to some studies that reported relatively even increases in all students, this study found that some students were still in the moderate category (Beacom, 2025; Ernawati, 2023; Welton, 2023). This difference can be explained by the context of the research subject who comes from the background of different study programs and the level of students' habits in independent learning that has not been fully formed.

This study contributes by providing empirical evidence that the combination of Flipped Classroom and Problem-Based Learning can be effectively applied to learning in higher education to improve students' problem-solving abilities. These findings show that moving material delivery activities to the pre-lecture stage, followed by collaborative problem-solving activities in the classroom, is able to create a more meaningful learning process and is oriented towards the development of higher level thinking. Another contribution of this research lies in the context of its application, namely in students from different study programs, thus enriching the understanding of the flexibility of the FC-PBL model in various academic settings. In addition, the results of this research can be used as a practical reference for lecturers in designing learning that not only emphasizes mastery of the material, but also encourages students to analyze problems, formulate solutions, and account for decisions made in the real context of lectures.

CONCLUSION

The results showed that there was a significant difference in problem-solving skills between students who learned using the Flipped Classroom learning model integrated with Problem-Based Learning (PBL) and students who learned with the conventional model. Thus, the application of the Flipped

Classroom-PBL model has proven to be more effective in improving students' problem-solving skills, as it provides greater opportunities for them to think critically, collaborate, and apply concepts directly in the context of problem solving.

The results of this study provide several important implications for the world of higher education. First, the application of the Flipped Classroom-PBL model can be used as a strategic alternative in designing a more active, collaborative, and oriented learning process that is oriented towards the development of high-level thinking skills, especially problem solving skills. Second, lecturers and educational institutions need to optimize the use of learning technologies such as videos, online platforms, and digital teaching materials so that students can prepare themselves before face-to-face meetings and focus more on analysis and problem-solving activities in the classroom. Third, these results are also the basis for education policymakers to encourage the application of innovative learning models more widely, in order to form graduates who are adaptive, creative, and ready to face the challenges of the Industrial Revolution 5.0 era.

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